Interreg Mediterranean
BIODIVERSITY PROTECTION

UNIVERSIDAD DE MÁLAGA
ETC UMA

MEDITERRANEAN BIODIVERSITY AND MARINE LITTER

An interaction knowledge base

In collaboration with:

MedCités
MedCities

MEDITERRANEAN BIODIVERSITY AND MARINE LITTER

An interaction knowledge base

This report is a joint effort of the Biodiversity Protection Community projects co-financed by the Interreg-MED Programme focusing on pollution aspects according to the PANACeA Roadmap for Working Group 1 on Biodiversity Protection and Management.

The projects featured in this report have supported the review of a spatial understanding of marine litter threats to Mediterranean marine life particularly in Marine Protected Areas (MPAs).

Citation:

Mediterranean biodiversity and marine litter: an interaction knowledge base, Interreg Med Biodiversity Protection project, 2019.

Authors:

Carlos Guitart (ETC-UMA), Dania Abdul Malak (ETC-UMA), Antonio Sánchez (ETC-UMA), Carolina Pérez Valverde (MedCities), Emanuele Bigagli (Independent Consultant, MedCities), Sonsoles San Román (ETC-UMA)

Contributors:

ACT4LITTER: Thomais Vlachogianni (MIO-ECSDE), Ignasi Mateo Rodriguez (UNEP MAP SCP/RAC)

AMARE: François Galgani (IFREMER), Simonetta Fraschetti (University of Naples Federico II)

MEDSEALITTER: Morgana Vighi (University of Barcelona), Antonella Arcangeli (ISPRA), Odei Garcia-Garin (University of Barcelona), Roberto Crosti (ISPRA)

PHAROS4MPAs: Catherine Piante (WWF France), Pierre Yves Hardy (WWF France)

PLASTICBUSTERS MPAs: Maria Cristina Fossi (University of Siena), Teresa Romeo (ISPRA), Cristina Panti (University of Siena), Alessandro Galli (University of Siena), Ilaria Caliani (University of Siena)

PANACeA: Konstantia Nikopoulou (MedCities)

Cover Photo: AP Images/European Union-EP

Back cover photo: annapolis_rose/flickr.com

Design and layout: Blueverdestudio.com

Table of Contents

Glossary

LEXICON	
Benthic	Of, relating to, or occurring at the bottom of a body of water.
Benthopelagic	Living and feeding near the bottom as well as in midwaters or near the surface. Feeding on benthic as well as free swimming organisms. The depth zone about 100 m. off the bottom at all depths below the edge of the continental shelf.
Biota	The animal and plant life of a particular region, habitat, or geological period
Colonization	The establishment of a species in an area not currently occupied by that species. Colonisation often involves dispersal across an area of unsuitable habitat. Marine litter items can become colonized and transport potentially invasive species into new habitats.
Demersal	Sinking to or lying on the bottom; living on or near the bottom and feeding on benthic organisms.
Entanglement	Many marine species such as seals, whales and marine turtles become entangled in marine litter, causing suffocation, strangulation and drowning. Marine litter can also restrict movement, reduce the ability to catch food and avoid predators, or cause lacerations and infections. The most frequent cause of entanglement is discarded fishing gear; other causes include 'six-pack' rings and balloon ribbons. (https://ec.europa.eu/environment/marine/pdf/flyer_marine_litter.pdf)
Ingestion	Mistaken as food or ingested accidentally during feeding, debris and litter may block the digestive tract or cause internal injuries and lead to death. It can also impair digestion and stunt growth as well as reproduction rates. There is in-creasing concern that, along with plastics, animals could be ingesting persistent organic pollutants (POPs) and toxic compounds such as medicines. (https://ec.europa.eu/environment/marine/pdf/flyer_marine_litter.pdf)
Isopod	Any freshwater, marine, or terrestrial crustacean of the order or suborder Isopoda, having seven pairs of legs typically adapted for crawling, and a dorsoventrally flattened body, and including wood lice, several aquatic parasites of crabs and shrimps, and numerous swimming or bottom-dwelling species.
Mesopelagic	Living or feeding at midwater at depths between 200 m and 1,000 m. Generally characterized by dim light and steep temperature gradients.
Neritic	Of, relating to, inhabiting, or constituting the belt or region of shallow water adjoining the seacoast.
Neustonic	The collection of microscopic and small organisms that inhabit the region on or just below the surface of a body of water.
Pelagic	Living and feeding in the open sea; associated with the surface or middle depths of a body of water; free swimming in the seas, oceans or open waters; not in association with the bottom. Many pelagic fish feed on plankton. In FishBase, referring to surface or mid water from 0 to 200 m depth.

ACRONYMS	
EBSA	Ecologically or Biologically Significant Areas are areas which, through scientific criteria, have been identified as important for the healthy functioning of our oceans and the services that they provide. In 2008, the ninth meeting of the Conference of the Parties to the Convention on Biological Diversity (COP 9 CBD) adopted the scientific criteria for EBSAs in need of protection in open-ocean waters and deep-sea habitats.
FRA	Fisheries Restricted Area. FRAs are established to ensure the protection of deep-sea sensitive habitats and of essential fish habitats (EFH) in well-defined sites.
GES	Good Environmental Status
IMAP	Integrated Monitoring and Assessment Programme and related Assessment Criteria. At their 19th Ordinary Meeting (COP 19, Athens, Greece, 9-12 February 2016), the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) - namely 21 Mediterranean countries and the European Union - adopted the IMAP.
MBL	MedBioLitter database on interactions between marine litter and biodiversity in the Mediterranean.
ML	Marine litter, debris. Human-created waste discharged into and/or found on the coastal or marine environment.
MPA	The term Marine Protected Area includes marine reserves, fully protected marine areas, no-take zones, marine sanctuaries, ocean sanctuaries, marine parks, locally managed marine areas, among other. They have different levels of protection, and the range of activities allowed or prohibited within their boundaries varies considerably too. WWF uses the term Marine Protected Area as an overarching description of: "An area designated and effectively managed to protect marine ecosystems, processes, habitats, and species, which can contribute to the restoration and replenishment of resources for social, economic, and cultural enrichment."
MSFD	The EU Marine Strategy Framework Directive. The MSFD was put in place to protect the marine ecosystem and biodiversity upon which our health and marine-related economic and social activities depend. To help EU countries achieve a good environmental status (GES), the directive sets out 11 illustrative qualitative descriptors.
RAC	Regional Activity Centre. There are several RACs in the Mediterranean under the umbrella of UNE MAP, among which: • The Plan Bleu Regional Activity Centre (PB/RAC) • The Priority Actions Programme Regional Activity Centre (PAP/RAC) • The Specially Protected Areas Regional Activity Centre (SPA/RAC) • The Regional Activity Centre for Sustainable Consumption and Production (SCP/RAC)
RAMSAR	A Ramsar site is a wetland site designated to be of international importance under the Ramsar Convention. The Convention on Wetlands, known as the Ramsar Convention, is an intergovernmental environmental treaty established in 1971 by UNESCO, which came into force in 1975. It provides for national action and international cooperation regarding the conservation of wetlands and the wise sustainable use of their resources.
SPAMI	Specially Protected Areas of Mediterranean Importance. Through the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA/BD Protocol), the Contracting Parties to the Barcelona Convention established the SPAMI List to promote cooperation in the management and conservation of natural areas, as well as in the protection of threatened species and their habitats. The conservation of the natural heritage is the basic aim that must characterize the SPAMIs. Since the 20th ordinary meeting of the Contracting Parties to the Barcelona Convention and its protocols, the SPAMI List includes 35 sites, among which one encompasses an area established also on the high sea: the Pelagos Sanctuary for marine mammals.
UNEP MAP	United Nations Environment Programme Mediterranean Action Plan. Also known as UN Environment MAP. Through the MAP, the Contracting Parties to the Barcelona Convention and its Protocols are determined to meet the challenges of protecting the marine and coastal environment while boosting regional and national plans to achieve sustainable development. The 22 Contracting Parties to the Barcelona Convention are: Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syrian Arab Republic, Tunisia, Turkey, and the European Union.


1
Photo by: Bru-nO/pixabay.com

Introduction

Marine litter is at present a top ranked pollution menace to the conservation and sustainability of marine biodiversity and healthy and functional ecosystems. There is a growing evidence of global marine ecosystems impacted by marine litter as a result of our unsustainable lifestyles associated with the 'plastic' revolution. The way litter pollution (from macro down to micro and nano scales) is affecting marine life is not fully understood yet, especially beyond short spatial and temporal scales. As the global production of plastics has been growing exponentially since 1960s and as there are already huge quantities of marine litter in the oceans and seas; such studies need to be urgently prioritized to allow the understanding of potential future scenarios and to support finding solutions to guarantee functional marine ecosystems and so the provision of proper ecosystem services.

The Mediterranean Sea is not an exception, and in addition to the efforts to generate evidence and knowledge on the quantities of litter present on beaches and in the sea - floating, present in the water column or accumulated in canyons and deep-sea areas -, it should be imperative to address the current gaps regarding the lack of knowledge on the impacts of marine litter on marine organisms.

This global and Mediterranean issue and the managerial challenges arising from it are the focus of governments and international organizations worldwide seeking to coordinate a global response to this common challenge. First, regarding the mobilization of better awareness, scientific research and priority actions, and secondly, by challenging established consumption patterns, lifestyles and economic inertias through the implementation of circular economy models. With this approach, the UN Environment/Barcelona Convention set the Regional Plan on Marine Litter Management for the Mediterranean 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 Program of the Mediterranean Sea and Coast (UN Environment/Barcelona Convention IMAP), including monitoring and assessment of marine litter (Ecological Objective 10). Moreover, European countries bordering the Northern part of the Mediterranean Sea are combating the 'plastic pollution' through the EU Marine Strategy Framework Directive (EU MSFD, Descriptor 10) and other more recent policies, such as the European Strategy for Plastics in a Circular Economy.

In the Mediterranean, the Interreg-Med programme (2014-2020) has co-financed several initiatives that tackle the issue of marine litter. The Mediterranean Biodiversity Protection Community, co-financed by Interreg Med and featured by PANACeA, is one of these networks and aims at ensuring harmonized approaches to provide transferable evidence-based solutions on this growing challenge in the region. Part of the contribution of this Interreg Med community is to increase the evidence and the understanding of marine litter concerns and to reduce the pressures coming from marine litter as well as its impacts on biodiversity and ecosystems in the Mediterranean region.

The main areas of work of this community to date include the compilation of knowledge and available information on monitoring, measures and actions in marine protected areas (MPAs) and beyond, and to provide tools to support biodiversity protection and management to a wide range of stakeholders from local managers to regional policy makers in the Mediterranean region. An insight on projects tackling marine litter policy, management, pressures, impacts and best practices to combat litter in the marine and coastal environment is presented in Table 1. Five projects (out of 11 thematic projects within the Mediterranean Biodiversity Protection Community) have pursued marine litter pollution knowledge objectives. The knowledge generated by the Biodiversity Protection community has been synthesized here to offer coordinated knowledge and practice in the Mediterranean region and to contribute to both the Mediterranean and international marine litter reduction challenges.

Five thematic projects within the Mediterranean Biodiversity Protection Community have pursued marine litter pollution knowledge objectives

Table 1. Summary of the projects within the Mediterranean Biodiversity Protection Community working on transferable solutions to reduce the pressures of marine litter in their respective selected Marine Protected Areas (MPAs)* - more information on each project is available in Annex I.

Acronym	Title	Marine litter related objectives	Marine Protected Areas participating
ACT4LITTER	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	*National Park of Kornati (Croatia); Thermaikos Gulf Protected Areas (Greece); MPA Miramare (Italy); MPA Torre Guaceto (Italy); Strunjan Landscape Park (Slovenia); MPA Torre del Cerrano (Italy); Ebro Delta Nature Park (Spain); Cabo de Gata-Níjar Natural Park/UNESCO Global Geopark (Spain); and MPA Levante de Mallorca-Cala Ratjada (Spain)*
AMARE	Actions for Marine Protected Areas	Novel approaches to monitoring ML providing georeferenced information on distribution and amounts in MPAs	*Alonissos Northern Sporades National Marine Park (Greece); Porto Cesareo MPA (Italy); Torre Guaceto MPA (Italy); The North-East Marine Protected Area – Maltese Islands (Malta); Freus d' Eivissa i Formentera – Balearic Islands (Spain)*
MEDSEALITTER	Developing Mediterranean-wide protocols to protect biodiversity from litter impact at basin and local MPA scales	Combined monitoring and assessment protocols for marine litter quantities and biodiversity interactions in the sea	*Capo Carbonara MPA, Italy; Cinque Terre MPA, Italy; Egadi MPA, Italy and MPAs included in the ferry transects Barcelona–Civitavecchia; Livorno-Bastia; Palermo-Cagliari; Palermo-Tunis; Ancona-Igoumenitsa-Patras.*
PANACeA	Mainstreaming management efforts in Mediterranean protected areas for better biodiversity protection	Synthesis and capitalization of current research, management and policy efforts and tools to tackle marine litter in the Mediterranean	*Mediterranean*
PHAROS4MPAs	Blue Economy and Marine Conservation: Safeguarding Mediterranean MPAs to achieve a Good Environmental Status	Study of drivers, activities and pressures in the marine environment related to pollution among others	*Marine Natural Park of the Gulf of Lion (France), Camargue Natura2000 Site (France), Samaria MPA, Amvrakikos Wetlands MPA (Greece), Delta Nestou, Vistonidas, Ismaridas MPA (Greece), Zakynthos Marine National Park (Greece), Miramare MPA (Italy), Cap de Creus MPA (Spain)*
PLASTICBUSTERS MPAs	Preserving biodiversity from plastics in Mediterranean Marine Protected Areas	Development of novel scientific approaches and understanding the impact on biodiversity and MPAs	*Karaburun-Sazani Island National Park (Albania), Cres-Lošinj MPA (Croatia), Bouches Bonifacio Parc Marin International (France), Hyeres National Park (France)*, Zakynthos Island National Park (Greece), Lampedusa MPA (Italy), Tuscan Archipelago National Park (Italy), Cabrera Archipelago National Park (Spain), Pelagos Sanctuary SPAMI (Italy/France/Monaco).* ** These areas are still to confirm their involvement in the transfer of project actions*

* Table 1 is not an exhaustive list of all projects in the Mediterranean but rather highlights the most relevant projects co-financed by the Interreg Med programme under the Biodiversity Protection theme that address marine litter.

Photo by: MedSeaLitter

Threats of marine litter on Mediterranean biodiversity

2.1 AN INTEGRATED REGIONAL APPROACH TO A GLOBAL THREAT

Marine litter, human-created waste discharged into and/or found on the coastal or marine environment, is listed among the main perceived threats to biodiversity, causing major concern due to its abundance, durability and persistence in the marine environment.

In order to improve our regional understanding on the degree of threat litter is imposing to the Mediterranean region, ETC-UMA developed under the PANACeA framework a clearinghouse mechanism to provide an overview of current efforts in place, including the creation of a Mediterranean marine litter and biodiversity interactions database known as MedBioLitter. MedBioLitter builds on an extensive literature search to review the current state of knowledge on the effects of marine litter on marine organisms in the Mediterranean region.

The MedBioLitter database on the interactions between marine litter and living organisms has been developed building on a meta-analysis from literature data sources that are georeferenced to allow further spatial assessments. The type of interaction between marine litter and biota in MedBioLitter is classified according to the following four

categories: ingestion, entanglement, colonization and others. The MedBioLitter classification follows the original approach by the LITTERBASE developed by the Alfred Wegener Institute (AWI, Germany), and is consistent with international frameworks in general terms, particularly the reported categories proposed in the review and synthesis work undertaken by the Convention on Biological Diversity (CBD, 2012 and 2016).

The interaction categories are used to show the direct and indirect forms of interactions with biota based on the spatial analysis linking the relative geographical areas of occurrence of biodiversity and the presence of marine litter. The direct interactions studied include ingestion and entanglement with marine litter including microlitter (ca. microplastics) and the indirect interactions related, for example, to the dispersal via rafting of colonized marine litter items (i.e. colonization), and the potential to facilitate the transport of invasive alien species, provision of new habitats or indirect ecosystem level effects.

> Marine litter is listed among the main perceived threats to biodiversity, causing major concern due to its abundance, durability and persistence in the marine environment.

The evidence reported on the interaction of different types of marine litter and biota informs about the impacts of this pressure (marine litter) on key species of marine flora and fauna populations inhabiting a specific ecosystem. The interactions with organisms have been reported to cause different levels of harm (ca. sub-lethal) and death (ca. lethal effects). Reporting on these interactions on the long run provides evidence on the pressures and impacts of marine litter on biota.

In the Mediterranean region, there is a lack of harmonized monitoring and assessment protocols for marine litter, being gaps that are delaying the timely management actions and policy responses to holistically protect Mediterranean biodiversity.

At EU level, within the the MSFD, the Task Group on marine litter provided in 2013 the guidelines for monitoring marine litter in EU waters. Theoretically these guidelines would set the standardized methods to be used for monitoring and assessment. The MEDSEALITTER project was developed to fill the gaps of the 2013 guidelines for monitoring harmonization. The guidelines are being updated at present to include MEDSEALITTER's results and should be available at the beginning of 2020.

Within the frameworks of the EU MSFD and UN Environment/Barcelona Convention IMAP and their components, Descriptor and Ecological objective 10, respectively, 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).

The work undergone by the PANACeA project based on the Biodiversity Protection Community efforts provide an integrated mechanism to enable assessing and monitoring marine litter in the Mediterranean. The MedBioLitter database, set as a long-term tool to assess the effect of marine litter on biodiversity and to support evidence-based decision making, is an important milestone to improve the Mediterranean response capacity to face the challenge of transboundary pollution, namely marine litter.

The database and the information available are currently hosted by the University of Malaga through the Mediterranean Biodiversity Protection Knowledge Platform (biodiversity.uma.es) developed in the framework of the Interreg Med project

PANACeA[1]. The MedBioLitter database is planned and structured to be regularly updated as new scientific literature sources become available.

2.2 THE KNOWN AND UNKNOWN IN THE MEDITERRANEAN REGION

Scientific research has revealed that many marine species are impacted by marine litter in all known habitat types in the Mediterranean Sea. According to literature, up to 134 species were reported to be affected by marine litter in the region (Deudero et al., 2015), and a recent study confirms 91 assessed species were affected by ingestion from different habitats, with most available studies conducted on demersal (32.9%), pelagic (27.7%) species, followed by benthic (14.7%), benthopelagic (16.5%), neritic (5.3%) and mesopelagic (2.9%) species (Fossi et al., 2018 and references therein). Entanglement and colonization interactions such as diverse blockage forms and physical functions impairment as well as rafting or provision of new habitats have been also investigated. Entanglement has been proposed to become a target indicator to be included in the upcoming policy (Galgani et al., 2018).

134 SPECIES

were reported to be affected by marine litter in the region

There are as well very few in-depth scientific studies on colonization of floating plastic materials in the Mediterranean Sea (Masó et al., 2016 and Dussud et al., 2018); implications for the marine ecosystem are still uncertain. Nevertheless, the types of interactions and their impact on species are not yet completely known nor even quantified, with available knowledge differing largely depending on the geographical area in question.

In addition to the gaps identified, the effect of climate change and ocean acidification among other additional pressures on biodiversity is still a major bottleneck that limits the capacity of decision-makers towards integrated responses to these issues. Such is the case, that the development of a harmonized and region-wide science-based knowledge system is fundamental to support and integrate parallel efforts to assess, monitor, and support future projections and potential scenarios for managers and decision-makers on which to build priority actions.

The MedBioLitter knowledge base by the Mediterranean biodiversity protection community, addresses this need. It builds on the combination of the results of the community of projects (Table 1) that worked in over 60 Mediterranean MPAs on different topics linked to biodiversity protection, including marine litter, and complements their knowledge base with available external peer reviewed scientific sources. The MedBioLitter is updated twice a year to include the most recent peer reviewed results published and maintained by the ETC-UMA, lead partner of the PANACeA project, to offer a unique regional knowledge base to develop a Mediterranean wide assessment on the interaction of marine litter with biota.

The results[2] of this assessment (Figure 1) show that regional variability in knowledge is prominent, and that Eastern and Southern Mediterranean regions are data poor, meaning that there is very little research implemented or reported in these areas and therefore the state of interactions between marine litter and biota is unknown. As observed in Figure 1, most of the scientific literature available corresponds to the Northern part of the Mediterranean Sea, particularly to the Western Mediterranean and the Adriatic ecoregions, where all the categories of interactions can be found. It should

[1] https://panaceacatalogue.adabyron.uma.es/gvsigonline/core/public_project_load/marinelitter/
[2] Based on MedBioLitter version 3 (September 2019) of the database: http://panaceaweb.adabyron.uma.es/medbiolitter/

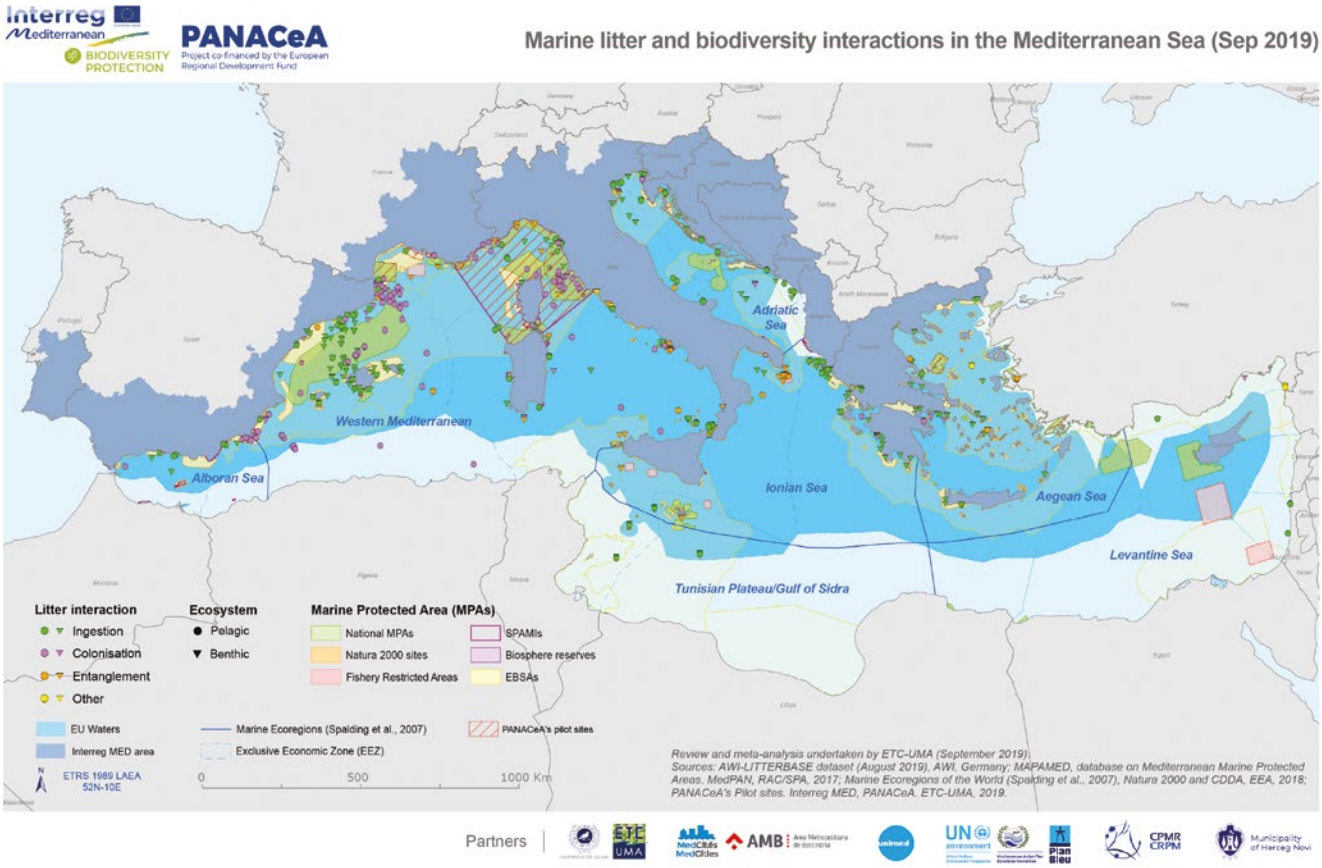


Figure 1. Assessment of interactions between marine litter and biota in the Mediterranean Sea

be mentioned that almost all the results obtained correspond to research monitoring (i.e. sampling operations performed to test scientific hypothesis) or opportunistic sampling, as a starting point for future investigations.

In the Mediterranean Sea, few countries have consolidated routine monitoring networks and programmes in place and fewer have started to report consistently, generally under the obligations of the EU Marine Strategy Framework Directive.

These gaps need to be urgently tackled at regional scale, accompanied by the corresponding regional financial and regulatory mechanisms that would enable the consolidation of a regional mechanism to properly monitor and assess this transboundary pressure in the Mediterranean Sea.

2.3 DISCOVERING MARINE LITTER EFFECTS ON BIODIVERSITY THROUGH SCIENTIFIC RESEARCH

The Med Biodiversity Protection Community is contributing with new regional findings related to the interactions of marine litter with different marine species in almost all marine habitats and commonly known Mediterranean ecological groups. As mentioned elsewhere in this document, the MEDSEALITTER project activities have studied the ingestion of microplastics by pelagic fish (*Boops boops*) and by benthic invertebrates (polychaeta spp), the ingestion of micro- and macroplastics by the loggerhead turtle (*Caretta caretta*) in Greece, Italy, France and Spain; and have evaluated the plastic ingestion probability by marine macro fauna in the Western Mediterranean subregion, based on several surveys combining the measurement of amounts and occurrence of

floating marine litter and marine organisms. In addition, MEDSEALITTER investigated the risk of exposure of marine species listed in the Habitats Directive (such as cetaceans and marine turtles) to marine litter in several Mediterranean areas. Similarly, the PLASTICBUSTERSMPAs project is studying the impacts of marine litter in several species from invertebrates (e.g. isopods, mussels, etc.), fish (*Engraulis encrasicolus*, *Sardina pilchardus*, etc.) and mammal species like the fin whale (*Balaenoptera physalus*), sperm whale (*Physeter macrocephalus*), as well as other groups in the whole Mediterranean region, and particularly in the Pelagos Sanctuary and several Mediterranean MPAs.

Building on the knowledge generated by these initiatives, this report synthesizes the revised meta-analysis undertaken from available literature sources and based on the initial revision from AWI-LITTERBASE Project, identifying the species affected by interactions with marine litter and their common ecological groups (see Figure 2).

The Med community is currently studying key marine species to be protected because of their long biological cycles and high potential vulnerability risks for the population's survival. Scientific knowledge on the number of species affected by interactions with marine litter is larger however, and the list is increasing, especially if planktonic organisms are considered.

More research is needed at species, habitat and ecosystem levels to comprehend the real impacts on biodiversity, addressing climate change and overexploitation effects.

The outcomes indicate that research and results achieved so far are rather centered on certain species, and future research efforts need to address marine litter pollution effects on additional species, including those with economic value, such as commercial fish species already impacted by overexploitation, to fully comprehend the dimension of challenges in Mediterranean marine ecosystems. Such effort needs to be done at species, habitat and ecosystem levels to support more holistically long-term management and conservation efforts, recalling the necessity to intensify research in the Southern part of the Mediterranean especially focused on species that are locally distributed (see Figure 1). This is particularly important as the range of distribution of some species is expected to change along with the meridionalisation phenomenon triggered by climate change effects.

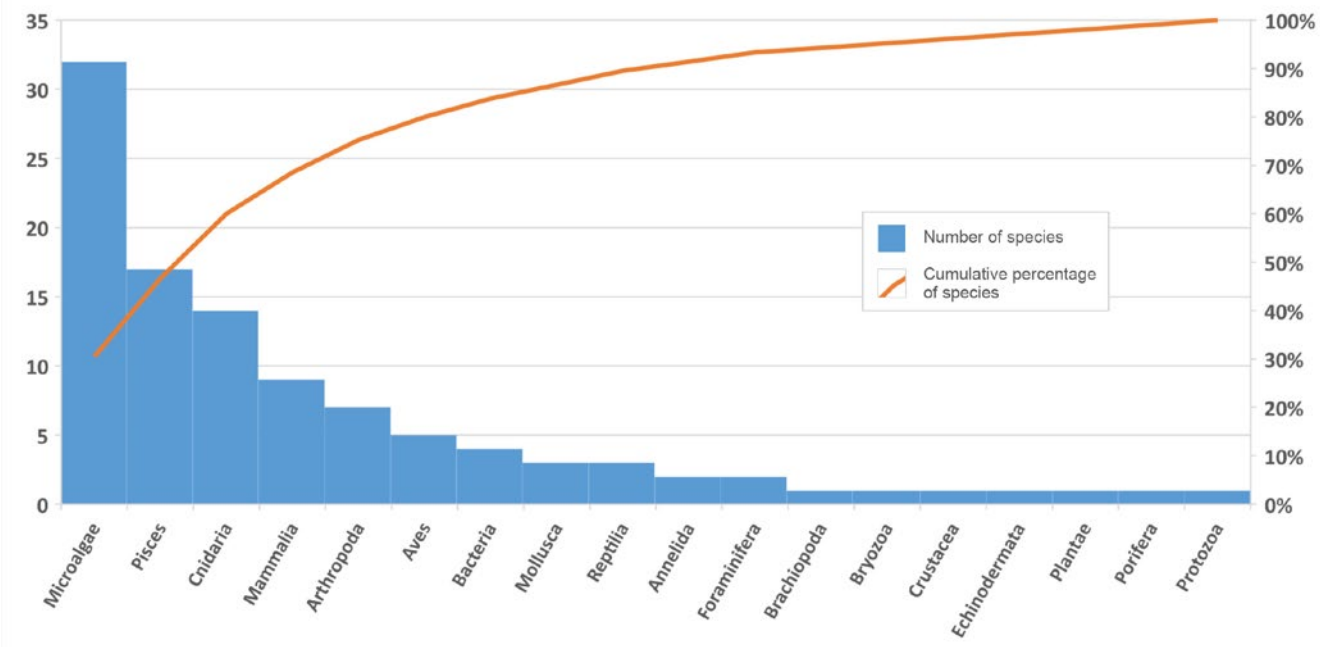


Figure 2. Distribution of known affected species by marine litter interactions according to main common ecological groups in the Mediterranean Sea. The meta-data analysis has been performed based on research publications from major scientific databases gathered in the MedBioLitter database (version September 2019). Note: in some cases, kingdom, phylum, class or subclass are shown for simplicity.

3

Photo by: Ignasi Mateo/ACT4LITTER

Assessment of marine litter interactions with Mediterranean biodiversity

Harmonized and more balanced knowledge on marine litter and biodiversity interactions in Mediterranean Marine Protected Areas (MPAs) is needed to support informed daily management priorities and policy making mechanisms. The MedBioLitter database recently developed is being used to set a baseline for a regional understanding on the impacts of marine litter on biodiversity in the Mediterranean region.

This Mediterranean-wide spatial assessment by ETC-UMA was performed using the MedBioLitter meta-analysis outcomes (September 2019). It aims at obtaining a regional understanding on the state of knowledge on biodiversity within Mediterranean MPAs, particularly those engaged by the projects co-financed by the Interreg Med Programme and within the ecological boundaries of the Mediterranean (i.e. Mediterranean ecoregions).

The MedBioLitter database has been linked to general layers for protected areas; the European Environmental Agency (EEA) for Natura 2000 Sites; the MedPAN layer for a complete map of protected areas in the Mediterranean Sea; a layer with the MPA sites involved in the Interreg Med co-financed projects focusing on biodiversity protection, and ecoregions in the Mediterranean (Spalding et al., 2007).

The regional assessment shows that the knowledge and spatial information published on the interactions between marine litter and biodiversity are scarce, irregular and very scattered within MPAs and beyond.

3.1 STATE OF KNOWLEDGE ON MARINE LITTER IMPACTS IN MEDITERRANEAN MPAS

Monitoring and management plans in Marine Protected Areas (MPAs) require evidence and knowledge of the marine litter interactions with protected species and biodiversity.

Table 2 lists the MPAs that have peer reviewed information on the pressures and impacts of marine litter on the species and habitats they contain and includes the MPAs (Green coral icon) coinciding with the sites participating in the community. Based on this assessment, out of the total MPAs in the Mediterranean (=1321 based on MAPAMED November 2017), only 2.6% have peer reviewed knowledge related to pressures and impacts from marine litter. Peer reviewed knowledge is only available for MPAs that belong to European Mediterranean countries while totally missing for non-EU MPAs in the Mediterranean. Participation of additional MPAs as partners and pilot sites in projects like PLASTICBUSTERSMPAs will allow for more updates to MedBioLitter in the near future.

Table 2. Mediterranean protected areas with available peer reviewed information on marine litter and biodiversity interactions including the coincidences with the participating sites within the Biodiversity Protection Community (in bold/green icon).

Croatia	• J.Molat-Dugi-Kornat-Murter-Pašman-Ugljan-Rivanj-Sestrunj-Molat – Natura 2000
	• Kaprije – Natra 2000
France	• Bouches de Bonifacio, Iles des Moines – Natura 2000
	• Calanques et îles marseillaises - Cap Canaille et massif du Grand Caunet – Natura 2000
	• Cap Bear- cap Cerbère – Natura 2000
	• Cap Corse et Agriate
	• Cap Rossu, Scandola, Pointe de La Reveletta, Canyon de Calvi – Natura 2000
	• **Marine Natural Park of the Gulf of Lion**
	• **Iles d'Hyères – Natura 2000**
	• **Iles Lavezzi, Bouches de Bonifacio – Natura 2000**
	• Iles Marseillaises - Cassidaigne – Natura 2000
	• Oiseaux marins de l'Agriate – Natura 2000
	• Plateau de Pertusato/ Bonifacio et îles Lavezzi – Natura 2000`
	• Plateau du Cap Corse – Natura 2000
	• Port-Cros – SPAMI
	• Porto/Scandola/Revellata/Calvi/Calanches de Piana (zone terrestre et marine) – Natura 2000
	• Rade d'Hyères – Natura 2000
	• Récifs des canyons Lacaze-Duthiers, Pruvot et Bourcart – Natura 2000
	• Récifs du mont sous-marin de l'Agriate – Natura 2000
	• Strait Of Bonifacio – SPAMI
France, Italy, Monaco	• **Pelagos Sanctuary for the Conservation of Marine Mammals** – SPAMI
Greece	• **Amvrakikos Kolpos, Delta Lourou Kai Arachthou (Petra, Mytikas, Evryteri Periochi)** – Natura 2000
	• Ethniko Parko Ygrotopon Kotychiou - Strofylias – National MPA
	• Korinthiakos Kolpos – Natura 2000
	• Kotychi lagoons – Ramsar site
	• Limnothalassa Kotychi - Alyki Lechainon – Natura 2000
	• Limnothalassa Kotychi, Brinia – Natura 2000
	• Limnothalasses Stenon Lefkadas (Palionis - Avlimon) Kai Alykes Lefkadas – Natura 2000
	• Nisia Antipsara Kai Nisides Daskalio, Mastrogiorgi, Prasonisi, Kato Nisi, Mesiako, Koutsoulia – Natura 2000
	• Nisides Parou Kai Notia Antiparos – Natura 2000
	• Nisoi Paxoi Kai Antipaxoi – Natura 2000

Greece (contd.)	• Oros Pilio Kai Paraktia Thalassia Zoni – Natura 2000 • Periochi Perivallontikou Elegchou Ethnikou Parkou Ygrotopon Amvrakikou • Thalassia Periochi Dytikis Kai Notiodytikis Kritis – Natura 2000 • Thalassia Periochi Kolpou Kyparissias: Akr. Katakolo - Kyparissia – Natura 2000 • Thalassia Periochi Notias Messinias – Natura 2000 • Thalassia Periochi Thrakis – Natura 2000 • Thalassia Zoni Notias Manis – Natura 2000
Italy	• Arcipelago delle Eolie - area marina e terrestre – Natura 2000 • Area naturale marina protetta Punta Campanella • Berchida e Bidderosa – Natura 2000 • **Capo Carbonara MPA Natura 2000** • Costa Viola – Natura 2000 • Fondali dell'isola di Salina – Natura 2000 • **Fondali marini di Punta Campanella e Capri – Natura 2000** • Fondali Noli - Bergeggi – Natura 2000 • Punta Campanella – SPAMI • Santuario per i Mammiferi Marini • Secche di Torre Flavia – Natura 2000 • **Parco nazionale dell' Arcipelago Toscano** • Lophelia reef off Capo Santa Maria di Leuca – Fisheries Restricted Area
Malta	• Il-Baħar ta' Madwar Filfla • Il-Baħar tal-Lbiċ • Żona fil-Baħar fil-Lbiċ – Natura 2000 • Żona fil-Baħar fl-Inħawi ta' Għar Lapsi u ta' Filfla – Natura 2000
Spain	• **Arxipiélago de Cabrera – Natura 2000** • Badies de Pollença i Alcúdia – Natura 2000 • Bahía de Málaga-Cerro Gordo – Natura 2000 • Canal de Menorca – Natura 2000 • **Cap de Creus – Natura 2000, SPAMI** • Cap Gros-Cap de Creus • Corredor de migración de cetáceos del Mediterráneo • Costa de l'Oest d'Eivissa – Natura 2000 • Costes del Garraf – Proposed as SPAMI • **Delta de l'Ebre – Natura 2000** • Espacio marino de l'Empordà – Natura 2000 • Espacio marino de Tabarca-Cabo de Palos – Natura 2000 • Espacio marino del Baix Llobregat-Garraf – Natura 2000 • Espacio marino del Delta de l'Ebre-Illes Columbretes – Natura 2000 • Espacio marino del norte de Mallorca – Natura 2000 • Espacio marino del norte y oeste de Menorca – Natura 2000 • Espacio marino del poniente de Mallorca – Natura 2000 • Espacio marino del poniente y norte de Ibiza – Natura 2000 • Espacio marino del sureste de Menorca – Natura 2000 • Fondos Marinos del Levante Almeriense – Natura 2000, SPAMI • Muntanyes d'Artà – Natura 2000 • **Reserva Marina de Levante de Mallorca-Cala Ratjada** • **Freus d'Eivissa i Formentera Marine Reserve – Natura 2000** • Sistema De Cañones Submarinos Occidentales Del Golfo De León – Natura 2000 • Valles submarinos del Escarpe de Mazarrón – Natura 2000

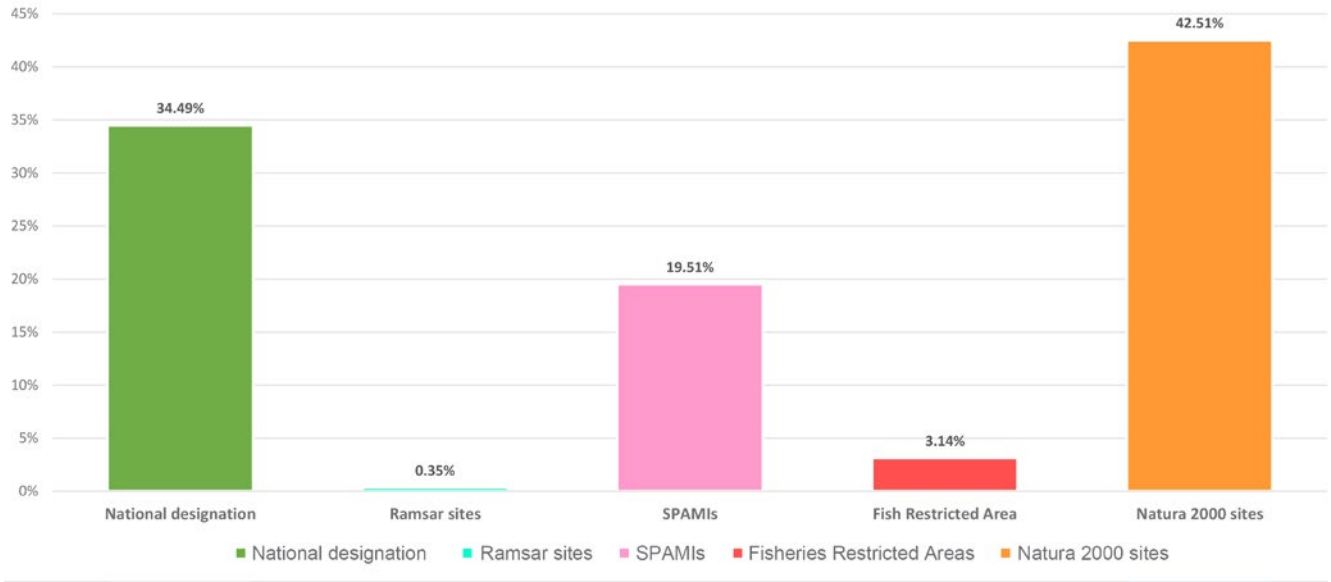


Figure 3. Distribution of monitoring data between types of protected areas in the Mediterranean Sea (based on the MedBioLitter database, September 2019).

Additionally, Figure 3 shows that, among the MPAs that have peer-reviewed information on marine litter interaction with biodiversity, the coincidence between the available monitoring sites information and protected geographical areas is larger for the Natura 2000 Sites designed under the EU Bird and Habitats Directives (42.51% of the area), followed by the data localized at nationally Designated areas (34.49%), SPAMIs (19.51%) and, to a lesser extent, FRAs (3.14%) and Ramsar sites (0.35%).

The assessment of marine litter impacts on MPAs shows that, despite the increase in published information on marine litter pollution occurrence, distribution and impacts on biodiversity in the Mediterranean Sea, the research efforts are not targeted and do not provide an understanding on the most common taxa in MPAs and beyond. This fact reveals the lack of a clear targeted policy that directs research efforts to contribute to a comprehensive regional assessment but rather research results coming from individual projects with different objectives. In brief, an integrated approach that targets common taxa in MPAs and in the Mediterranean ecoregions is still majorly lacking, except for cetaceans (under the leadership of ACCOBAMS in the Mediterranean) and would require further efforts to assess the environmental impacts and to guide regional remediation actions.

An integrated approach that targets common taxa in MPAs and in the Mediterranean ecoregions is still majorly lacking, except for cetaceans

Marine Protected Areas participating in the Biodiversity Protection Community

Out of the 57 protected areas engaged in the community up to September 2019 (Annex II), only 13 pilot sites (around 23%) have peer reviewed information on marine litter.

This calls for the need to publish more information from the community´s results to support a peer-reviewed process with the community´s outcomes and to inform more effectively the regional assessments on marine litter to be maintained through the MedBioLitter in the upcoming years.

As publishing in scientific journals and the peer review processes are time consuming, some additional peer reviewed articles are expected from several institutions participating within the community in the upcoming period. Once published, this additional knowledge will be added to future versions of the MedBioLitter database and the regional assessments planned for the coming period.

3.2 STATE OF KNOWLEDGE ON MARINE LITTER IMPACTS IN THE MEDITERRANEAN SEA

The assessment of the state of knowledge available on the impacts of marine litter on Mediterranean biodiversity according to the MedBioLitter database (September 2019) reveals that there are around 102 original peer-reviewed publications that reported encounters between organisms and marine litter and 138 species studied. 3% of the species assessed are classified as Endangered by the IUCN Red list of Threatened Species.

Among the categories of marine litter assessed, plastic litter accounted for 87% of the associations between marine litter and biota. Numerous direct and indirect consequences were recorded, namely colonization, entanglement, ingestion, and others; showing the potential for sublethal effects as common impacts.

3.3 STATE OF KNOWLEDGE ON MARINE LITTER IMPACTS ON MARINE HABITATS

The information hosted by the MedBioLitter database has been overlaid with the EUNIS Habitat classification system to assess the linkages between the information on biodiversity impacted by marine litter and the different habitat types. The interactions between biodiversity and marine litter published were assessed in the pelagic and benthic ecosystems; this is reflected through some additional layers of information complementary to each of the ecosystems.

Marine litter and biodiversity interactions have been classified following international policy standards in four main categories: ingestion, entanglement, colonization and others, which collects studies with experimental information on interactions, such as forced field experiments, or information difficult to classify under the other three categories.

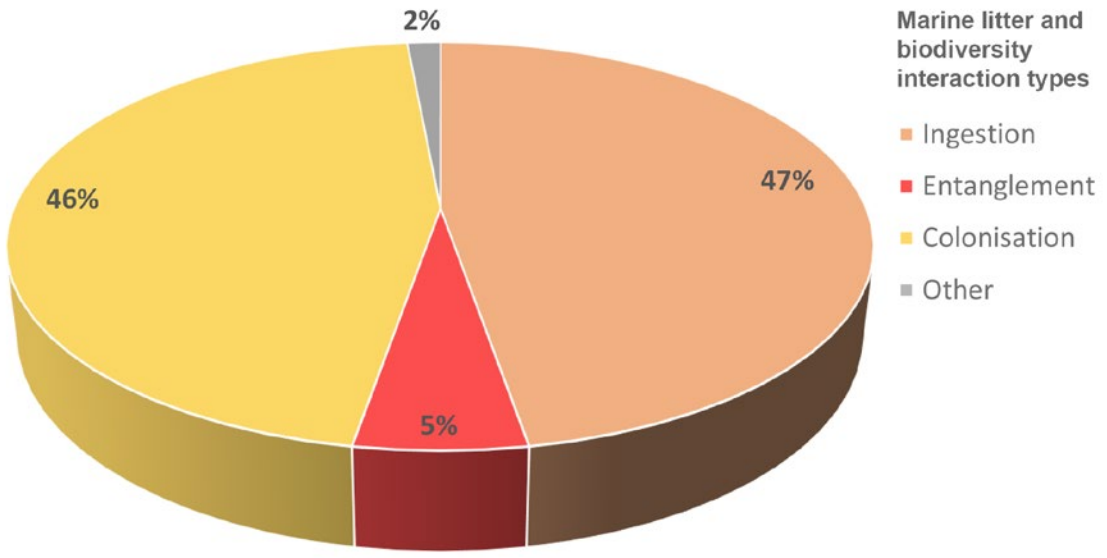


Figure 4. Distribution of knowledge on interactions types between biodiversity and marine litter present in the pelagic ecosystem in the Mediterranean Sea.

3.3.1 Biodiversity impacted by marine litter in pelagic ecosystems

The results of the meta-data analysis on the interaction types with species belonging to the pelagic ecosystem are presented in Figure 4. The figure shows that ingestion and colonization are the most frequent interactions found in pelagic ecosystems (47% and 46% respectively), whereas entanglement is less frequently recorded. Main species groups studied in this ecosystem type are fishes, turtles and cetaceans accounting for 21%, 15% and 11% of the studied species.

It is noticeable that the meta-analysis showed many datasets recorded for colonization in the pelagic ecosystem and a low representativity of the entanglement category. This high percentage of colonization found is perceived as a direct consequence of the inclusion in the database of a high number of individual species from the planktonic realm, such as cyanobacteria and microalgae, colonizing and inhabiting floating litter.

Species groups studied in this ecosystem type are fishes, turtles and cetaceans

The inclusion of a further in-depth analysis of these categories in the future might result in some further distinctive features, where drifting and rafting could be also considered as a separate category, and should not be overlooked, especially in the case of species interacting with floating litter.

The Mediterranean map in Figure 5 shows the spatial results available on the impacts on biodiversity in pelagic ecosystems and the location of marine protected areas. Most of the knowledge available on pelagic ecosystems is known in near-coastal areas, including coastal MPAs, rather than offshore, except for the Pelagos Sanctuary.

The results show that the Aegean and the Levantine Seas contain very little and sporadic information on biodiversity interactions with marine litter, with limited cases on entanglement, colonization and ingestion registered in few coastal areas.

The situation in pelagic ecosystems of the Adriatic Sea is very similar. The very few studies reported on the interactions of marine litter with biodiversity reveal greater ingestion than entanglement and colonization data recorded in the region.

In the Western Mediterranean, the highest number of datasets on interactions are found primarily in two places: the area of the North Western Mediterranean connected to the Gulf of Lion and the Pelagos Sanctuary. In this region, most studies are performed in commercial fishing areas, coastal and near coastal areas, whilst offshore information is

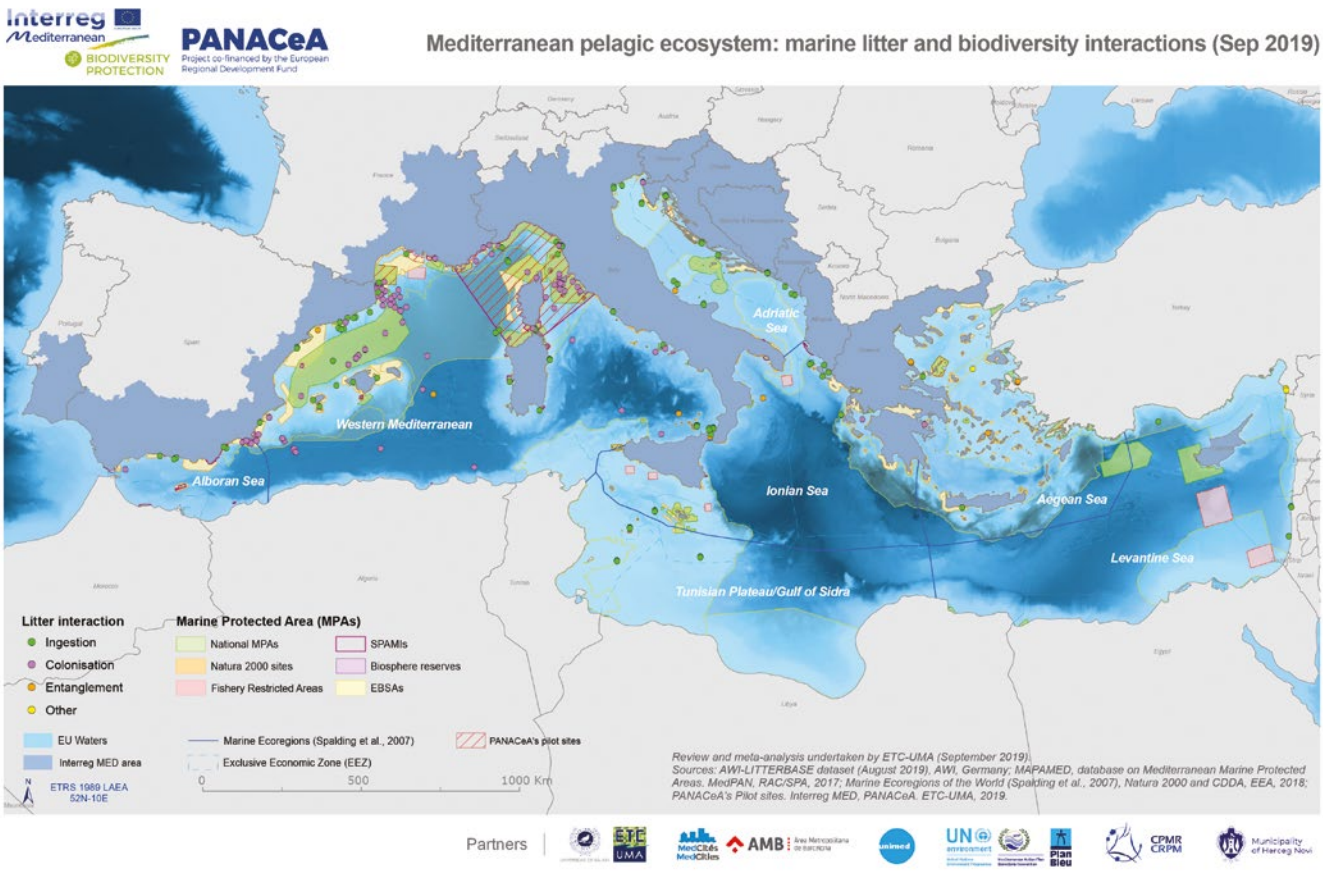


Figure 5. The map shows the interactions encountered between pelagic biota and marine litter inside and outside protected areas.

related to either marine mammals or turtles, in addition to some records on colonization of floating litter by planktonic species.

More information on zoom-in maps per Mediterranean ecoregion are shown in Figure 9.

3.3.2 Biodiversity impacted by marine litter in benthic ecosystems

The assessment performed on benthic habitats combined information on benthic species with the available knowledge on the benthic habitats, bathymetry and geomorphology of the Mediterranean Sea provided by the EUNIS layer (European Environment Agency).

Figure 6 shows the proportion of interaction types encountered in benthic habitats, where ingestion and entanglement are the main two impacts studied in this ecosystem type with 60% and 21% of the studied cases gathered within the MedBioLitter in this ecosystem type, followed by cases of colonization (14%), and several studies (5%) focusing on other types of interaction. Main species groups studied in the benthic ecosystem are fishes, cold water corals and arthropods, accounting for 24%, 21%, and 16% of species studied.

Main species groups studied in the benthic ecosystem are fishes, cold water corals and arthropods

The Mediterranean map in Figure 7 synthesizes main research published on the impacts of marine litter on biodiversity in benthic ecosystems and includes marine protected areas. Most of the knowledge available on benthic ecosystems refers to near-coastal areas, including coastal MPAs, rather than offshore, except for the Pelagos Sanctuary.

It can be observed that for the benthic habitats in the Aegean and the Levantine Seas, there is very sporadic information on the state of biodiversity interactions with marine

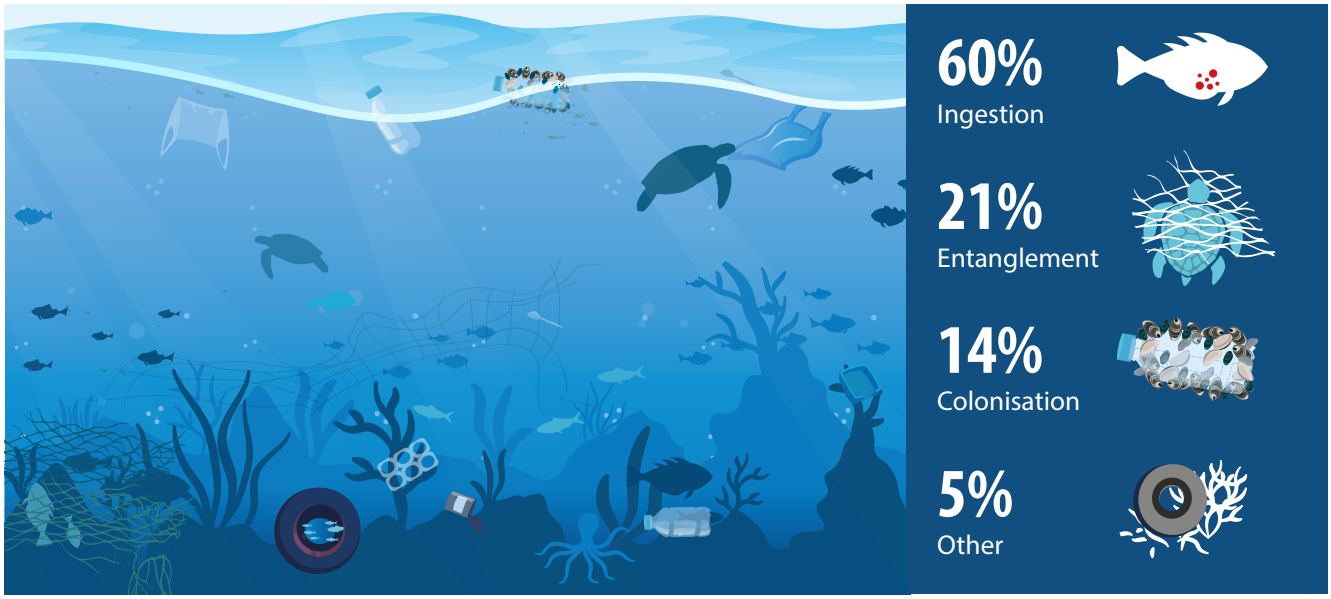


Figure 6. Distribution of knowledge on interaction types in benthic ecosystems in the Mediterranean Sea.

litter. The results show limited cases on entanglement (4), colonization (8) and ingestion (4), registered in few coastal areas.

In order to develop a deeper understanding on biodiversity interaction with marine litter, the marine habitat classification of the European Nature Information System (EUNIS) is applied in MedBioLitter.

The four main EUNIS habitat groups (at level 1) affected by marine litter shown in Figure 8 indicate that according to the knowledge published most of the interactions of

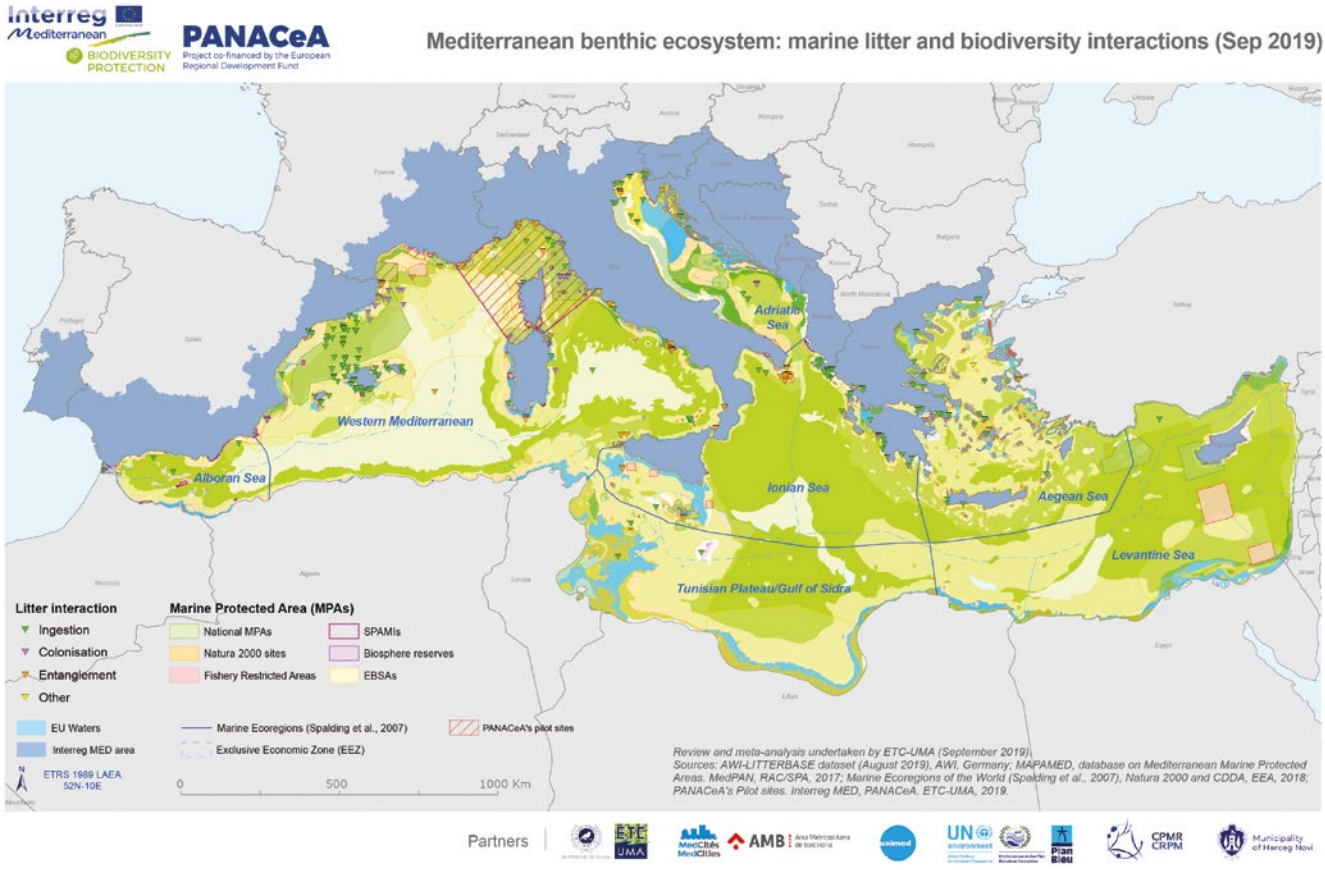


Figure 7. The map shows a selection of the data available on interactions of marine litter with benthic biota using the European Nature Information System (EUNIS) classification system to allow a better understanding of the bottom geomorphology and litter pollution in the Mediterranean Sea.

marine litter with biodiversity takes place in sublittoral sediments (A5) (51.9%) and over the deep-sea bed (A6) (45.8%), i.e. over sandy and muddy habitats followed, to a lesser extent, by hard substrata, namely the circalittoral rock (A4) and the infralittoral rock (A3), where the published studies account for 1.9% and 0.5% of the cases respectively.

Furthermore, few subclassifications (at EUNIS level 2) have been observed for A4, A5 and A6, pointing in occasions to specific substrates and habitats 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) or *Facies of sandy muds with Thenea muricata* (A6.511), the latter belonging to the deep-sea habitats in the Mediterranean Sea.

Further refinement would support the identification of the impacts on sensitive Mediterranean biodiversity and potentially threatened habitats

Such analysis undertaken in the future with further refinement would support the identification of the impacts on sensitive Mediterranean biodiversity and potentially threatened habitats that need to be prioritized for targeted management and more effective protection.

As a result of the spatial analysis, the regional deep-sea habitats impacted by marine litter included in A6 (*Deep-sea bed (sand, mud including biocenosis)*), represent around 25% of the data assessed and show that these habitats are heavily impacted by entanglement. These habitats include, among others, the submarine canyons and deep-sea bottom of the Gulf of Lion (NW Mediterranean), the fish restricted area (FRA) of Santa Maria di Leuca (Southern Italy), the Portofino Promontory (Ligurian Sea), or the deep-sea bottom of the Sicilian Strait area in the Central Mediterranean Sea.

The most representative species impacted, largely by entanglement, in these areas include 'cold-water-corals (CWC)' species, namely *Madrepora oculata; Lophelia pertusa; Paramuricea clavata* (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). The protection of these fragile, long-lived, and rich species in the Mediterranean is high priority as threats to them are mounting mainly linked to climate change effects and pollution affecting heavily the Mediterranean region.

More information on zoom-in maps per Mediterranean ecoregion are shown in Figure 9.

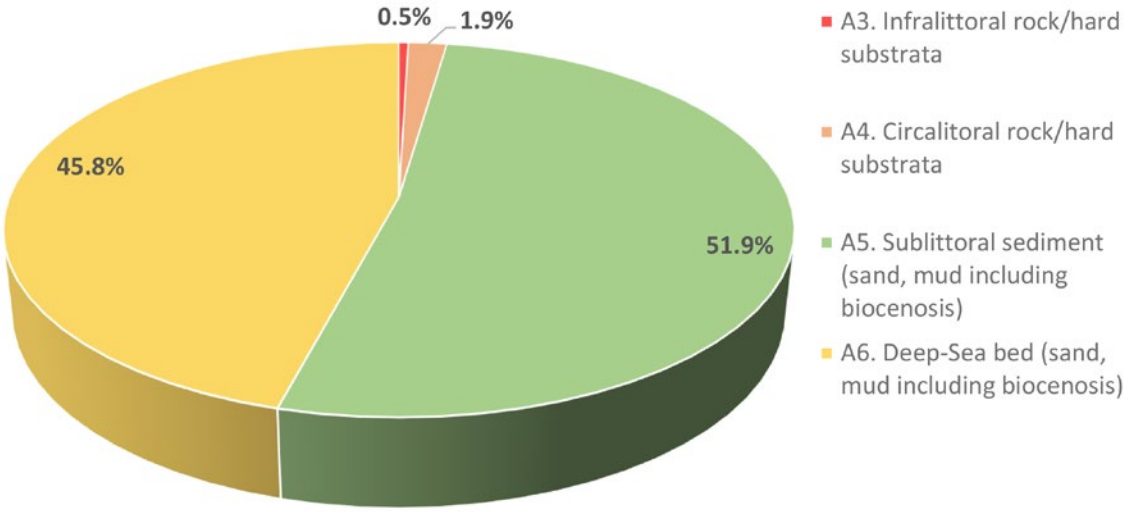


Figure 8. Percentages of available data according to type of benthic bottom habitats and substrates from literature sources after a meta-analysis and spatial assessment in the Mediterranean.

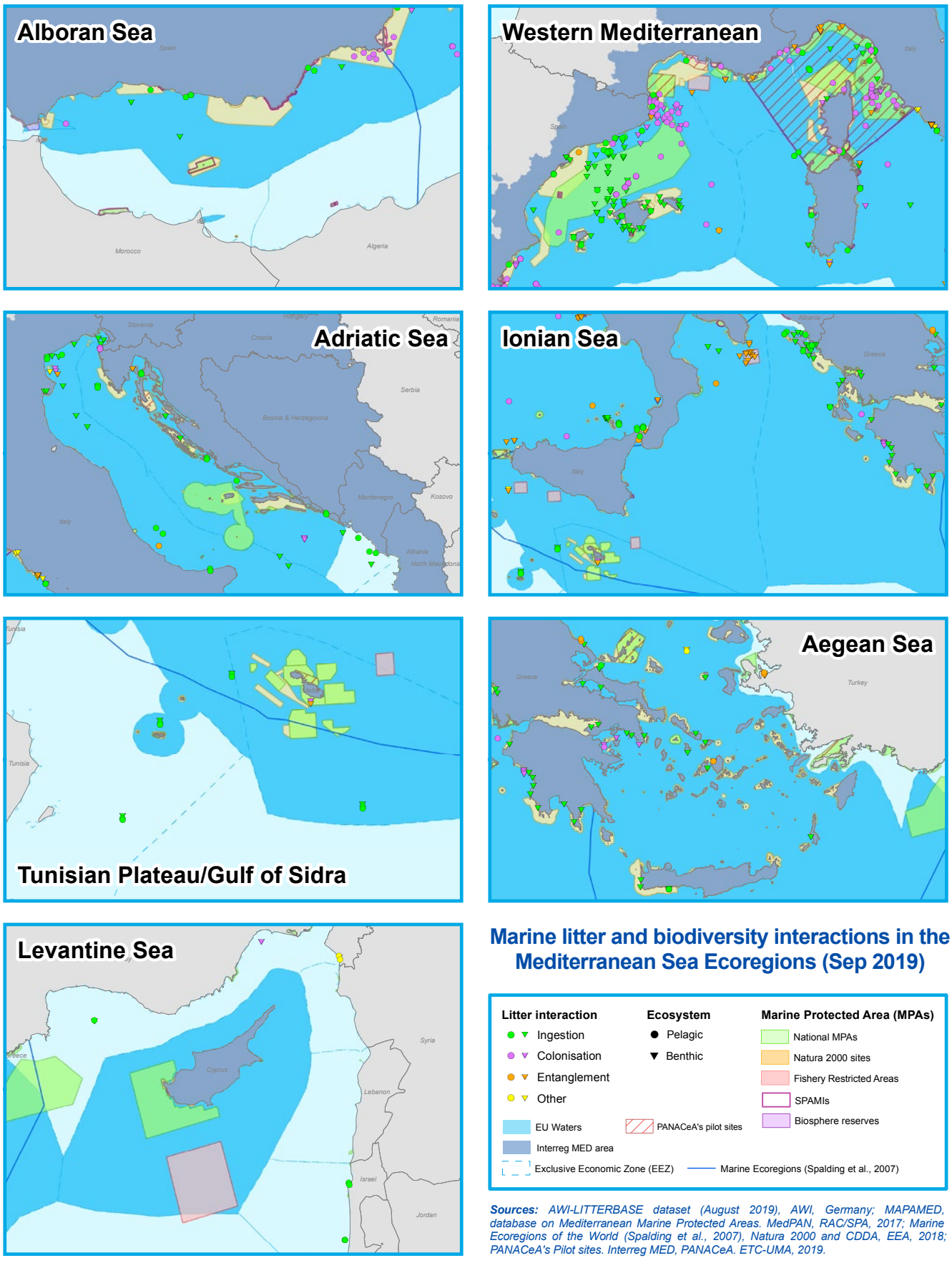


Figure 9. Marine litter and biodiversity interactions in the Mediterranean Sea by ecoregions and MPAs.

3.4 STATE OF KNOWLEDGE ON MARINE LITTER IMPACTS IN MEDITERRANEAN ECOREGIONS

MedBioLitter, ecoregions and MPA data have been combined and used to analyze and study the distribution of marine litter knowledge in the Mediterranean Sea. Figure 9 and Table 2 show the results of this analysis.

The assessment shows that most of the marine litter knowledge currently focuses on the Western Mediterranean ecoregion (61.1% of MedBioLitter entries), followed by the Ionian, Adriatic and Aegean Seas (13.3%, 10.4% and 8%). Waters belonging to the countries of the European Union present more than 90% of the data, which highlights the lack of information in the Southern part of the Mediterranean.

In the Western Mediterranean ecoregion, most data are located between the coast of Spain and France, in the area of the Mediterranean Cetacean Corridor and the Pelagos Sanctuary.

The analysis at MPA level also shows that significant efforts are being made to study these areas. Nearly 38% of the data available are within MPAs although this percentage could reach 50% or even more if buffering areas close to these were considered. Almost 50% of the knowledge in the Western Mediterranean and Alboran Sea are in MPAs (48.8% and 46.7%). The Ionian and Aegean Sea also present a relevant amount of studies in protected areas, being 30.2% and 23.7%, respectively. The Adriatic Sea, despite having an important surface of MPAs, shows a much lower percentage of studies focused on the interaction of marine litter with biota (4.1%). This is also the case in the Levantine Sea, which currently has a very limited amount of knowledge available.

Table 3. Results of MedBioLitter data distribution analysis by ecoregions and MPAs.

	Adriatic Sea	Aegean Sea	Alboran Sea	Ionian Sea	Levantine Sea	Tunisian Plateau / Gulf of Sidra	Western Mediterranean	Mediterranean Sea
Ecoregion size	131857	314417	83889	368744	476517	392838	757665	2525927
Number of MBL entries	49	38	15	63	10	9	289	473
% MBL entries	10.4	8	3.2	13.3	2.1	1.9	61.1	100
Number of MPA designations	291	236	54	195	34	10	415	1235
Surface of MPAs	11515	23820	6449	15551	28629	663	171876	258503
% Ecoregion surface protected	8.73	7.58	7.69	4.22	6.01	0.17	22.68	10.2
Number of MBL entries within MPAs	2	9	7	19			141	178
% MBL entries within MPAS	4.1	23.7	46.7	30.2			48.8	37.6

Photo by: ACT4LITTER

MedBioLitter: The Mediterranean database on marine litter impacts – State and Outlook

4.1 DATABASE AND INFORMATION GATHERING, INTEGRATION AND PARAMETERS

The MedBioLitter database summarizes the results of scientific studies on biodiversity and marine litter interactions in the Mediterranean Sea. To this end, information has been collected from different data sources; institutions and projects working on marine litter; and relevant peer-reviewed publications. The original main source of data has been the LITTERBASE (AWI) coverage within the Mediterranean. LITTERBASE follows a similar approach to MedBioLitter, summarizing global results from scientific studies in understandable maps and figures.

The main information used by MedBioLitter is the location and type of interaction, followed by the type of habitat, species and marine litter associated with the event. Location is extracted directly when the coordinates of the study area are provided or there are GIS layers available. Locations have also been digitized from existing maps. In particular cases, the location is estimated from the description of the study area. Information on the type of interaction, affected species, etc. is compiled based on the detailed reading of publications.

From here, ancillary data and external sources are used to check whether the area of interaction is in a protected area, the species conservation status (based on the IUCN Red List), the habitat name, political relevance, etc. to complete with as much information as possible. In addition, for each entry, details on the publications included are collected (authors, title, year and doi) to help others easily access the data sources.

4.2 UPDATING PROCESS OF THE MEDBIOLITTER DATABASE

MedBioLitter is proposed as a database reviewed and updated every 6 months, resulting in two versions per year: one in February and one in September. The updating process includes the identification and selection of new entries for the Mediterranean Sea as included in LITTERBASE and additional searches and study of peer reviewed publications. Updates are implemented by the MedBioLitter team in ETC-UMA.

Individuals and institutions interested in adding their peer-reviewed results can send their manuscripts or publications to the MedBiolitter team for consideration and integration in the database. A contact form is available online from the Mediterranean Biodiversity Protection Knowledge Platform (biodiversity.uma.es).

Furthermore, authors interested in providing their data and research outcomes can also do so following the required parameters and format by uploading their data through the "submit data" bottom on the Mediterranean Biodiversity Protection Knowledge Platform.

4.3 COMMUNICATING KEY INFORMATION

Additional review of scientific literature combined with the detailed outcomes of the Biodiversity Protection Community of projects in different areas of the Mediterranean Sea and their MPAs will complete and update this meta-analysis and spatial assessment in the future, including new external sources as they become available. A Mediterranean overview on current impacts related to marine litter and biodiversity will provide the basis to develop a more comprehensive knowledge on the Biodiversity Protection Community's activities related to the findings on biodiversity interactions in the Mediterranean. These spatial information maps, including related information on pressures at different regional, sub-regional and national scales, will assist the identification of priority areas and gaps and foster an integrated approach to marine litter threats in the region.

Spatial information maps, including related information on pressures at different regional, sub-regional and national scales, will assist the identification of priority areas and gaps and foster an integrated approach to marine litter threats.

The resulting knowledge will be included in the Interreg Med Biodiversity Protection Knowledge Platform developed to accommodate the results of the community of projects and additional relevant knowledge to allow for a common repository of data and their communication to regional and international stakeholders and interested parties.

> Waters belonging to the countries of the European Union present more than 90% of the data, which highlights the lack of information in the Southern part of the Mediterranean

Mahdia, Tunisia @ HNBS-Pixabay


5
Photo by: ACT4LITTER

Key messages to policy makers

1 Science has demonstrated that most common species, ecological groups and ecosystem trophic levels (producers such as planktonic communities, consumers such as the commercial fish families and large predators and long-lived species such as turtles and cetaceans) interact with marine litter and are impacted to death in some cases.

2 More than 100 species in all common ecological groups have been identified in the scientific literature as impacted by marine litter and the numbers will increase in the Mediterranean region and globally because of increased scientific research initiatives funded in the last decade.

3 Though some peer reviewed information exists, the knowledge available on the status of biodiversity within MPAs is very low in terms of interaction with marine litter pollution; representativeness at a Mediterranean scale is lacking.

4 The geographical unbalance in terms of knowledge availability and the lack of consolidated routine networks and programmes in most of Mediterranean countries are perceived by the Mediterranean Biodiversity Protection Community as gaps that need to be urgently tackled at regional scale, accompanied by the corresponding financial and regulatory mechanisms.

5 Management plans for MPAs should consider measures to reduce litter pollution and include surveys on the marine biodiversity status, knowing that MPAs are also affected by external sources of litter and other distinct continuous pressures.

6 There is an opportunity to investigate marine pollution effects to biodiversity in selected species in MPAs, as those are meant to have reduced, controlled and monitored pressures and impacts from human activities.

7 Studies on biodiversity effects in controlled environments such as MPAs should not be extrapolated directly to larger scales (sub-regional or regional) as the impacts could be underestimated, despite the patchiness of drivers and known pressures in the Mediterranean.

8 Further science-practice-policy strategies to approach marine litter pollution effects in the Mediterranean Sea biodiversity still need to be refined, harmonized and aligned with ongoing policy developments (EU MSFD, UN MAP/ IMAP) and scientific evidence.

9 It is an informative quantitative fact that monitoring strategies are more advanced for marine macro and micro litter monitoring in marine compartments than for monitoring litter impact on marine biodiversity. This fact impedes a full comprehension and understanding of marine litter effects on biodiversity, limiting therefore our current knowledge on the overall impact to take action.

10 An integrated approach that targets common species or group of species in MPAs and in the Mediterranean ecoregions is still majorly lacking and would require further efforts to assess the environmental impacts and to be able to guide regional remediation actions.

11 Such integrated approach would enable the consolidation of a regional mechanism to properly monitor and assess this transboundary pressure in the Mediterranean Sea and its trends over time, as partial solutions and actions taken only at local and country level have proved not to be fully effective.

Annexes

Photo by: Alexis Rosenfield/MPA-ADAPT

Annex I

Marine litter science by the Mediterranean biodiversity protection community

OVERVIEW ON MED PROJECTS WORKING ON MARINE LITTER

Several projects in the Interreg Med community focusing on biodiversity protection are supporting the identification of solutions to the pressures and impacts of marine litter on biodiversity in the Mediterranean. Their combined efforts are set to find viable and transferable measures to tackle and combat litter pollution, including beach monitoring and management measures (ACT4LITTER), as well as putting in place mechanisms and protocols to monitor the effect of litter on long-lived species like marine mammals and reptiles (MEDSEALITTER, PLASTICBUSTERSMPAs). The knowledge generated by these projects and others is being gathered, harmonized, georeferenced and published in an accessible manner and maintained to enable protected areas and natural resource managers, and policy-makers to use it and so ensure an evidence-based mechanism to support their daily activities and decisions (AMAre, PANACeA, PHAROS4MPAs).

1.1 ACT4LITTER

ACT4LITTER has worked on filling some of the gaps identified by marine protected area (MPA) managers to tackle marine litter pressures increasingly affecting protected areas in the Mediterranean Sea. The initiative gathered, reviewed, and shortlisted a set of effective transferable measures that can be implemented by MPA managers to tackle the problem of marine litter on site.

A total of 105 showcases of implemented measures were identified in literature including regulatory policy instruments; voluntary agreements; economic/ market-based instruments; awareness raising and environmental education; and practices and activities. The measures showcased have been grouped in 25 types; moreover, the measures were fully mapped to provide valuable information on their implementation on the ground. In this respect, the main characteristics of each measure were mapped: type of litter tackled, scale of implementation, and potential role of MPA managers in their implementation (implementer, facilitator, or promoter).

THE ACT4LITTER CATEGORIES OF MARINE LITTER MEASURES

1. Adopt-a-beach scheme

2. Awareness raising campaign targeted to boaters

3. Banning specific items and activities

4. Promoting best practices for ecotourism

5. Promoting best practices for recreational fishing

6. Campaign to reduce plastic water bottles

7. Cleanup campagin and removal action

8. Deposite-refund system / revers vending machines

9. Derelict fishing gear management scheme

10. Eco-labelling

11. Setting up an Enviornmental Management System

12. Imposing a fee/tax/levy

13. Implementing the fishing for litter scheme

14. Improving port reception facilities for waste

15. Improving waste management on-board

16. Improving wastewater management systems

17. Marking and retrieval of fishing gear

18. Promoting extended producer responsibility schemes

19. Promoting the replacement of single-use plastics

20. Public awareness raising campaign

21. Actions to reduce cigarette butts on beaches

22. Promoting the Responsible Beach Shack Bars initiative

23. Establishing a return-refund system for packaging

24. Campaign to phase out microplastics in cosmetics

25. Upclycling and/or reclycling

The mapped measures included in the ACT4LITTER decision-supporting tool are available through a user-friendly online webpage developed to assist MPA managers in the practical identification of the most effective measures to rely on for their specific context (i.e. marine litter pressure in their MPA).

A central output of the ACT4LITTER project was the development of 9 Action Plans to curb marine litter in the following MPAs: Kornati (Croatia); Miramare (Italy); Thermaikos Gulf Protected Areas (Greece); Torre Guaceto (Italy); Strunjan (Slovenia); Torre del Cerrano (Italy); Ebro Delta (Spain); Cabo de Gata (Spain); and Llevant de Mallorca-Cala Ratjada (Spain). The Action Plans were developed step-by-step; by engaging all relevant stakeholders, these pilot MPAs sought to identify effective priority measures against marine litter, which would reflect their specific context and characteristics. At the heart of the elaboration process of the Action Plans lays the Decision-supporting Tool, which facilitated the shortlisting of priority measures.

The collective experience of the pilot MPAs set the baseline for a common, urgent response by Mediterranean MPAs to deal with marine litter. This response, along with its strategic elements, was captured in a joint plan, whose aim is to assist other MPA managers in the Mediterranean to achieve their conservation goals.

In an effort to obtain a wider consensus on which actions should be included within a set of no-regret measures, ACT4LITTER ran a survey to gather the feedback of 110 MPA managers from 17 Mediterranean countries, namely Albania, Algeria, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Monaco, Slovenia, Spain, Tunisia, Turkey.

In addition, ACT4LITTER developed a series of seasonal beach litter campaigns that aimed not only to gather data on marine litter quantity, distribution, and composition, but also to engage managers in an exercise of participatory science, which would contribute to building skills needed for monitoring marine litter. Four editions of the "Marine Litter Watch Month" were organized in the context of ACT4LITTER in winter, spring, summer, and autumn 2018. The winter edition took place from mid-December 2017 to mid-January 2018; it engaged about 20 MPA management bodies, NGOs and other organizations in coastal and marine protected areas in Albania, France, Greece, Italy, Slovenia, Spain, and Turkey. Marine litter was measured and classified in a total of 28 sites in 22 beaches, using the methodology developed by the MSFD TG ML (Vlachogianni, 2019). Overall, the Marine Litter Watch Month proved to be an effective tool for gathering essential marine litter data, providing valuable baseline information on the amounts and the full spectrum of marine litter deposited on the beaches of protected areas in the Mediterranean. Moreover, it served as a useful blueprint for setting up participatory-science campaigns.

Photo by: Mariano Cebolla/ACT4LITTER

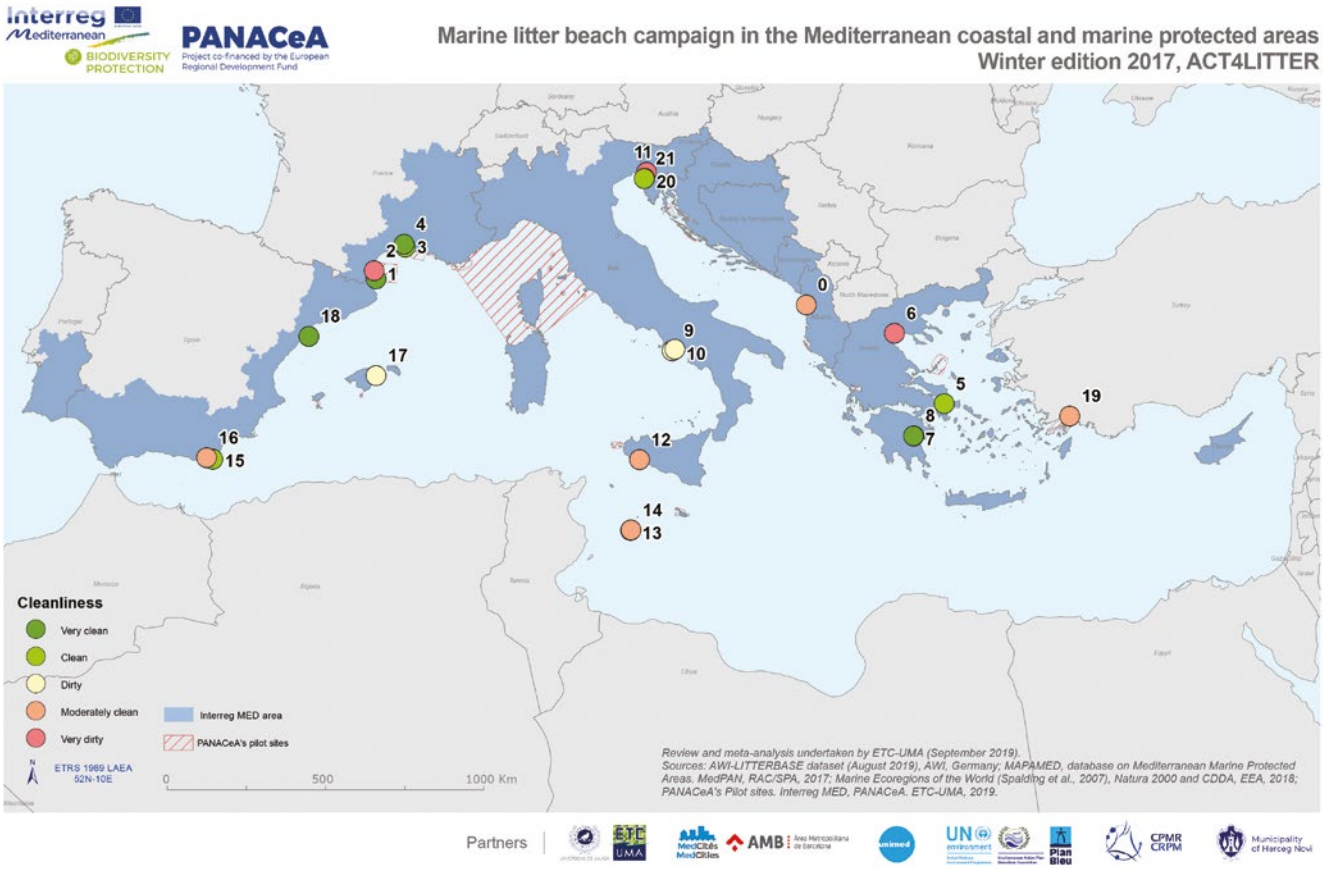


Figure 1A. Location of beaches studied by ACT4LITTER during the marine litter beach campaign in Mediterranean coastal and marine protected areas (mid Dec. 2017 to mid-January 2018).

Beach ID	Region MPA	Beach name	Cleanliness
1	Gulf of Lion MPA	Fourat	Very clean
4	Cote Languedocienne Natura 2000	Boucanet	Very clean
8	Parnon and Moustos Natura 2000	Kazarba	Very clean
18	Ebro Delta Nature Park	Serrallo	Very clean
3	Espiguette Natura 2000	Espiguette	Clean
5	Marathon and Schinias National Park	Schinias	Clean
7	Parnon and Moustos Natura 2000	Cherronisi	Clean
15	Cabo de Gata-Níjar Natural Park/UNESCO Global geopark	Embarcadero de los Escullos	Clean
20	Strunjan Landscape Park	Bele Skale	Clean
21	Strunjan Landscape Park	Strunjan	Clean
0	Karaburun-Sazan MPA	Zvernec	Moderately clean
12	MPA Secche di Tor Paterno	Capo San Marco	Moderately clean
13	MPA Pelagie Islands	Cala Palme	Moderately clean
14	MPA Pelagie Islands	Cala Pisana	Moderately clean
16	Cabo de Gata-Níjar Natural Park/UNESCO Global geopark	Torre Garcia	Moderately clean
19	Gökova Special Environmental Protection Area	Akcapinar	Moderately clean
9	MPA Punta Campanella	Marina del Cantone	Dirty
10	MPA Punta Campanella	Tordigliano	Dirty
17	MPA Levante de Mallorca-Cala Ratjada	Cala Mesquida	Dirty
2	Gulf of Lion MPA	Crouste	Very dirty
6	Thermaikos Gulf Protected Areas	Alyki Kitrous	Very dirty
11	MPA Miramare	Miramare	Very dirty

Table 1A. Results of the marine litter beach campaign in Mediterranean coastal and marine protected areas produced by ACT4LITTER (Dec. 2017 to mid-January 2018).

1.2 MEDSEALITTER

Within the development and testing of the protocols for marine litter monitoring, the MEDSEALITTER project analyzed the ingestion of plastics by several marine species including fishes, the loggerhead turtle, bogues and Polychaeta (marine annelid worms).

About 140 stranded loggerhead turtles (*Caretta caretta*) were collected in 2017 and 2018 thanks to stranding networks in Spain, France, Italy, and Greece. Individuals were necropsied and their digestive tract contents were examined. The average frequency of occurrence of impacted sea turtles (i.e. the number of specimens with ingested litter/total number of specimens analyzed) was approximately 65%. The main types of litter ingested by sea turtles were plastic sheets, fragments of thick plastics and plastic threads, and some indicative litter items, found in the digestive tracts, were beer labels, lollipop sticks, balloons, and candy wrappers.

A total of 630 individuals of bogue (*Boops boops*) were sampled in 2018 and 2019 across the four countries involved in the project and analyzed so far, and results highlighted a frequency of occurrence (%) of ingested microplastics (i.e. the percentage of the individuals examined with ingested microplastics) of approximately 50%, and an average number of microplastics per individual of 1.5 considering all individuals examined and 3.0 considering only individuals found with ingested microplastics.

As for the samples obtained in Spain, a study was recently published (Garcia-Garin et al 2019) with results from a total of 102 individuals of bogue (*Boops boops*) sampled in three areas: an industrialized area near Barcelona; an MPA (Cap de Creus); and an intermediate-polluted area near Blanes. Ingested microplastics were found in 46% of the bogues analyzed, with an abundance ranging from 1.5 to 2.3 items per individual. Polypropylene was the most common polymer type, followed by tetra pack and polystyrene. Among the assessed areas, Barcelona was the most polluted, with an occurrence of ingested microplastics of 64%, while the frequency in the Cap de Creus MPA and in the Blanes area was around 35%.

In addition, the identification of areas of overlap between marine litter and biodiversity was performed in the context of the project through two studies.

The first study focused on the middle latitudes of the Western Mediterranean Basin (Campana et al., 2018). It revealed that the overlaps of marine litter with cetaceans are generally high in this region, especially in

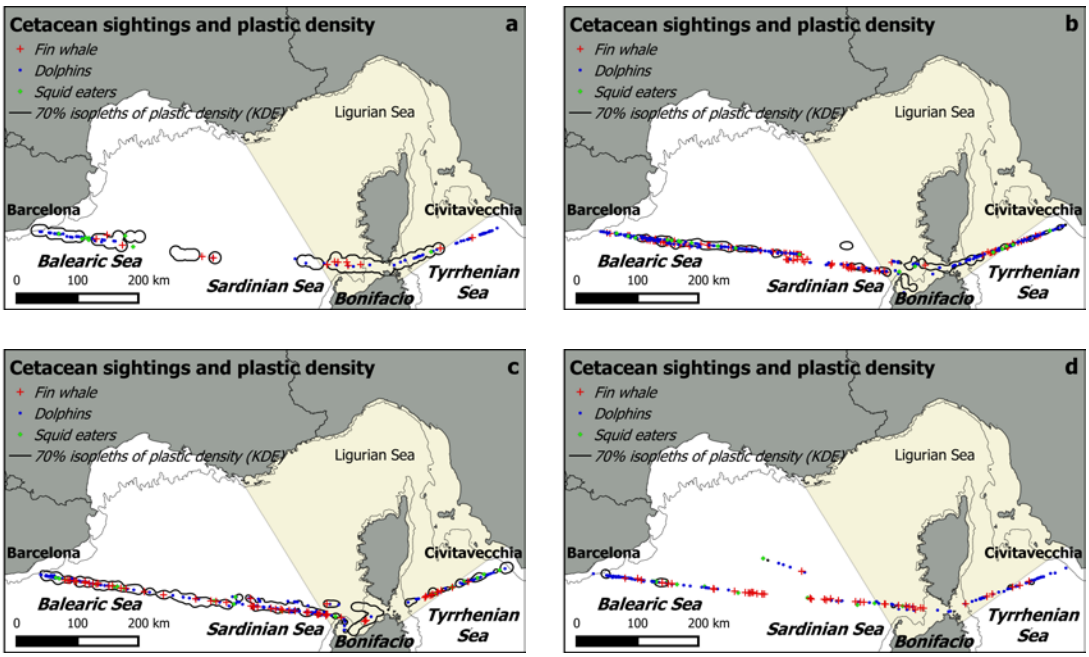


Figure 2A. Seasonal cetacean sightings and rates of plastic density obtained from kernel density estimation along the transect from Barcelona (Spain) to Civitavecchia (Italy). **a)** winter; **b)** spring; **c)** summer; **d)** autumn.

spring and summer, the highest being in the Balearic Islands, the Bonifacio Strait and the Sardinian Sea, while the lowest overlaps are in autumn and winter in the Balearic Islands and the Bonifacio Strait (see Figure 2A).

The second study focused on finding overlaps between floating marine litter and the distribution of loggerhead sea turtles (*Caretta caretta*) along the transects already used for the monitoring of floating marine litter (Arcangeli et al., 2018). The main findings show that the areas with the highest risk to sea turtles due to the presence of marine litter are the Sardinian-Sicily Channel (especially during summer) and the Adriatic Sea (during all seasons) (see Figure 3A). This threat is particularly important in the southern Adriatic Sea, which is supposed to be a developmental habitat and a nursery area for juvenile turtles including the green sea turtle (*Chelonia mydas*). The Sardinian-Balearic Sea is another critical area that requires attention, due to the overlap between litter concentration and the presence of loggerhead turtles, especially during spring and summer.

Furthermore, results obtained during the field testing of the protocols for monitoring floating litter from ferries, medium size vessels and aerial observer-based and photographic surveys still have to be analyzed to determine overlapping areas where concurrent marine macro fauna species and floating marine litter are present. The determination of these areas would provide an indication of potential areas at risk for sensitive species of marine mammals and reptiles across the Western Mediterranean Basin. In addition, also the contribution of rivers to marine litter was investigated with a study along the Tiber river in Italy (Crosti et al. 2018).

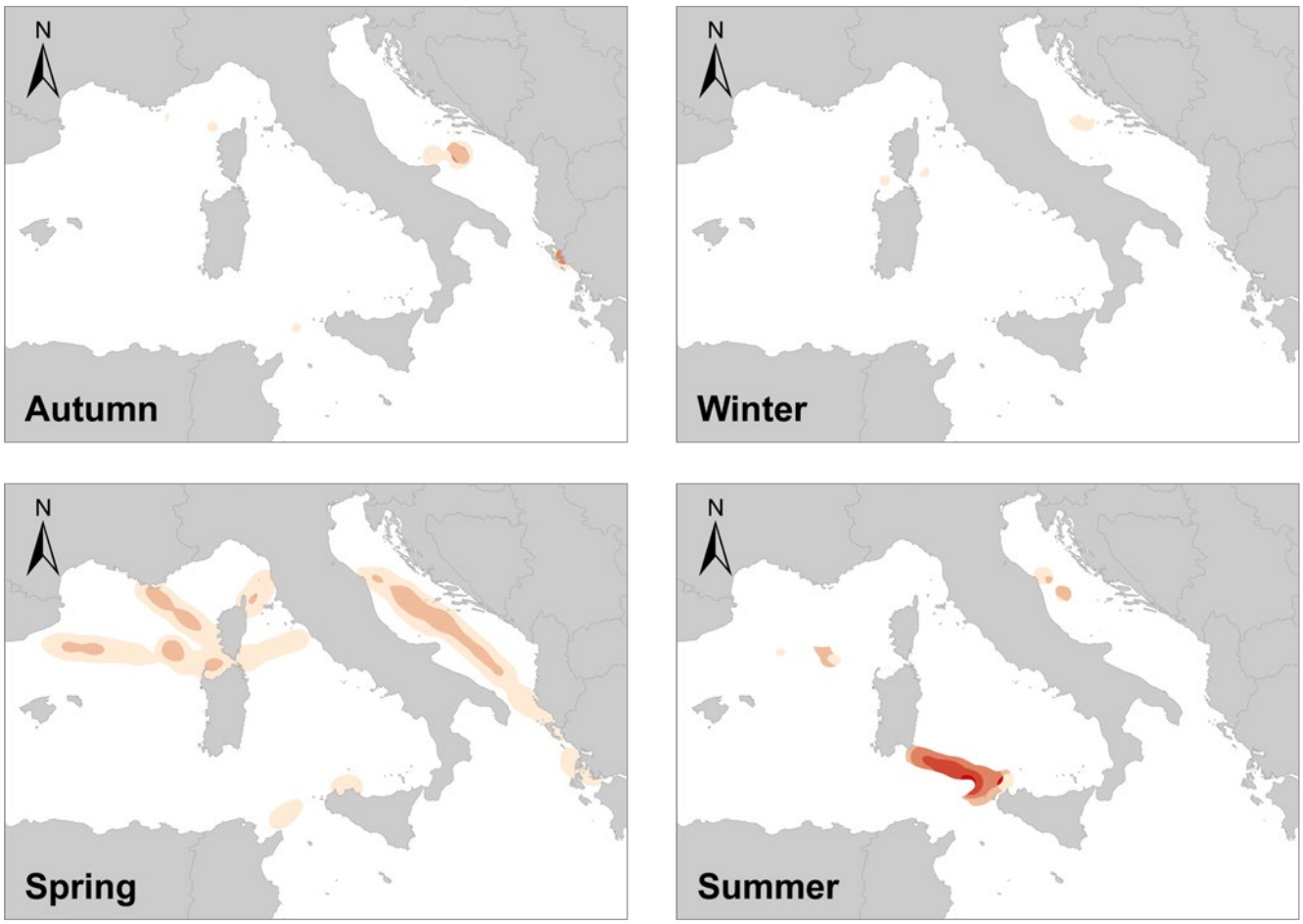


Figure 3A. 2013-2018 seasonal spatial overlaps between floating marine litter and loggerhead sea turtle (*Caretta caretta*) distribution (MEDSEALITTER).

1.3 PLASTICBUSTERSMPAS

Understanding marine litter effects on biodiversity and addressing regional gaps necessarily needs the proper selection of bioindicator species, as well as the development of routine monitoring systems to enable the assessment of the state and trends of marine ecosystems in terms of marine litter pollution (Fossi et al., 2018b). PLASTICBUSTERSMPAs provides a comprehensive, multifaceted and coordinated approach to fight marine litter in Mediterranean pelagic and coastal marine protected areas towards healthy marine ecosystems, through targeted monitoring and assessment, prevention and mitigation actions.

Very few studies have investigated the effects of ingestion of marine litter on animal health; PLASTICBUSTERSMPAs is moving a step forward in this direction and aims to further advance the knowledge of the impacts of marine litter on biota by investigating litter ingestion at different trophic levels and in organisms living in different habitats, entanglement, and the use of litter as transport vector and habitat for other species. The projects addresses the entire management cycle of marine litter.

Regarding marine litter ingestion, this project investigated the occurrence of marine litter ingestion and traces of plastic-related chemicals and their effects by biomarker responses using different species and developing bioindicators of impact on two main categories of biota: commercially harvested species, and endangered species such as sea turtles, sea birds and marine mammals (stranded, hospitalized and free-ranging organisms). The methodology used is illustrated in Figure 4A.

Some species have been proposed as indicators for coastal and pelagic waters, like the loggerhead sea turtle (*Caretta caretta*) and the sperm whale (*Physeter macrocephalus*); the choice and application of the protocol is being set and agreed on in close collaboration and building on the work of other relevant initiatives namely on MEDSEALITTER project results, as well as on the work of the INDICIT project and of the MSFD TG ML and IMAP indicators.

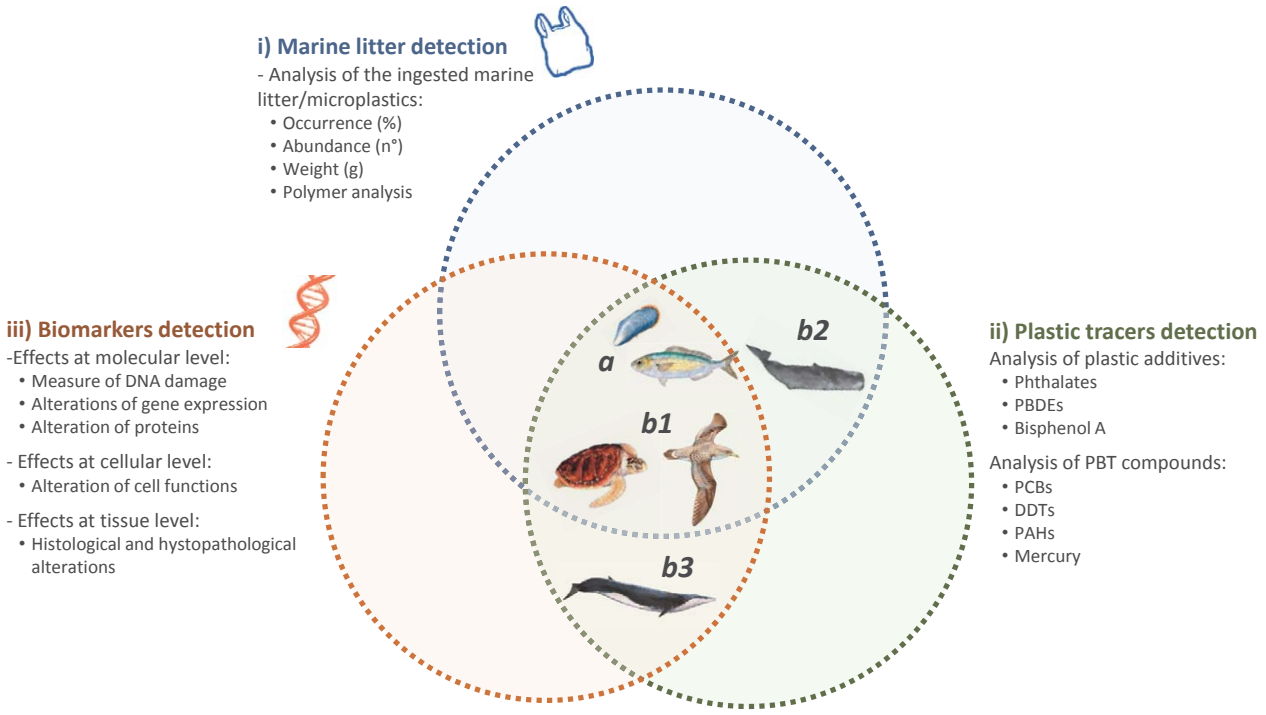


Figure 4A. The methodology for the detection of marine litter impacts on biota adopted by the PLASTICBUSTERSMPAs project (Fossi et al., 2018a).

These harmonized approaches and the methodologies developed for the simultaneous investigation of macrolitter and microlitter in the water column are being tested in selected sites. The first test of a comprehensive monitoring strategy to evaluate the impact of marine litter on endangered fauna was performed in the summer of 2018 in the Pelagos Sanctuary, where researchers of the University of Siena surveyed dolphins and whales as sentinels of the impact of macro-litter and micro-litter.

It has been in summer 2019 when the harmonized approach has been widely and intensively tested.

In June 2019 at the National Marine Park of Zakynthos (Greece) the Institute of Oceanography and the Institute of Marine Biological Resources and Inland Waters of the Hellenic Centre for Marine Research carried out 10 floating micro-litter surveys, covering a distance of 20 km. The research team also monitored floating macrolitter and collected several invertebrate and fish species (mussels, sea urchin, crabs, mullets, etc.) to detect the presence and effects of marine litter on biota and samples from endangered species (monk seal and Scopoli's shearwater).

From May to September 2019, the most comprehensive monitoring activity ever realized in the Pelagos Sanctuary dedicated 40 days to simultaneous monitoring and sampling.

In July 2019 the approach was tested at the Tuscan Archipelago National Park. A two-week mission focused on monitoring macro- and microlitter floating on the sea-surface, recording the presence of biota, sampling endangered species (cetaceans) as well as commercial species (fishes and invertebrates) to assess the amount of ingested litter and collection of field data to validate the project's marine litter transport and accumulation models. In a collaborative effort by UNISI, ISPRA, IFREMER, OEC, PNAT, Pelagos Secretariat and LaMMA, seven islands were monitored by 19 researchers who realized the following activities: 71 manta-trawls, 131 floating marine litter surveys, 11 cetacean skin biopsies, 120 mussel samples, 20 pools of neustonic indicators and 100 fish samples.

A team of six researchers from the COB -IEO, in collaboration with the Cabrera Archipelago National Maritime-Terrestrial Park, were involved in another scientific expedition between 26 July and 6 August 2019 to assess microplastics in the water surface and on sediments. The ingestion of microplastics by some fish species, sea urchins and holothurians, was also investigated. During the scientific expedition 22 seafloor monitoring with divers, 104 organisms (mussels, holothurians, sea urchin and fish species) and beach litter monitoring were performed. A similar campaign is planned in winter to contrast results.

The results of all campaigns are feeding into a comprehensive diagnostic analysis of the impacts of marine litter on biodiversity and endangered species in Mediterranean. The field data will moreover serve to validate the project's marine litter transport and accumulation models. The forecasting model to identify marine litter hotspots will provide valuable information to support targeted marine litter prevention and mitigation actions in the most affected Mediterranean MPAs.

After the studying and monitoring phase PLASTICBUSTERSMPAs will set-up and implement at least 10 marine litter demonstration projects in pilot MPAs. Measures to be implemented will be based on the impacts diagnosed in the monitoring phase and measures which can be directly implemented by MPA managers will be prioritized.

Demos will showcase MPA-relevant marine litter prevention measures to reduce the impact of ML in the selected MPAs. Learned lessons will be captured in a set of comprehensive guidelines to support replication actions.

Photo by: Plastic Busters MPAs

1.4 AMAre

The AMAre project has developed an online tool that aims to improve marine litter and other biodiversity and administrative data access, harmonization, and sharing to MPAs where the project has been involved (see Table 1). Floating marine litter monitoring activities have taken place in Torre Guaceto and other sites in collaboration with other community projects.

The AMAre WebGIS is an online tool which consists of a web-based portal designed for the interactive visualization of the spatial data collected among protected areas participating in the project and organized in a common spatial infrastructure (see Figure 5A).

The portal harmonizes relatively large and multi-dimensional datasets. Its spatial coverage include five MPAs, from West to East: Freus d'Elvissa i Formentera (Spain); the North-East MPA (Malta); Porto Cesareo MPA (Italy); Torre Guaceto MPA (Italy); and the Sporades Islands MPA (Greece). It combines georeferenced data with graphs, charts, tables, and text to enable open access and re-usable results of the project for the management of the MPAs in a coordinated manner. The data contained in the AMAre geoportal can also be visualized through the Biodiversity Protection Knowledge Platform.

The AMAre metadata are available online through the metadata catalogue. AMAre dedicated part of the project to train the personnel of the pilot MPAs in using the geospatial and other tools, targeted especially to MPA managers.

Figure 5A. A screenshot of the AMAre WebGIS with data collected for the MPA pilot sites in the project.

1.5 PHAROS4MPAs

PHAROS4MPAs is another Interreg Med co-funded project, which aims at delivering recommendations on the necessary practical collaboration between MPAs and 7 maritime sectors: energy (offshore windfarms), transport (maritime traffic and ports, cruise), tourism (leisure boating and recreational fisheries) and seafood (aquaculture, small-scale fisheries).

This will be supported by the inclusion of MPA network issues in the national maritime spatial plans that EU Mediterranean States are developing by 2021 and in the strategies developed for maritime sectors. Ultimately, the project will contribute to maintaining marine biodiversity and ecosystems through strengthening the management and networking of Mediterranean MPAs.

Among the policy briefs and recommendations released by the project, the marine litter issue can be transversally identified into the following sectors, which represents potential sources of marine litter production:

Offshore wind industry can be a source of marine metal pollution, as a single turbine's sacrificial anodes input 0.5-1 ton of metals into the marine environment every year. Even if this is not a "visible" marine litter source of production, this sector must be also considered when addressing marine litter issues.

Maritime transport is also among main sources of shipping-related contamination in the Mediterranean. The release of antifouling paints (Tributyltin (TBT) and its degradation products), as well as oil and exhaust emissions, sewage and ballast waters, are well known to be a marine pollution source from the maritime transport sector. Despite the banning of TBT since 1998, the most toxic material with high ecotoxicological impacts, some actual paintings may still be harmful by containing heavy metals and polycyclic aromatic hydrocarbons, highly detrimental to organisms, which may bioaccumulate and biomagnify through the food chain, reaching humans by seafood consumption.

The cruise sector is a source of solid waste pollution, including marine litter with plastics and other inorganic and organic materials. It represents a growing problem and waste management practices on cruise ships are still showing weaknesses in terms of "basic technical conditions for communal and hazardous waste disposal, resulting in emissions of hazardous substances such as dioxins (through incineration), floating macro waste and micro and nano plastics, with consequent impacts on marine fauna." PHAROS4MPAs results also underline that "each cruise ship passenger produces an average of 4 kilos of solid waste each day: this would mean that a cruise ship carrying 2,000 people would produce 8 tons of solid waste per day." As PHAROS4MPAs concentrates its analysis on the necessary practical collaboration between

MPAs and maritime sectors, it was identified that MPAs become themselves important attractions for the Mediterranean cruise industry. "They may receive large numbers of visitors from cruise ships on daily excursions – the MPA at Portofino is a prominent example – with potentially massive impacts from littering and damages to the precious natural resources of the area. This trend is likely to continue in the future, as tourists' desire for pristine destinations and unique experiences continues to grow."

Leisure and tour boating are equally a source of sustainability concerns. Even if its related environmental pressures depend on the type and size of boat, several sources of marine pollution result from this activity: artificial light emissions, boat strikes on marine mammals and turtles, and other harmful actions like fish feeding, collecting sea animals, and throwing away marine litter. Human waste is a global threat in all oceans and the Mediterranean is particularly sensitive, especially due to its low renewal rate (from 80 to 90 years). According to the FAO (2016), "In upcoming years seasonal population pressure increase is expected. The everyday human waste from leisure boating is threefold, with black water, grey water and marine litter dropping." About Marine litter dropping, "Most of the waste produced on board a recreational craft is similar to the household waste found in any home. This litter may be dropped to the sea by many recreational boat users and has become a serious pollution threat to marine protected areas (UNEP, 2015)". "A passenger at sea produces an average of 0.5 to 4 kilos of solid waste each day. Concerning litter, plastic represents the main threat. Plastics can be decomposed by microorganisms or by the action of time, becoming microplastics, which can be ingested by other organisms and bio accumulated through the trophic chain" (Bordbar et al., 2018).

The boat itself can become "garbage" if the owner cannot purchase a recycling or end or boat services. Free or cheap recycling solutions have to be provided to boaters. A working group chaired by the European Commission with the European Boating Industry is currently working on the topic of end-of-life boats. France is one of the first countries worldwide that has free recycling of leisure boats.

ACT4LITTER, DeFishGear, ML REPAIR are among past and ongoing EU projects also dealing with marine litter in MPAs and Natura 2000 sites: "Monitoring results show the amount of marine litter in MPAs is often higher during the non-tourist season months which indicates that the majority of marine litter comes by sea currents and winds, and that marine litter is accumulated in the sea from various sources and locations, and also churned up from below the thermocline when the autumn wind start to mix the water column." Unless there is no local utility companies, MPAs are not the competent authority for the solid waste management in their area. Some MPAs financially contribute to their work depending on the number of visitors in the MPA and whether they are charging entrance fees or taxes (e.g. Mljet National Park, Croatia). Cleaning actions, on a voluntary basis are often organized and sometimes the only way to collect huge amounts of marine litter accumulated on the coast.

Photo by: enrique lopez garre /pixabay.com

Concerning Aquaculture and small scale fisheries, though shellfish are usually considered an environmentally sound animal species to farm, they do generate a limited ecological impact, especially for mussel culture, where the use of disposal of plastic socks is a source of concern in several areas of the Mediterranean, particularly in the Adriatic and Ionian Seas. Plastic nets represent the 7th most common category of litter recorded on beaches and 3rd most common category on the seafloor. In the Adriatic Sea, mussel nets and other aquaculture litter from shellfish farming are widespread, leading to a greater risk exposure for wild species and local populations. Marine litter from aquaculture is still an emerging issue not sufficiently addressed, and among its policy recommendations, PHAROS4MPAs underlines that "national aquaculture strategies must ensure sustainable development and growth, avoiding potential negative impacts in terms of non-indigenous species, eutrophication, seafloor integrity, concentrations of contaminants (both in the water generally and in seafood specifically), populations of commercial fish, and marine litter."

A significant fraction of marine litter is produced by the Small-Scale Fisheries sector (SSF); lost or abandoned fishing gears (nets, hooks and lines). A so-called "ghost gear" can continue to catch fish, and gear of all kinds can harm sessile animals like corals and gorgonians. Lost or abandoned "ghost" fishing gear is a pollution source for microplastics which can enter organisms. The European Commission identified that fishing gear accounts for 27% of all beach litter – around 20% of all gear is eventually lost at sea. In addition, fishermen also throw away garbage in some areas and others actively contribute to garbage collection at sea such as in the Reseacyclons' Project.

PHAROS4MPAs stresses as recommendations: Small-scale fishers can play a key role in collecting marine litter, and contribute to the reduction of ghost fishing by collecting lost fishing gear, which can in turn be reused or recycled. Derelict fishing gear management schemes could be established from collection to final treatment or recycling together with waste collection plans in landing sites. Finally, to guarantee a good and fair access to landing sites, adequately equipped to facilitate SSF activities, with fully serviced docking areas, moorings, refrigerated warehousing, drinking water, ice machines, litter disposal and recycling (e.g. for expandable polystyrene boxes, etc.) can significantly reduce the impact of the SSF sector in terms of marine litter pollution in the Mediterranean.

Other environmental impacts are associated with recreational fishing and the potential environmental impacts of fishing gear lost or abandoned at sea: Lines and nets can remain in the water column as litter and on the seabed for many years still capturing fish, particularly in rocky habitats, resulting in additional mortality of both target and non-target species as well as abrasive action on soft and hard habitats. Plastic fishing lines and lead and lost nets are a major source of marine pollution in some areas. In particular, lead (from sinkers or weights used by many fishers) is very toxic when dissolved in water, and may end up affecting organisms. Lead bioaccumulates and may be biomagnified through the trophic chain, before reaching human beings when they consume seafood. Recreational fishers are also susceptible of garbage dropping.

PHAROS4MPAs released a series of policy briefs and recommendations where marine litter is identified a crossing issue in almost all studied sectors, thus representing a major pressure coming either from leisure/ recreational human activities or business-oriented sectors.

Photo by: Erich Westendarp/pixabay.com

1.6. MEDITERRANEAN BIODIVERSITY PROTECTION INITIATIVE PANACEA

Devised as an entry point to scientific evidence and supporting best practice on protected area management and ecosystem-based policy-making in the region, the Mediterranean Biodiversity Protection Platform is the main long-term communication and capitalization tool developed by the PANACeA project, the umbrella horizontal Interreg Med initiative supporting biodiversity protection projects. The objective of this knowledge platform is to give visibility to effective methodologies, key project outcomes and tools, and actions towards improved biodiversity management. By uniting scientific evidence, practice, and policy, this platform is the gate to main results derived mainly from the Interreg Med Programme projects on biodiversity protection and a knowledge reference to support regional environmental and sectoral policy decisions and actions on biodiversity protection, natural resource management, and sustainable growth in Mediterranean protected areas and beyond.

In the work developed concerning pollution, PANACeA consolidated on one hand a regional knowledge base on the pressure and pollution of marine litter in the Mediterranean called MedBioLitter, and on the other, a framework for an integrated protocol to be implemented at a regional scale to address marine litter in the Mediterranean Sea.

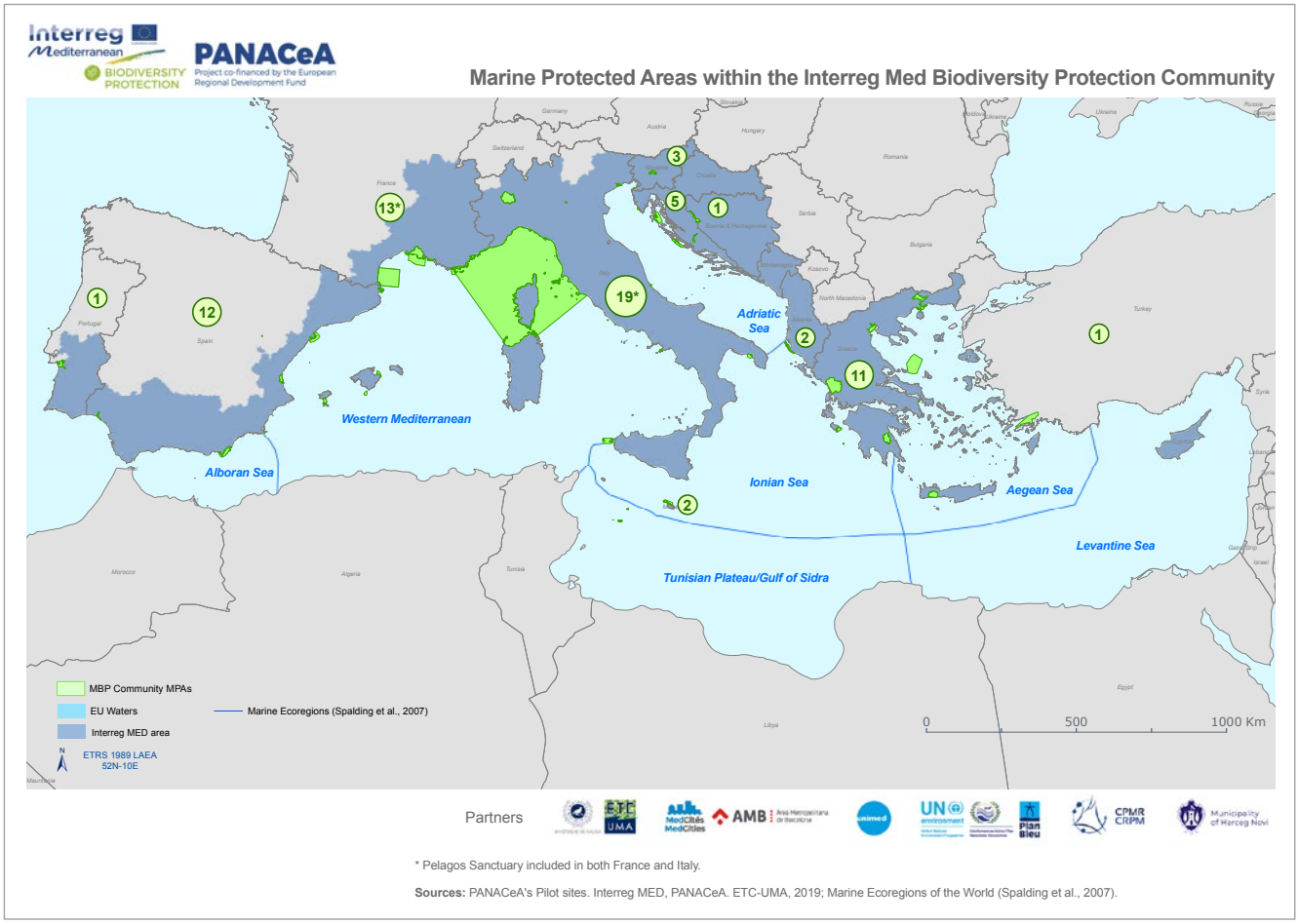
- The MedBioLitter database is a meta-analysis achieved by gathering in a meaningful way the community´s outcomes on marine litter impacts and external peer reviewed data sources; and by crossing the harmonized data to a geo-referenced database on the evidence available on the impacts of marine litter registered on biota in the whole Mediterranean basin. It includes knowledge on macro- and microlitter (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).

  The knowledge repository provides a baseline for a regional marine litter assessment and enables the identification and the crossing of information on the interaction found in literature between marine litter and biota spatially represented. It also allows for analyzing interaction data with a wide range of ecological criteria (taxa, species, ecoregion, trophic level, habitat class, biogeographical zone), management type (inside or outside protected areas), type of marine litter (polymer, fishnet, plastic,…), policy setting/subregions (IMAP, MSFD, CBD). Furthermore, MedBioLitter provides reference to the publication source of the data (author, title, doi,…). An example of the structure of the MedBioLitter database is available in Annex III.

- The policy report "Tackling Marine Litter in the Mediterranean: Knowledge & Tools" aims to synthesize and showcase the contribution of the Biodiversity Protection Community and other Interreg MED projects to the development and/or refinement of marine litter assessment and management tools, putting a special emphasis on the tools that can be used in Mediterranean MPAs. Moreover, it identifies current gaps in knowledge and management, advancing recommendations for further action for both EU and Mediterranean policymakers, governance mechanisms and funding instruments.

Annex II

List of Marine Protected Areas in Interreg Med Biodiversity Protection projects



- Karaburun-Sazani Island (Albania)
- Una, National Park (Bosnia-Herzegovina)
- Brijuni National Park (Croatia)
- Cres-Losinj MPA (Croatia)
- Kornati National Park (Croatia)
- Krka National Park (Croatia)
- Telascica Nature Park (Croatia)
- Bonifacio Strait Nature Reserve (France)
- Camargue Natura 2000 site (France)
- Cap Roux MPA (France)
- Cote Bleue MPA (France)
- Espiguette Natura 2000 (France)
- Marine Natural Park of the Gulf of Lion (France)
- Port-Cros National Park (France)
- Verdier marshes (France)
- Amvrakikos Wetlands MPA (Greece)
- Axios - Loudias - Aliakmonas Delta National Park (Greece)

- Delta Nestou, Vistonidas, Ismaridas (MPA) (Greece)
- Ecodevelopment area Karla-Mavrovouni-Kefalovriso-Velestino (Greece)
- Mountain Parnon (Greece)
- Moustos wetland Natura 2000 (Greece)
- National Marine Park of Alonissos Northern Sporades (N.M.P.A.N.S) (Greece)
- Samaria MPA (Greece)
- Schinias Marathon National Park (Greece)
- Zakynthos Marine National Park (Greece)
- Caorle lagoon system (Italy)
- Capo Carbonara MPA (Italy)
- Cinque Terre National Park (Italy)
- Egadi Islands MPA (Italy)
- Mincio River Regional Park (Italy)
- Pelagie Islands MPA (Italy)
- Porto Cesareo Marine Protected Area (Italy)
- Portofino MPA (Italy)
- Punta Campanella MPA (Italy)
- Secche di Tor Paterno MPA (Italy)
- Shoreline - Miramare MPA (Italy)
- Torre del Cerrano MPA (Italy)
- Torre Guaceto MPA (Italy)
- Tuscan Archipelago National Park (PNAT) (Italy)
- Vercelli plain (Italy)
- Pelagos Sanctuary for Mediterranean Marine Mammals (Italy/France/Monaco)
- Gozo Island (Malta)
- Iż-Żona Protetta tal-Baħar tal-Grigal (Malta North-East Marine Protected Area) (Malta)
- Melides lagoon (Portugal)
- Ljubljansko Barje nature park (Slovenia)
- Strunjan Landscape Park (Slovenia)
- Cabo de Gata-Níjar Natural Park/UNESCO Global Geopark – Andalucia (Spain)
- Cabo de Palos MPA (Spain)
- Cala Ratjada MPA – Balearic Islands (Spain)
- Cañizar Lagoon (Spain)
- Cap de Creus MPA (Spain)
- Ebro Delta Nature Park (Spain)
- Freus d'Eivissa i Formentera Marine Reserve (Spain) (Spain)
- La Albufera Natural Park (Spain)
- Odiel marshes (Spain)
- Parque Nacional Del Archipiélago De Cabrera (Spain)
- Gökova Special Environmental Protection Area (Turkey)

Annex III

Example of entry extracted from MedBioLitter showing its structure

MedBioLitter Database (DB) structure	Example of one peer reviewed article included in the DB
Publication code	27
Latitude	36,25535
Longitude	31,34318
Coordinate	Rough
IMAP ecoregion	Aegean and Levantine Seas
MSFD subregion	Aegean and Levantine Seas
Sea name	Turkish Sea
Inside an MPA	No
MPA type	
BPC area	No
Taxon	Actinopterygii
Sp name	other fish sp. (28)
% affected of the 'sampled population'	0
N. of specimens studied	0
Conservation status	Non-targeted
Conservation type	Commercial
Feeding behavior	Zooplanktivorous
Trophic level	2nd. consumers
Marine litter interaction	Ingestion
CBD Interaction	Y
MSFD relevant	Y
IMAP relevant	Y
Type of litter (EU): Artificial Polymer	APMs
Type of litter: fishnets	
Type of litter: plastic	Y
Habitat	Benthic

MedBioLitter Database (DB) structure	Example of one peer reviewed article included in the DB
EUNIS class	A6.51: Mediterranean communities of bathyal muds
EUNIS code	A6.51
MSFD benthic habitat	Upper bathyal sediment or Lower bathyal sediment
Biozone	Mediterranean bathyal
Authors	Güven, O., Gökdağ, K., Jovanović, B., Kıdeyş, A. E.
Year	2017
Title	Microplastic litter composition of the Turkish territorial waters of the Mediterranean Sea, and its occurrence in the gastrointestinal tract of fish
Doi	http://dx.doi.org/10.1016/j.envpol.2017.01.025
Version	2019-02-28Z
Featureid	MedBioLitter_vfeb2019.81

References

Arcangeli, A. et al., 2018. Amount, composition, and spatial distribution of floating macro litter along fixed trans-border transects in the Mediterranean basin, Marine Pollution Bulletin 129 (2), 545-554. ISSN 0025-326X. https://doi.org/10.1016/j.marpolbul.2017.10.028.

Bavestrello, G. et al., 1997. Damage by fishing activities to the Gorgonian coral *Paramuricea clavata* in the Ligurian Sea. Aquatic Conservation, 7, 253-262.

Campana, I., et al., 2018. Seasonal patterns of floating macro-litter across the Western Mediterranean Sea: a potential threat for cetacean species. Rendi conti Lincei. Scienze Fisiche e Naturali. https://doi.org/10.1007/s12210-018-0680-0

Cau et al., 2018. Dumping to the abyss: single-use marine litter invading bathyal plains of the Sardinian margin (Tyrrhenian Sea). Marine Pollution Bulletin, 135, 845–851

CBD, 2012. Secretariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel—GEF (2012). *Impacts of Marine Debris on Biodiversity: Current Status and Potential Solutions*, Montreal, Technical Series No. 67, 61 pages

CBD, 2016. Marine Debris: Understanding, Preventing and Mitigating the Significant Adverse Impacts on Marine and Coastal Biodiversity. Technical Series No.83. Secretariat of the Convention on Biological Diversity, Montreal, 78 pages

Consoli, P. et al., 2018. Marine litter in an EBSA (Ecologically or Biologically Significant Area) of the central Mediterranean Sea: Abundance, composition, impact on benthic species and basis for monitoring entanglement. Environmental Pollution, 236, 405-415

Deudero, S. and Alomar, C. Mediterranean marine biodiversity under threat: Reviewing influence of marine litter on species. Marine Pollution Bulletin 98, 58–68

D'Onghia, G. et al., 2017. Anthropogenic impact in the Santa Maria di Leuca cold-water coral province (Mediterranean Sea): Observations and conservation straits. Deep-Sea Research II, 145, 87–101

Dussud et al., 2018. Evidence of niche partitioning among bacteria living on plastics, organic particles and surrounding seawaters. Environmental Pollution, 236, 807-816

Fabri, M. C. et al., 2014. Megafauna of vulnerable marine ecosystems in French Mediterranean submarine canyons: Spatial distribution and anthropogenic impacts. Deep Sea Research Part II: Topical Studies in Oceanography, 104, 184-207

Fossi, C., et al., 2018a. Bioindicators for monitoring marine litter ingestion and its impacts on Mediterranean biodiversity. Environmental Pollution, 237, 1023-1040

Fossi, C. et al., 2018b. A Review of Plastic-Associated Pressures: Cetaceans of the Mediterranean Sea and Eastern Australian Shearwaters as Case Studies. Front. Mar. Sci. 5:173.doi: 10.3389/fmars.2018.00173

Galgani et al., 2018. Marine animal forests as useful indicators of entanglement by marine litter. Marine Pollution Bulletin, 135, 735–738

Garcia-Garin O., Vighi M, Aguilar A., Tsangaris C., Digka N., Kaberi H., Borrell, A. 2019. *Boops boops* as a bioindicator of microplastic pollution along the Spanish Catalan coast. Marine Pollution Bulletin 149: 110648. https://doi.org/10.1016/j.marpolbul.2019.110648

Masó et al., 2016. Microfouling communities from pelagic and benthic marine plastic debris sampled across Mediterranean coastal waters. Sci. Mar. 80S1: 117-127. http://dx.doi.org/10.3989/scimar.04281.10A

Spalding, M.D., Helen, E.F., Gerald, R.A., Davidson, N., Ferdaña Z.A., Finlayson, M., Halpern, B.S., Jorge, M.A., Lombana, A., Lourie, S.A., Martin, K.D., McManus, E., Molnar, J., Recchia, C.A., Robertson, J. (2008). Marine Ecoregions of the World: A Bioregionalization of Coastal and Shelf Areas. BioScience, Volume 57, Issue 7, July 2007, Pages 573–583, https://doi.org/10.1641/B570707

Taviani, M. et al., 2017. The "Sardinian cold-water coral province" in the context of the Mediterranean coral ecosystems. Deep Sea Research Part II: Topical Studies in Oceanography, 145, 61-78

UNEP/MAP SPA/RAC, 2018. Defining the most representative species for IMAP Candidate Indicator24. By Fr. Galgani. Ed. SPA/RAC, Tunis: 37 pp + Annexes

Veiga, J.M., Fleet, D., Kinsey, S., Nilsson, P., Vlachogianni, T., Werner, S., Galgani, F., Thompson, R.C., Dagevos, J., Gago, J., Sobral, P. and Cronin, R.; 2016; Identifying Sources of Marine Litter. MSFD GESTG Marine Litter Thematic Report; JRC Technical Report; EUR 28309; doi:10.2788/018068

Vlachogianni, T., 2019. Marine Litter in Mediterranean coastal and marine protected areas – How bad is it. A snapshot assessment report on the amounts, composition and sources of marine litter found on beaches, Interreg Med ACT4LITTER & MIO-ECSDE.

Vlachogianni, T., Fossi M.C., Anastasopoulou, A., Alomar, C., Aparicio, A., Baini, M., Caliani, I., Campani, T., Casini, S., Consoli, P., Deudero, S., Galgani, F., Kaberi H., Panti, C., E. Romeo, T., Tsangaris, C., Zeri, C., 2018. State-of-the-art methods to monitor marine litter and its impacts on biodiversity. Interreg Med Plastic Busters MPAs project.

Werner, S., Budziak, A., van Franeker, J., Galgani, F., Hanke, G., Maes, T., Matiddi, M., Nilsson, P., Oosterbaan, L., Priestland, E., Thompson, R., Veiga, J. and Vlachogianni, T.; 2016; Harm caused by Marine Litter. MSFD GES TG Marine Litter - Thematic Report; JRC Technical report; EUR 28317 EN;doi:10.2788/690366

PANACeA resources related to pollution and marine litter

FACTSHEETS

- Marine litter and biodiversity interactions in the Mediterranean Sea
- Tackling Marine Litter in the Mediterranean: Knowledge and Tools

REPORTS

- Tackling Marine Litter in the Mediterranean: Knowledge & Tools, Policy report, March 2019
- Marine Litter knowledge and tools in Mediterranean protected areas, MARLICE workshop report, Seville, 11-12 April 2019
- Ecosystem-based approaches to managing transboundary and cumulative impacts in the Mediterranean, with a focus on marine plastic litter and climate change, Workshop report, Cairo, 27 November 2018

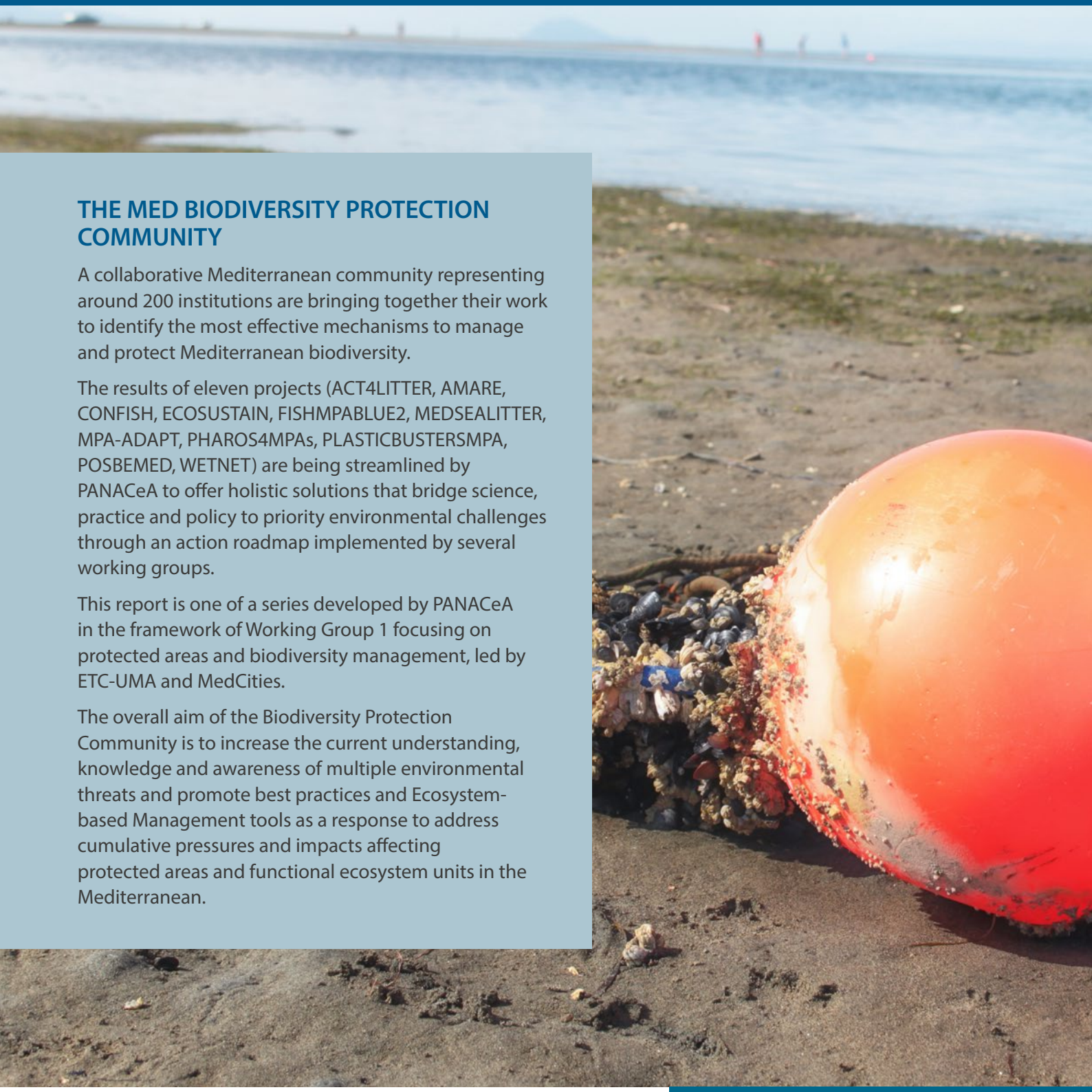
WEBINARS

- Marine litter in Interreg Med, 17 July 2017 – Watch the video.

ONLINE PORTALS

- MedBioLitter: database on marine litter interactions with marine biodiversity in the Mediterranean
- biodiversity.uma.es

PANACeA partners also contributed to the Report from the Marine Litter Topic Group led by SCP/RAC as Stockholm Convention Regional Centre in Spain "Plastic and toxic additives & the circular economy, the role of the Basel & Stockholm Conventions", March 2019



THE MED BIODIVERSITY PROTECTION COMMUNITY

A collaborative Mediterranean community representing around 200 institutions are bringing together their work to identify the most effective mechanisms to manage and protect Mediterranean biodiversity.

The results of eleven projects (ACT4LITTER, AMARE, CONFISH, ECOSUSTAIN, FISHMPABLUE2, MEDSEALITTER, MPA-ADAPT, PHAROS4MPAs, PLASTICBUSTERSMPA, POSBEMED, WETNET) are being streamlined by PANACeA to offer holistic solutions that bridge science, practice and policy to priority environmental challenges through an action roadmap implemented by several working groups.

This report is one of a series developed by PANACeA in the framework of Working Group 1 focusing on protected areas and biodiversity management, led by ETC-UMA and MedCities.

The overall aim of the Biodiversity Protection Community is to increase the current understanding, knowledge and awareness of multiple environmental threats and promote best practices and Ecosystem-based Management tools as a response to address cumulative pressures and impacts affecting protected areas and functional ecosystem units in the Mediterranean.

Interreg Mediterranean BIODIVERSITY PROTECTION

Project co-financed by the European Regional Development Fund

The MED Biodiversity Protection Community is featured by PANACeA

https://biodiversity-protection.interreg-med.eu
https://www.facebook.com/PanaceaInterregMed
@MEDCommunity3_2
panacea-med@uma.es
https://www.linkedin.com/groups/13511318/
MedBioLitter