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Agenda item 6.1: Report on Activities Carried Out in the Framework of UNEP/MAP since COP 18

Updated Report on Marine Litter Assessment in the Mediterranean

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Updated Report on Marine Litter Assessment in the Mediterranean

UNEP/MAP
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1. INTRODUCTION TO ASSESMENT

1.1. The general framework: UNEP'S Marine Litter Programme

1. Marine litter is a complex and multi-dimensional problem with significant implications for the marine and coastal environment and human activities the world over. It originates from many sources and has a wide spectrum of negative environmental, economic, safety, health, and cultural impacts. Despite efforts made internationally, regionally, and nationally, there are indications that the marine litter problem continues to worsen.

2. Marine litter is one of the 8 contaminants of the UNEP/GPA for the protection of marine environment from land based sources and activities. The problem of marine litter was recognized by the UN General Assembly (UNGA), which in its Resolution A/60/L.22 - Oceans and the Law of the Sea - of 29 November 2005, in articles 65-70, calls for national, regional, and global actions to address the problem of marine litter. This GA resolution notes the lack of information and data on marine litter, encourages States to develop partnerships with industry and civil society, urges States to integrate the issue of marine litter within national environmental strategies, and encourages them to cooperate regionally and sub-regionally to develop and implement joint prevention and recovery programs for marine litter. In response to the UNGA call, UNEP (Global Programme of Action (GPA) and the Regional Seas Programme), through its Global Marine Litter Initiative, took an active role in addressing the challenge by assisting 11 Regional Seas around the world (Baltic Sea, Black Sea, Caspian Sea, East Asian Seas, Eastern Africa, Mediterranean Sea, Northwest Pacific, Red Sea and Gulf of Aden, South Asian Seas, South East Pacific, and Wider Caribbean) in organizing and implementing regional activities on marine litter.

3. Taking into account the UNGA Resolution, the ongoing regional activities organized through the Regional Seas Programme of the United Nations Environment Programme, and the outcome of the 2nd Intergovernmental Review of the GPA, it has been agreed that the strategy to address the problem of marine litter at the regional level needs to be based on the development and implementation of the Regional Action Plans for Marine Litter or Regional Strategies for the Sustainable Management of Marine Litter. It has also been agreed that the development and implementation of a Regional Strategy should pass through the following three phases:

   - Phase I: Assessment of the regional situation;
   - Phase II: Preparation of the Regional Strategy, including a regional meeting of experts and national authorities; and
   - Phase III: The integration of the Regional Strategy into the Programme of Work of the respective Regional Seas Programmes and the Implementation of the Regional Strategy at the national and regional level.

4. The adoption of the Honolulu Strategy and Honolulu Commitment in 2011 and, more recently, the particular emphasis on marine litter issues at the Rio+20 Summit 2012 are clear indications of the high priority given to such issues at a more global level.
5. More recently, leading scientists and policymakers acknowledged that marine litter remained a "tremendous challenge" (http://www.unep.org/newscentre/default.aspx?DocumentID=2791&ArticleID=10903) in almost all regions of the world, with clear impacts on marine ecosystems and estimates of the overall financial damage to marine ecosystems by plastic standing at US $13 billion each year.

1.2. The Mediterranean context

6. Marine litter has been an issue of concern in the Mediterranean since the 1970s. Within the framework of the Barcelona Convention, the Mediterranean countries adopted in 1980 a Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources. In this Protocol, the importance of dealing with the problem of marine litter was recognized. The Protocol was amended in 1996, and Annex I defined as one of the categories of substances "Litter as any persistent manufactured or processed solid material which is discarded, disposed of, or abandoned in the marine and coastal environment".

7. The Mediterranean was also designated a Special Area for the purposes of Annex V of the MARPOL 73/78 Convention. The Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) at its 57th Session (31st March – 4th April 2008) adopted a MEPC resolution establishing the date on which the MARPOL Annex V (Regulations for the Prevention of Pollution by Garbage from Ships) special area regulations shall take effect in the Mediterranean Sea. MEPC decided that the discharge requirements for special areas of MARPOL Annex V shall take effect for the Mediterranean Sea on 1st May 2009. Consequently, for all ships, as from 1st May 2009, disposal into the Mediterranean Sea of the following was prohibited: all plastics, including but not limited to synthetic ropes, synthetic fishing nets and plastic garbage bags; and all other garbage, including paper products, rags, glass, metal, bottles, crockery, dunnage, lining and packing materials.

8. In July 2011, MEPC 62 adopted, by resolution, MEPC.201 (62), the revised MARPOL Annex V, which entered into force on 1 January 2013. In March 2012, MEPC 63 adopted the 2012 Guidelines for the implementation of MARPOL Annex V (resolution MEPC.219(63)) and the 2012 Guidelines for the development of garbage management plans (resolution MEPC.220(63)). Under the revised MARPOL Annex V, garbage includes all kinds of food, domestic and operational waste, all plastics, cargo residues, incinerator ashes, cooking oil, fishing gear, and animal carcasses generated during the normal operation of the ship and liable to be disposed of continuously or periodically. Garbage does not include fresh fish generated as a result of fishing activities undertaken during the voyage, or as a result of aquaculture activities.

9. This Annex also obliges Governments to ensure the provision of adequate reception facilities at ports and terminals for the reception of garbage. Under Annex V, the Mediterranean Sea area was defined as a special area due to its oceanographic and ecological condition and the particular heavy maritime traffic, low water exchange, endangered marine species, etc. This meant special considerations had to be implemented for port state control, such as placards for passengers ships, garbage management plans (Resolution MEPC.220-63), garbage record books, cargo residues, and a shipboard incinerator.

10. UNEP/MAP, jointly with IOC and FAO, recognizing the lack of information on marine and coastal litter in the Mediterranean, convened in 1987 an *ad hoc* meeting on persistent materials (UNEP/IOC/FAO, 1991) and recommended a pilot survey that was organized in 1988 by UNEP/MAP in cooperation with IOC and FAO, with five participating countries (Cyprus, Israel, Italy, Spain and Turkey). This pilot survey is considered as a landmark activity for the assessment of coastal and marine litter in the Mediterranean. This was followed by the publication of a Comprehensive Bibliography on Marine Litter containing 440 references and an Assessment of the State of Pollution of the Mediterranean Sea by Persistent Synthetic Materials, which can Float, Sink or Remain in Suspension by UNEP/MAP in 1991 (UNEP/IOC/FAO, 1991).

11. The Eleventh Meeting of the Contracting Parties (COP11, Tunisia, 1999) asked the UNEP/MAP Secretariat to take action on coastal and marine litter and to prepare a relevant assessment. A Consultation Meeting on Marine and Coastal Wastes in the Mediterranean was

held, and several documents were prepared, supporting a project on Marine and Coastal Litter Management. The results of the assessment showed that the main sources of coastal litter in the region are river runoff, tourist activities, and coastal urban centers. This indicates that the inadequate management of coastal solid waste is responsible for the presence of litter on the beaches, in the water, and on the sea bed. Almost all the Mediterranean countries have policies for the management of coastal solid waste, but the enforcement of the policies is weak due to the poor coordination between different national and local administrations dealing with solid waste issues. Local administration and municipalities are the ultimate responsible parties for the management of coastal litter in the region when the role of the Ministry of environment is limited to its control.

12. Based on these facts, UNEP/MAP-MEDPOL Programme built up a strategy to assist coastal local authorities to improve the management of coastal solid waste and prevent the introduction of litter into the marine environment. Along this line, MEDPOL implemented with RAMOGE and UNADEP a pilot project (UNEP/MAP/MEDPOL, 2004) and, in cooperation with World Health Organisation and within the framework of the Strategic Action Programme (SAP), prepared Guidelines for Management of Coastal Litter for the Mediterranean Region (MAP/UNEP/MED POL, 2004).

13. With the support of the Regional Seas Programme of UNEP, UNEP/MAP-MEDPOL developed in 2006 a public awareness and education campaign entitled "Keep the Mediterranean Litter-free Campaign" implemented by regional NGOs such as the Mediterranean Information Office for Environment, Culture and Sustainable Development (MIO-ECSDE), the Hellenic Marine Environment Protection Association (HELMEPA), and Clean Up Greece (Clean Up Greece/HELMPEPA/MIO-ECSDE, 2007). The objective was to educate the general public as well as all other stakeholders, such as the maritime industry, the tourism sector, agriculture, regional and national authorities, NGOs, the media, etc. Numerous international organizations and NGOs have conducted surveys and beach cleanup campaigns yielding data and information on marine and coastal litter pollution of the Mediterranean Sea. These efforts, which remain ongoing, are considered to be reliable sources of data and information.

14. The findings and recommendations of this campaign and assessment led to the preparation of a Marine Litter strategic framework in the Mediterranean, adopted by COP12, February 2012, Paris, France, which guided the development and adoption of the Marine Litter Regional Plan (MLRP) by COP18, Istanbul, Turkey, 2013, in the framework of Article 15 of the LBS Protocol of the Barcelona Convention.

15. The Barcelona Convention and its Protocols, the MLRP and where appropriate the EU Marine Strategy Framework Directive (MSFD) are the only legal frameworks and instruments applicable in the Mediterranean with regards to marine litter management.

16. The adoption of the MLRP in 2013 made the Mediterranean the first regional sea committed to legally binding measures, programmes, and related implementation timetables on marine litter management at regional and national levels, thus contributing to the Honolulu Commitment and the Rio + 20 marine litter target.

17. The major objectives of the MLRP are to achieve good environmental status through the prevention and reduction of marine litter and by limiting its environmental, health, and socio-economic impacts to a minimum. Most of the measures aim at improving solid waste management, implementing innovative tools related to a sustainable production and consumption, using economic incentives, and removing existing marine litter and eliminating ofhot spots, etc. The MLRP provides a sound framework for knowledge enhancement, monitoring and assessment, research, awareness, and cooperation and partnerships among different stakeholders at regional and national levels, including the scientific community and the large public. In this respect, the MEDPOL programme of UNEP/MAP is mandated to

undertake the assessment of marine litter on a six-year basis at the Mediterranean level as well as to coordinate the formulation and implementation of a marine litter monitoring programme based on an ecosystem approach by all Mediterranean countries. The MLRP indicates a list of 30 priority research topics on marine litter and invites the research community to actively contribute to filling these gaps in knowledge, facilitating the efficient implementation of measures and assessing their effectiveness.

2. MARINE LITTER IN THE MEDITERRANEAN SEA

18. The Mediterranean Sea has been described as one of the areas most affected by marine litter in the world. Human activities generate considerable amounts of waste, and quantities are increasing, although they vary between countries. Some of the largest amounts of Municipal Solid Waste (MSW) generated annually per person occur in the Mediterranean Sea (208 – 760 kg/Year, http://www.atlas.d-waste.com/). Plastic, which is the main litter component, has now become ubiquitous and may comprise up to 95% of waste accumulated on shorelines, the ocean surface, or sea floor.

19. A majority of these materials do not decompose, or decompose slowly. This phenomenon is particularly critical on the sea floor, where 90% of litter caught in benthic trawls is plastic, and even more so on the surface of the sea, where that figure can reach up to 100%. (Galil *et al.* 1995, Galgani *et al.*, 1995 & 2000, Ioakeimidis *et al.*, 2014)

20. Surveys conducted to date show considerable spatial variability. Accumulation rates vary widely and are influenced by many factors, such as the presence of large cities, shore use, hydrodynamics, and maritime activities. They are higher in enclosed seas such as the Mediterranean basin, which has some of the highest densities of marine litter stranded on the sea floor, sometimes reaching over 100,000 items / km² (Galgani *et al.*, 2000). Plastic densities on the deep sea floor did not change between 1994 and 2009 in the Gulf of Lions (Galgani *et al.*, 2011). Conversely, the abundance of debris in deep waters, such as the central Mediterranean, was found to increase over the years (Koutsodendris *et al.*, 2008; Ioakeimidis *et al.*, 2014).

21. In the Mediterranean, reports from Greece (Koutsodendris *et al.*, 2008; Ioakeimidis et al, 2014) classify land-based sources (up to 69% of litter) and vessel-based sources (up to 26%) as the two predominant litter sources. In addition, litter items have variable floatability and hence variable dispersal potential.

22. The issue of marine litter and related information on the amounts and types in the Mediterranean is rather complicated, as it is addressed principally by scientific institutions and sub-regional and local authorities in most countries on the one hand and by competent NGOs on the other.

23. Collection of information is a task that requires considerable human resources directly and indirectly related to the subject along with a sophisticated central coordination mechanism. Unfortunately, this is a recent undertaking for the Mediterranean. However, a relatively systematic and reliable source for amounts and types of litter is usually the existing NGO initiatives in the region. NGO efforts are the most significant in terms of surveying and cleaning beaches and the sea and providing information on the volume and types of litter existing in the Mediterranean. The most significant of these initiatives at the regional level are the following:

    - *MIO-ECSDE organizes marine litter related events, including clean-ups, in the framework of its annual Mediterranean Action Day (since 1998) with an average participation of member NGOs from 12 Mediterranean countries.*

- *The Australian organization Clean up the World organizes clean-ups in September with around 115 countries worldwide, many of which in the Mediterranean.*
- *The International Coastal Cleanup (ICC) campaign is coordinated globally by the Washington-based NGO Ocean Conservancy in cooperation with NGOs in over 100 countries and is the largest one-day cleanup event in the world.*
- *The Italian environmental organization Legambiente coordinates every spring-summer beach clean ups in the Mediterranean.*

24. Furthermore, initiatives of varying importance are taken up by NGOs, local authorities and other partners at national and local level in almost all Mediterranean countries. All of the above initiatives succeed in gathering thousands of volunteers in the Mediterranean countries with the purpose not only to clean the coasts, rivers, and lakes in their local communities but also to raise awareness amongst students, citizens, and various stakeholders about the serious implications of marine litter and to inspire people to make a difference and improve their daily environmental conduct.

25. For the purpose of this assessment, the figures resulting from various clean-ups were compared, and it was deduced that a common synthesis is not possible due to the fact that each initiative is conducted with different data cards, standards, and measures (litter types are classified differently, if at all; in some cases litter is measured in items while in others by weight, etc.), while certain crucial information is completely lacking (length of coast cleaned, type of coast, proximity of coast to sources of litter, etc.).

2.1. Origin, typology and pathways

2.1.1. Sources of marine litter in the Mediterranean

26. Sources of marine litter are traditionally classified as either land-based or sea-based, depending on where the litter enters the water. Other factors, such as ocean current patterns, climate, tides, and proximity to urban centres, waste disposal sites, industrial and recreational areas, shipping lanes, and commercial fishing grounds, influence the type and amount of marine litter found in open ocean areas or collected along beaches and ocean, including underwater areas.

27. Identifying the source of many litter items is a complex task, as marine litter enters the ocean from point and diffuse sources both land-based and ocean-based, and can travel long distances before being deposited onto shorelines or settling on the bottom of the ocean, sea, or bays. The release of litter and garbage from coastal landfills, water transports, recreational beaches, and illegal dumping all contribute to the marine litter problem. Marine litter can be transported indirectly to the sea or coast by rivers, drains, sewage outlets and storm water outflows, road run-off, or can be blown there by winds. Land-based sources include tourism and recreational use of the coast, general public litter, fly tipping, local businesses, industry, harbours, and unprotected waste disposal sites.

28. According to the Joint Group of Experts on the Scientific Aspects of Marine Environmental Pollution (GESAMP) (1991), land-based sources account for up to 80% of the world's marine pollution. Much of the litter reaches the ocean by beach-going activities, being blown into the water, or is carried by creeks, rivers, and storm drains/sewers to ocean areas. A recent study (Jambeck *et al.*, 2015) analyzed the sources of marine debris and estimated that 4.8 to 12.7 million tons of plastic were dumped into the ocean in 2010, the average being about 8.8 million tons. The 208,519 millions inhabitants of coastal areas were generating 360,939 tons of waste everyday, 10% of which is plastic, with an estimated 2% of waste ending up as litter on beaches (From US national litter studies). An estimated 731 tons of plastic was littered every day with important differences depending on country (table 2.1.1a). Researchers predict that, without management measures, the amount of plastic dumped will raise by a factor of ten in the next decade and by a factor of 2.17 between 2010 and 2025 in the Mediterranean Sea.

29. Land based source pollution can be measured mainly in rivers or storm drains, although there is temporal heterogeneity due to weather events. In the Mediterranean Sea, there is only one study (Vianello *et al.*, 2015) on the concentration of litter in the Po river, ranging from 1 (Spring) to 12.2 items/m^3 (winter), averaging inputs at a level of 50 billons particles every year. Another study (Tweehyusen, 2015) demonstrated that 677 tons of microplastics were entering the Mediterranean Sea every year. Data on microparticles in the Danube river indicated an average plastic load in the range of 317 – 4,665 items per 1000 m^3 (79.4% industrial, 20.6% others) which equates to 4.8 - 24.2 grams per 1000 m^3. Information from studies in northern Europe also demonstrated that the majority of litter is plastic, and that sanitary products may constitute up to 22% of riverine inputs (in number, Moritt *et al.*, 2014). Riverine litter is most often deposited to both sides of the river mouths on coastal beaches, and their abundance generally declines with an increase in distance from the river mouth except for large rivers (Rhone, Po, Ebro, Nile) where flow may transport litter very far from estuaries (Galgani *et al.*, 2000; Pham *et al.*, 2014). The situation of the wadi on the south shore of the Mediterranean is of special interest. The presence of pollution and garbage is particularly persistent in a semi-arid climate where annual rainfall is concentrated into just a few months. This may exacerbate the spreading of debris pollution during rainfall only by means of river transport as for sediment transport (Achite & Ouillon, 2007, Ludwig *et al.*, 2009). Uncontrolled discharges also act as main sources of litter in the Mediterranean Sea. For example, only 39 (29%) of the 133 coastal cities from Algeria are controlling their waste discharges in adapted structures, without taking illegal deposit in account (Makhoukf, 2012).

Country	Coastal population [1]	Waste generation rate [kg/person/day] [2]	% Plastic in waste stream[2]	% Inadequately managed waste[3]	Waste generation [kg/day]	Plastic waste generation [kg/day]	Inadequately managed plastic waste [kg/day][4]	Plastic waste littered [kg/day][4]
Albania	2 530 533	0,77	9	45	1 948 510	174 392	77 897	3 488
Algeria	16 556 580	1,2	12	58	19 867 896	2 374 214	1 378 693	47 484
Bosnia/Herzegovina	585 582	1,2	12	40	702 698	83 972	33 813	1 679
Croatia	1 602 782	2,1	12	9	3 365 842	402 218	37 053	8 044
Cyprus	840 556	2,07	12	0	1 739 951	207 924	831	4 158
Egypt	21 750 943	1,37	13	67	29 798 792	3 858 944	2 572 170	77 179
France	17 287 280	1,92	10	0	33 191 578	3 302 562	0	66 051
Greece	9 794 702	2	10	0	19 589 404	1 949 146	0	38 983
Israel	6 677 810	2,12	14	1	14 156 957	1 974 896	12 577	39 498
Italy	33 822 532	2,23	6	0	75 424 246	4 487 743	0	89 755
Lebanon	3 890 871	1,18	8	34	4 591 228	365 003	123 700	7 300
Libya	4 050 128	1,2	12	23	4 860 154	580 788	132 985	11 616
Malta	404 707	1,78	12	6	720 378	86 085	5 456	1 722
Monaco	34 050	2,1	12	0	71 505	8 545	0	171
Montenegro	260 336	1,2	12	30	312 403	37 332	11 353	747
Morocco	17 303 431	1,46	5	66	25 263 009	1 250 519	824 650	25 010
Gaza	3 045 258	0,79	8	6	2 405 754	191 257	11 515	3 825
Slovenia	336 594	1,21	12	1	407 279	48 670	550	973
Spain	22 771 488	2,13	13	0	48 503 269	6 281 173	0	125 623
Syria	3 621 997	1,37	13	65	4 962 136	642 597	419 763	12 852
Tunisia	7 274 973	1,2	12	60	8 729 968	1 043 231	621 077	20 865
Turkey	34 042 862	1,77	12	16	60 255 866	7 200 576	1 187 323	144 012
Total/mean	208 519 478	2	11	23	360 939 138	36 560 188	7 451 413	731 036

Table 2.1.1a: Coastal Population and Waste/plastic generation in 2010 in the Mediterranean countries (After Jambeck et al., 2015 and http://jambeck.engr.uga.edu/landplasticinput). (1) Coastal populations were estimated from global population around a 50 km buffer from the coastline, (2) World bank estimates, (3) modelled, (4) extrapolated/calculated.

30. Ocean-based sources for marine litter include merchant shipping, ferries and cruise liners, commercial and recreational fishing vessels, military fleets, research vessels, pleasure craft, and offshore installations such as oil and gas platforms, drilling rigs, and aquaculture sites.

31. There is no specific evaluation of litter originating from ships in the Mediterranean Sea. However, with an evaluation of inputs from ships at 6 million tons worldwide and 30% of the maritime traffic worldwide (http://www.unep.org/regionalseas/marinelitter/about/distribution/) occuring in the Mediterranean sea, one may expect more than a million tons of garbage coming from ships to the Mediterranean.

32. Because some items can be attributed to certain sources with a high level of confidence, the broad categories can be further detailed into use-categories sources such as recreational litter, shipping litter, fishing litter, sewage-related debris, tourist litter, “sanitary” litter and “medical” litter. These sub-categories provide valuable information for setting targets and reduction measures, as they are the most easily linked to measures.

33. Assessments of the composition of beach litter in different regions of the Mediterranean Sea show that synthetic materials (bottles, bags, caps/lids, fishing nets, and small pieces of unidentifiable plastic and polystyrene) make up the largest proportion of overall litter pollution.

34. Even the most remote parts of the Mediterranean are affected by marine litter. The findings of the “Assessment of the status of marine litter in the Mediterranean” (2009) undertaken by UNEP/MAP MEDPOL in collaboration with the Mediterranean Information Office for Environment, Culture and Sustainable Development (MIO-ECSDE), the Hellenic Marine Environment Protection Association (HELMEPA), and Clean up Greece Environmental Organization, illustrate that although useful data on types and quantity of marine litter exists in the region, it is inconsistent and geographically restricted mainly to parts of the North Mediterranean.

35. Items found on Mediterranean beaches indicate a predominance of land-based litter, stemming mostly from recreational/tourism activities (40% in ARCADIS, 2014, >50% in Öko-Institut, 2012 and Ocean Conservancy/ICC, 2002-2006). Household-related waste, including sanitary waste, is also of great relevance (40% in ARCADIS, 2014). The amount of litter originating from recreational/tourism activities greatly increases during and after the tourism season. Smoking related wastes in general also seems to be a significant problem in the Mediterranean, as several surveys suggest (UNEP 2009). Finally, the fishing industry is of significance (UNEP, 2013), as well as the shipping industry, especially off the African coast.

36. While classification has certain drawbacks (for example, litter from food consumption may be both in the *Shoreline and Recreational Activities* category and from crews/passengers on board all types of vessels and boats), this system provides a good overall basis for classifying marine litter items according to the activities that produce them and for monitoring their increasing/decreasing trends.
37. According to the analysis of data collected, shoreline and recreational activities were the main source every year of the last decade, until it was surpassed by smoking-related waste (Unep, 2011).

38. A study primarily based on the analysis of data collected within the framework of the ICC campaigns in Mediterranean countries (http://www.oceanconservancy.org/our-work/international-coastal-cleanup/) provided a classification system (table 2.1.1b).

Table 2.1.1b: Classification of marine litter by source (in accordance with Ocean Conservancy's ICC campaign – with minor adjustments).

Shoreline and Recreational Activities
Litter from land-based activities such as fast food consumption, beachgoers, picnics, sports and recreation, festivals, as well as litter washed from streets, parking lots and storm drains and as a result of poor waste disposal schemes and illegal dumping. Litter items classified in this category include plastic bags, balloons, beverage bottles (plastic & glass) and aluminium cans, caps/lids, clothing, cups/plates/forks/knives/spoons, food wrappers/containers, pull tabs, shotgun shells/wadding, six-pack holders, straws/stirrers and toys
Sea/Waterway Activities
Recreational fishing and boating, commercial fishing, cargo/military/passenger and cruise ship operations and offshore industries such as oil drilling. Litter items included bait containers, bleach/cleaner bottles, buoys/floats, crab/lobster/fish traps, crates, fishing nets and lines, fishing lures/light sticks, light bulbs/tubes, oil/lube tubes, pallets, plastic sheeting, rope and strapping bands.
Smoking-Related Activities
Improper disposal of cigarette filters, cigar tips, lighters and tobacco product packaging is common on both land and sea.
Dumping Activities
Legal and illegal dumping of construction materials, large household items, etc. often results in coastal litter. Other litter items classified in this category include batteries, cars/car parts, tires and drums.
Medical/Personal Hygiene
This litter can result from people improperly disposing of waste in toilets and city streets. Since medical and personal hygiene litter often enters the waste stream through sewer systems, its presence on the beach can indicate the presence of other, unseen pollutants. Litter items classified in this category includes condoms, diapers, syringes and tampons.

39. Marine litter from smoking related activities accounts for 40% of total marine litter in the same period and 53.5% of the top ten items counted in 2013. Although the number of litter items from smokers dropped significantly between 2004 and 2005, since 2005 it has been on the rise again. The figure in the Mediterranean is considerably higher than the global average, especially in some countries (Greece), and constitutes a serious problem that has to be given priority in a Regional Strategy to address the issue.

40. Sea and waterway activities account for 5% of marine litter in the Mediterranean and have remained steadily low throughout the period under study. This could be largely due to the fact that all vessels above 400 tons or carrying more than 15 persons are obliged to implement garbage management plans in accordance with international maritime law. It is also true that the situation concerning the availability of reception facilities in the major Mediterranean ports has improved in recent years. Prohibitions regarding the disposal of solid wastes are particularly strict in sea areas with special characteristics, such as the Mediterranean, which is termed a Special Area under the MARPOL International Convention.

41. Problems still exist in relation to the operation and use of port reception facilities. Seafarers and shipping companies still complain that, although crews on board merchant vessels may implement waste management plans that include the separation of solid wastes in accordance with international legislative requirements, the efficiency of the shore side management of these separated waste streams often remains in question. Ships should not be deterred from discharging waste to port reception facilities due to high costs, complicated procedures, unnecessary paperwork, excessive sanitary regulations, customs regulations, etc. Furthermore, coastal municipalities must make sure that the waste left in reception facilities is properly

taken care of on land in a manner that is optimal in terms of caring for the environment and human health. It is essential that governments, local/port authorities, the maritime industry, and other stakeholders enhance their cooperation in order to address all remaining problems regarding the availability of port reception facilities, and the collection, treatment, and disposal of waste. This need is more urgent in the case of smaller fishing harbours and marinas, where even greater problems exist.

42. Equally low are the figures for marine litter relating to "*dumping activities and medical/personal hygiene"*, which make up 2% and 1% of all marine litter in the Mediterranean respectively. From the above evidence, it is clear that marine litter from shoreline and recreational activities and from smoking related activities are two areas for priority action by regional policies or awareness raising campaigns in the Mediterranean.

43. Marine litter from shoreline and recreational activities has its root cause in the fact that the situation of solid waste management in most Mediterranean countries is still very poor. Funding, awareness, participation of individuals, and good practices are insufficient in this area. Currently, both legal and illegal waste handling practices contribute to the presence of marine litter. The inadvertent release of litter from coastal landfills and garbage from water transports, recreational beach and roadside litter, and the illegal dumping of domestic and industrial garbage into coastal and marine waters are practices contributing to the marine litter problem.

44. Tourism needs a clean environment. Therefore, the efficient handling of solid waste is a key issue in the planning of tourism zones and in the requirements/regulations by governments to the tourism developers. With globalisation shifting power away from governments and into the hands of the private sector, there are bound to be negative effects on the environment despite the benefits from this trend.

45. Marine litter from shoreline and recreational activities is highly connected to tourism. Due to the region’s natural and cultural resources, desirable climate, and location close to key markets, the Mediterranean Sea is one of the biggest tourist regions in the world. Many of the tourist destinations are concentrated along the coast with summer as the most popular season, and have a heavy dependence on the marine environment. Tourist revenue is of significant socio-economic importance for the coastal regions and is an important growth sector for the Mediterranean partner countries. In 2010, 50 million tourists visited the region, up from 38.5 million in 2006. For the last two decades, the countries of the Southern and Eastern Mediterranean have recorded the highest growth rates in inbound world tourism (9% annual growth). At the same time, domestic tourism in these countries also grew progressively. The economic performance of tourism in the region has been surprising, given the security risks, natural disasters, oil price rises, and politic or economic uncertainties in the region.

46. Table 2.1.1c shows the tourism development over the last five years, between 2006 and 2010, for the Southern and Eastern Mediterranean countries belonging to the Facility for Euro-Mediterranean Investment and Partnership (FEMIP). Despite political unrest in some of the Partner Countries, the total annual average growth rate in 2006 was 12%, doubling the world average as measured in terms of tourist arrivals and tourist expenditure

Table 2.1.1c: Tourist arrivals and tourist expenditures in southern/eastern Mediterranean countries from 2006 to 2010

	2006		2010		2006-2010
Country	Tourists arrival	Tourist expenditure	Tourists arrival	Tourist expenditure	Annual growth
Algeria	1,4	0,1	1,9	0,2	8,9
Egypt	9,1	5,3	14	11,4	13,5
Gaza(1)	ND	ND	0,52	0,3	ND
Israel	1,8	1,4	2,8	3,8	13,8
Lebanon	1,1	ND	2,1	2,3	22,7
Morocco	6,6	4,8	9,3	5,9	10,2
Syria	8	1,7	8,5	2,2	1,6
Tunisia	6,6	1,6	6,9	2,7	1,4

Source: (*http://www.eib.org/infocentre/publications/all/femip-for-the-mediterranean-promoting-tourism-development.htm?lang=fr). (1) Data from west bank*

47. At the basin level, tourist arrivals have been increased from 175 million to 306 million between 1995 and 2011(table 2.1.1d).

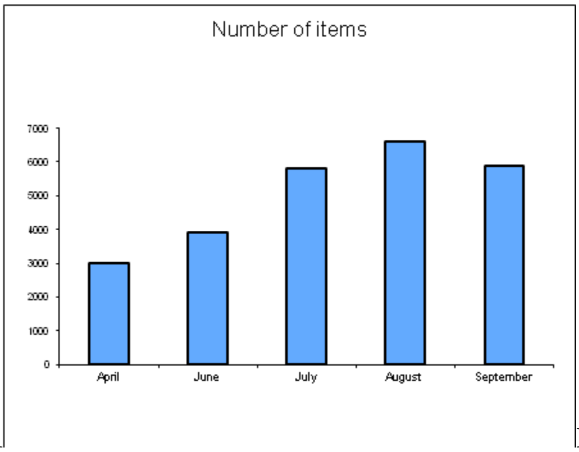
Table 2.1.1d: Tourism related activity in the Mediterranean Sea (source http://www2.unwto.org/)

Activity	1995	1998	2001	2004	2007	2011
Tourists arrivals	175	205	235	251	292	306
Tourist expenditure	87	116	155	162	186	190

48. Many studies dedicated to the local beaches surveys and litter collection provide information on litter and tourism. During summer season, the populations of seaside towns are sometimes double what they are in wintertime. In some tourist areas, more than 75% of the annual waste production is generated in summer season. According to statistics from holiday destinations in the Mediterranean (Bibione/Italy and Kos/Greece), tourists generate an average of 10% to 15% more waste than inhabitants. In the example of Kos Island, the tourism period is from April to October, with 70% of the total annual waste produced during this period (UNEP 2011).

49. Malta, where over 20% of the Global Net Production is generated from tourism, realized an increase of packaging (37% of municipal solid waste) in 2004 and introduced “bring-in sites” with 400 stations installed by 2006 (State of the Environment Report Malta, 2005, in UNEP 2011). Unfortunately, no new data regarding the results of the introduction is yet available, and the latest report from 2005 still shows an increasing waste production per capita and tourism.

50. Research funded by the Balearic Government in 2005 (Martinez-Ribes *et al.*, 2007) focused on the origin and abundance of beach debris in the Balearic Islands, including Mallorca, Menorca, and Ibiza, which are all main tourist destinations. This fundamental study shows similarities to other tourism areas and is therefore very helpful regarding the sources of littering, which are highly connected to tourism. Litter found in summertime is twice as much as in winter (Figure 2.1.1e).

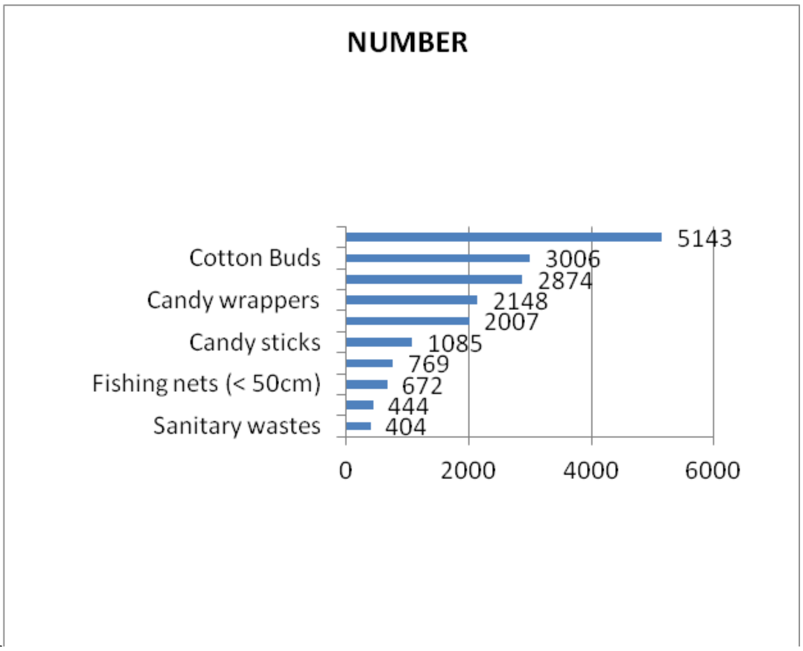
A 

B 

Figure 2.1.1e: Monthly variation of debris items (A) and percentage of hotel occupation for the corresponding date (B) in the Balearic Islands (Source Martinez-Ribes et al., 2007).

51. In another example, Israel achieved good results with their pollution abatement Clean Coast Index, involving Municipalities and NGOs in beach clean-ups (Ministry of Environmental Protection, 2008). Although there is no data about the types and quantities of litter pollution in the coastal areas, the published index shows a 30% reduction of littered beaches. Raising public awareness with leaflets and competitions in tourism and public areas supported the strategy, and the ongoing efforts will be continued on a yearly basis to continue to tackle the litter problem on the shorelines of Israel.

52. Finally, data from a monitoring experiment on a sample of 52 beaches in France (Mer-terre.org, figure 2.1.1f) confirmed the existance of tourism and fishing related activities as main sources of litter.

A 

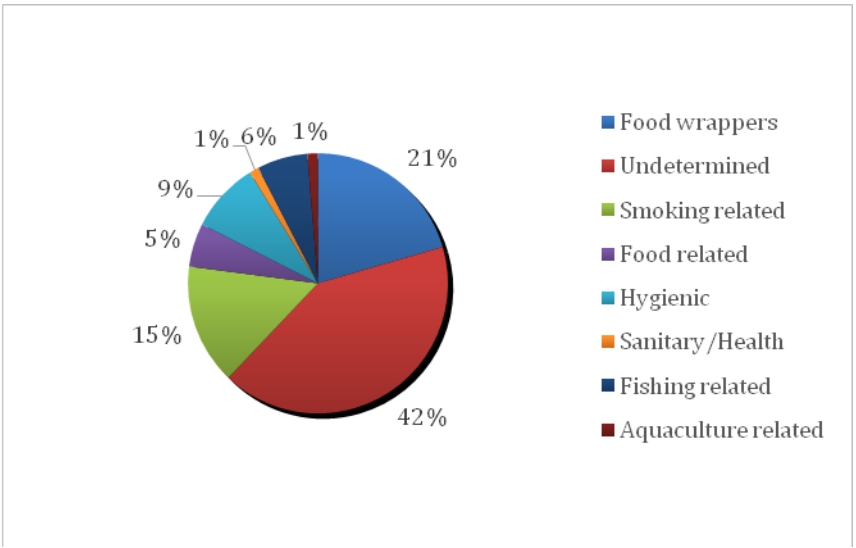


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Figure 2.1.1f: Tops ten items (A) and main sources of litter (B) collected on 52 beaches samples around Marseille between 2008 and 2014 (Source Mer-terre.org)

2.1.2 Circulation

53. Circulation is the primary driver of marine litter transport. Currents are responsible for the advection of items of every size at all depths, as a function of their composition and specific weight (zambianchi *et al.*, in CIESM, 2014). This is also true for litter that is less dense than seawater and floats at the surface, thus easily accumulateing in convergent regions. The role of currents, however, may be quite complex. The possible chaotic characteristics of even two dimensional time-dependent flows makes transport difficult to predict and causes a number of non-trivial Lagrangian behaviour expressions, resulting in the formation of attractive and repulsive features of coastal and offshore flow fields. Models are however crucial for assessing budgets of marine litter at large scale.

54. The main large oceanic aggregation patterns (‘‘garbage patches’’) are characterised by high densities areas of marine debris that are now quite well described and identified (Lebreton *et al.*, 2012;) with accumulation structures in most of the main oceanic basins directly correlated to the anticyclonic wind force and its associated Ekman transport. At a finer scale, regional seas have also been under investigation. Semi-enclosed seas that are surrounded by developed areas, such as the Mediterranean Sea, are likely to have particularly high concentration of marine debris (Barnes and Milner, 2005; Galgani *et al.*, 2014). There, studies have already documented the beaching of litter, its transport on the surface (Aliani *et al.*, 2003, Mansui *et al.*, 2014), and its accumulation on the sea floor (Galgani *et al.*, 1995 a and 1996; Galil *et al.*, 1995; Pham *et al.*, 2014; Ramirez-Llodra *et al.*, 2013).

55. Three dimensional models simulating the circulation in the Mediterranean Sea are presently available to the scientific community, even in an operational (predictive) mode. They are getting more and more accurate thanks to the ever increasing abundance of in situ data and the development of sophisticated assimilation techniques for such data. An effort to better understand local wind-induced effects on floating material, windage, and Stokes’ drift is still needed however, as are dedicated investigations on the possible functioning, role, and parametrization of sub mesoscale structures, both in a two-dimensional and a three-dimensional perspective. Coastal related input and stranding processes also need to be investigated. For this, coastal studies may require the development or refinement and focusing of regional models, characterized by higher spatial and temporal resolutions.

56. The Mediterranean situation appears particularly delicate regarding the possible accumulation of floating plastics, since the basin is characterized by a net inflow of surface waters of

Atlantic origin through the Strait of Gibraltar, with no outflow possibility for items less dense than seawater anywhere. In addition to this, floating items flowing from the Suez Canal must not be overlooked, in particular for the possibility of litter representing a vector for invasive species.

57. The existing numerical simulations enable to picture possible scenarios of accumulation and to quantify likely coastal impacts of floating marine debris.

58. In the Mediterranean, the variability of the surface circulation is very high as the basin has many constraints. No global data set exists on surface marine debris and real world simulation must consider anthropogenic sources, such as harbours, highly populated coastal cities, river outflows for the inland sources, and large cargo and passenger ships routes as well as tourism seasonal variability at sea. Nevertheless, some scenarios could be hypothesised to evaluate a realistic distribution through simulations based on homogeneous and continuous deployment of litter (Figure 2.1.2.a). Only few large sub-basins appear as possible retention areas, namely the north-western Mediterranean and the Tyrrhenian sub-basins, the southern Adriatic, and the Gulf of Syrt (Poullain *et al.*, 2012; Mansui *et al.*, 2014). These regions lose their retention character for longer duration journeys however, because no permanent gyres, lasting longer than a few months, are occurring in the Mediterranean and because seasonal and inter-annual variability alter the water movements and the distribution of litter.

59. Some of the specific gyres in the western basin could retain and export floating objects and redistribute them after a shift in the large scale circulation. If the western Mediterranean coasts presents a very low impact, the southern coastal strip of the eastern Mediterranean basin seems to be a prefered beaching destination, where debris stagnating along the Tunisian and Libyan coasts could come to rest from the open sea accumulation region in the Gulf of Syrt (Erikssen *et al.*, 2014; Mansui *et al.*, 2014). As a counterpart, the Levantine sub-basin appears more as a local and potential source of debris for its coast (Mansui *et al.*, 2014).

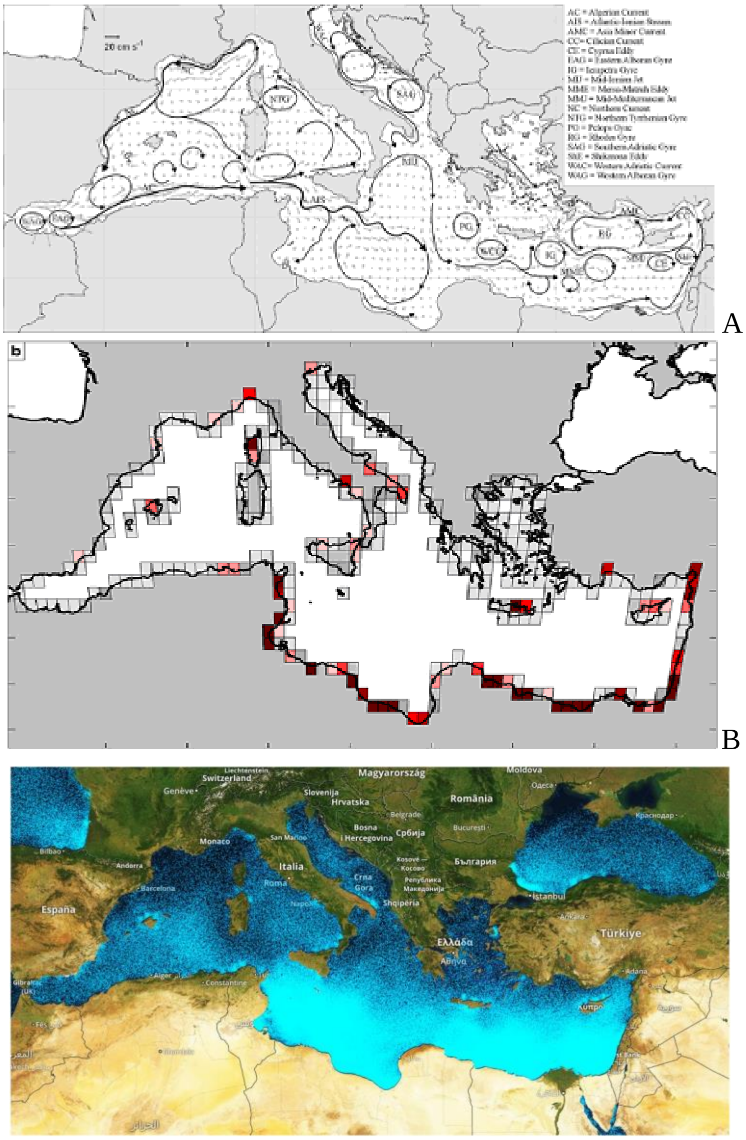


Figure 2.1.2a: General predictive scheme of (A) the surface water circulation the Mediterranean Sea (data from drifters, Poullain et al., 2012), (B) litter stranding on Mediterranean Beaches (Mansui et al., 2014) and floating plastic particles (Erikssen et al., 2014)

2.1.3 Typology of marine litter in the Mediterranean

60. Marine litter in the Mediterranean includes a wide variety of substances also encountered in other marine and coastal areas of the world. Based on data provided by the Ocean Conservancy and processed and analyzed by HELMEPA from beach clean-ups in Mediterranean countries within the framework of the ICC campaign, the main types of litter found on Mediterranean beaches, floating on the sea surface, or lying on the seabed are listed in Table 2.1.3 a and table 2.1.3b hereunder.

Table 2.1.3a: Main types of marine litter in the Mediterranean (ICC after UNEP, 2011)

Plastics: bags, balloons, beverage bottles, caps/lids, food wrappers/ containers, six-pack holders, straws/stirrers, sheeting/tarps, tobacco packaging and lighters
Glass: beverage bottles, light bulbs
Paper and cardboard of all types
Metals: aluminium beverage cans, pull tabs, oil drums, aerosol containers, tin cans, scrap, household appliances, car parts
Polystyrene: cups/plates/cutlery, packaging, buoys
Cloth: clothing, furniture, shoes
Rubber: gloves, boots/soles, tires
Fishing related waste: abandoned/lost fishing nets/line and other gear
Munitions: shotgun shells/wadding
Wood: construction timber, crates and pallets, furniture, fragments of all the previous
Cigarette filters and cigar tips
Sanitary or sewage related litter: condoms, diapers, syringes, tampons
Other: rope, toys, strapping bands

Table 2.1.3b: Top ten items in the Mediterranean Sea (International Coastal Clean-up, ICC, 2014). Total number is the number of items collected on 59.2 miles of beaches from 8 different countries.

	cigarette butts	**food wrappers**	**plastic bottles**	**caps**	**straws/ stirrers**	**Grocery bags (plast.)**	**glass bottles**	**other plastic bags**	**paper bags**	**cans**
Total collected number	98117	6796	11295	16490	24724	6350	3443	4706	2436	6405
number /100m	175	12	20	29	44	11	6	8	4	11

61. By far the No. 1 type of marine litter in the Mediterranean is cigarette filters (closely followed by cigar tips), which constitute a real menace to the region and can be found even in the most remote coastal areas. Thus, 4858 volunteers collected 95641 cigarette filters in 2013, which corresponds to almost 19.6 cigarette filters per volunteer, while the global average in 2006 was only 3.66 cigarette filters per volunteer. The degradation time for each type of litter is an important factor, as some may degrade fast, in the range of months or years, indicating more concern.
62. Four categories of items seem to be most prominent on the beaches in the northern part of the Mediterranean (Table 2.1.3c):
63. Items found indicate a predominance of land-based litter, stemming mostly from recreational/tourism activities (40% in ARCADIS, 2014, >50% in Öko-Institut, 2012 and Ocean Conservancy/ICC 2002-2006).
64. Household-related waste, including sanitary waste, is also of great relevance (40% in ARCADIS 2014); the amount of litter originating from recreational/tourism activities greatly increases during and after the tourism season.
65. Smoking-related wastes in general seems to be a significant problem in the Mediterranean, as several surveys suggest (UNEP 2009).
66. Also, the fishing industry is of significance (UNEP, 2013), as well as shipping (the latter especially off the African coast).

Table 2.1.3c: Composition/ sources of marine litter in the Mediterranean (After Interwies et al., 2013)

Source (Literature)	Items/Consistency (beaches; top five)	Type of material	Sources
ARCADIS 2014)	- Cotton bud sticks - Plastic/polystyrene pieces - Crisp/sweets/chips - Other sanitary items - Charcoal (201 items) Ports: 1: Crisp/sweets packets and lolly sticks 2: cigarette butts 3: cotton bud sticks	Beaches: Plastics: 50% by volume: 80% (Barcelona Provincial Government, cited in ARCADIS) Ports: 29% plastics, 22% wood, 21% organic matter	Recreational & tourism:40% Households(combined):40% Coastal tourism: 32,3% Toilet/sanitary: 26,2% household: 11,2% Waste collection: 6% Recreational: 5,6%
Öko-Institut (2012; figures mainly from UNEP 2009)	-Cigarette butts: 29,1% - Caps/lids: 6,7% - Beverage cans: 6,3% - Beverage bottles (glass): 5,5% - Cigarette lighters: 5,2%	Beaches: 37-80% plastics Floating: 60-83% plastics Sea-floor: 36-90% plastics	Recreational/shoreline activities: >50%, Increase in tourism season
UNEP/MAP (cited in ARCADIS 2014)	-Cigarette butts/filters: 27% -Cigar Tips: 10% -Plastic bottles: 9,8% Plastic -bags: 8,5% - Aluminum cans: 7,6%	Floating: 83% plastics	
Ocean Conservancy/ICC 2002-2006			Beach litter: recreational activities: 52% Smoking-related activities: 40% waterways activities: 5%
JRC IES (2011)		Beach:83% plastics/polystyrene	

67. In a project along the Coasts of El-Mina and Tripoli/Lebanon, ***t***en fishermen were selected to collect all marine litter caught in their nets on a daily basis, store them in plastic bags and record date, name of the fishing vessel and the location of fishing activities. Marine litter was divided in six categories:

1. Cloth;
2. Fishing material;
3. Glass;
4. Metal;
5. Paper; and
6. Plastic

68. Volumes were estimated, data was entered and processed in a specially designed Geographical Information System, percentages were calculated, and maps identifying the location of marine litter were generated. All six categories were present in the waters of El-Mina/Tripoli in the following percentages: 1) Cloth: 1.74%; 2) Fishing material: 1.74%; 3) Glass: 1.16%; 4) Metal: 16.81%; 5) Paper: 0.87%; and 6) Plastic: 77.68%. Litter was mostly found in areas of high anthropological stress, mainly at the mouth of the Abou Ali River, the fishing and commercial ports, the conglomeration of rocks off the El-Mina headland, and around the Palm

Island Reserve. The results revealed the influence of human activities and river inputs. Temporal trends indicated the presence of plastic and metal over the whole period of collection, while all other categories were collected sporadically. This passive method for monitoring marine litter at minimal costs has been validated and can be applied to other areas around the Mediterranean. Analysis of the data also revealed that the presence of the different litter categories occurred at different frequencies according to the month of sampling. Plastic and metal were present over the five month period while the other litter categories occurred in some months and not others. The lowest percentages were recorded in the month of October, coinciding with the end of the tourism season and dry weather. August and September experience high tourism activities, while the first rains start at the end of October and intensify in November and December. This might explain the difference in percent waste collected during the five month period. *(Source: Marine Resources & Coastal Zone Management Program, 2005)*

69. On the sea floor, compilation of data from 16 studies covering the entire basin of the Mediterranean Sea (see chapter 2.2.4) confirmed the importance of plastic, at 62.7 % +/- 5.47 of total debris. This was also confirmed by an analysis of data from regular monitoring of litter on the sea floor in the gulf of Lion (figure 2.1.3a)

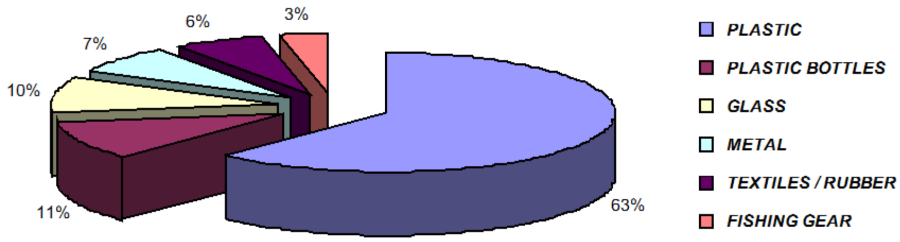
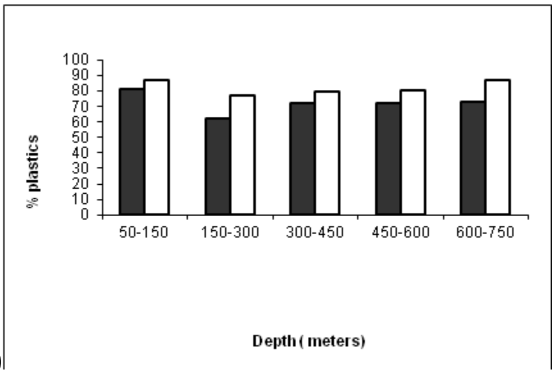


Figure 2.1.3a: Typology of debris collected between 30 and 800m in the Gulf of Lion, France (MEDITS cruises, average from 70 stations/year and 15 years monitoring, 1994-2009, Galgani et al., 2011)

70. Analysis of litter density from trawl surveys revealed plastic to be the most common litter recovered (found in 98% of the trawls, Ramirez lodrat *et al.*, 2013). This high percentage of plastic is not related to the depth when considering sandy bottoms. Analysis of data from 2011 (Gulf of Lion, Galgani *et al.* unpublished) and 2013 (Guven *et al.*, 2013) demonstrated the constant percentage of plastics between 50 and 750 m (figure 2.1.3b). This pattern is somewhat different when considering rocky slopes, where the important losses of fishing gears account for an important part of debris in upper part of canyons, thus decreasing the percentage of plastics. An analysis of data from surveys led by various European laboratories between 1999 and 2011 (Pham *et al.*, 2014) showed that in canyons, plastic was the dominant litter items (50%) followed by fishing gear (25%), On slopes, the dominant litter items recovered was fishing gear (59%), followed by plastic (31%).

(A) 

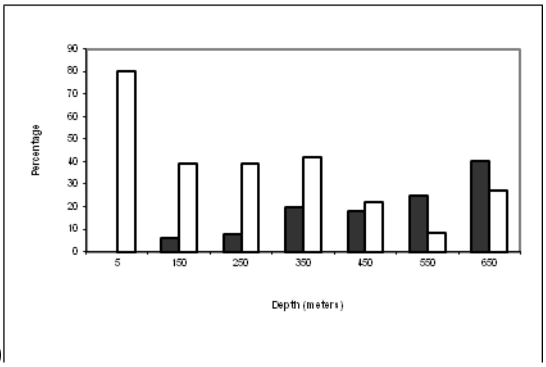
(B) 

Figure 2.1.3b: (A) Percentage of plastics in litter collected by trawling at different depths in the gulf of Lion (black bars, 2011, 69 tows, Galgani et al, original data) and south east Turkey (white bars, 2013, 38 tows, Guven et al., 2013) and (B) percentages of plastics (black bars) and fishing gears (white bars) of debris observed on rocky slopes of 18 canyons off the French Mediterranean coasts (101 ROV dives in 2009, 700-800m, Fabri et al.,2014).

71. Deep analysis finally detected that the “Distance to the coast“ variable accounted for less than 20% of the variance in the distribution of litter between canyons (Fabri *et al.*, 2014). In the Maltese Islands (Misfud *et al.*, 2012), litter was found to be significantly positively correlated to mean wave height, mean wave energy density, and distance to the nearest shore. Plastic, the main litter constituent, showed the same correlation patterns, as well as depth and distance to the nearest bunkering area. Glass was positively correlated to all of the different fishing activities considered.

72. In some areas, fishing gears may account for the largest part of debris, depending on fishing activity. As an example (Figure 2.1.3c), a quantitative assessment of debris present in the deep seafloor (30–300 m depth) was carried out in 26 areas off the coast of three Italian regions in the Tyrrhenian Sea, using a Remotely Operated Vehicle (ROV). The dominant type of debris (89%) consisted of fishing gear, mainly lines, while plastic objects were recorded only occasionally. Abundant quantities of gear were found on rocky banks in Sicily and Campania (0.09–0.12 debris/m^2), proving intense fishing activity.

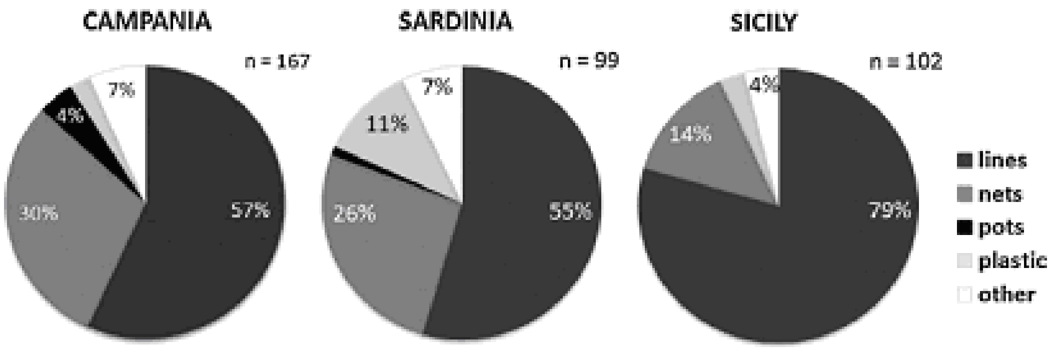


Figure 2.1.3c: Frequency of occurrence of marine debris items found in each region by debris category. ‘‘n’’ refers to the total number of debris items recorded in each region (Angiolillo et al., 2015, in press)

73. Finally, analysis of the composition of floating litter, including considerably large debris and small fragments measuring less than 2.5 cm referred as mesoparticles and microparticles, demonstrates again the prevalence of plastic (accounting for more than 95%, sometimes up to

100%). This is mainly because the density of many synthetic polymers, such as polyethylene and polypropylene, allows them to float at the surface, while most heavier materials, such as metals and glass, sink unless they are closed (drums, bottles, etc.).

2.1.4 Degradation of marine litter at sea

74. Studies have shown that debris found in oceans is dominated by plastics. They are made by bonding low molecular weight molecules called monomers (ethylene, propylene, etc.) in different chemical reactions to make high molecular weight compounds known as synthetic polymers (polyethylene, polypropylene, etc.) or by modifying high molecular natural materials. These materials are usually mixed with some other chemicals or additives in order to obtain the desired properties for a product. These include plasticisers, adhesives, flame retardants and pigments.

75. It may take centuries for physical, chemical and biological processes to degrade plastics to secondary microplastics (OSPAR, 2015) in the oceans. Table 2.1.4a below provides an indication of the necessary time for the decomposition of various litter items in the marine environment. It is worth noting that, unbeknownst to the majority of the public, it may take between 1-5 years for a cigarette filter to decompose in the marine environment. The slow decomposition of cigarette filters is mainly due to contained substances such as foamed plastic and chemicals, which may also cause serious health problems to marine fauna and flora (UNEP, 2011). Moreover, litter on the sea floor may persist for longer periods due to lower bacterial degradation rates in the dark and lower concentrations of oxygen.

Table 2.1.4a: How long it take for marine litter to decompose?

Item	Degradation time
Glass bottle	1 million years
fishing line	600 years
plastic bottle	450 years
aluminium can	80-200 years
rubber boot sole	50-80 years
plastic cup	50 years
tin can	50 years
nylon fabric	30-40 years
plastic bag	10-20 years
cigarette filter	1-5 years
woollen clothes	1-5 years
Plywood	1-3 years
Cartboard	3 months
apple core	2 months
Newspaper	6 weeks
orange peel	2-5 weeks
paper towel	2-4 weeks

Source: The Ocean Conservancy

76. As persistence is a key characteristic of plastics at sea, improving our knowledge on degradation processes will need to consider many aspects such as abrasion (mechanical), photo degradation, and thermal, chemical and biological degradation. With respect to the last point, it is important to not only consider the species and metabolic pathways involved, but also the entire process (attachment and biofilm formation, bio-deterioration, bio-fragmentation, bio-assimilation and bio-mineralisation). To date, the little data available on the evaluation of degradation is related to laboratory studies. Surface properties such as surface functional groups, surface topography, point of zero charge, and color change are

important factors that may vary during degradation with changes in surface properties that may explain interaction between plastics, microbes, and pollutants. However, Standardized tests are still needed, and most of the knowledge on plastic degradation processes uses culture-based approaches for biodegradation studies.

77. One of the serious hypotheses regarding the degradation of "missing" plastic at sea is that the fragmentation processes may finally lead to sub micrometric fragments, defined as nanoplastics, which could not be detected and monitored so far. Little is known about the true extent of the damage caused by these nanoplastics, but they may have much greater impacts than microplastics on the marine ecosystem because of their very special physico-chemical properties (high surface to volume ratio, slow rate of sedimentation or flotation, size close to membrane permeability) and their potential to be directly ingested by the smallest marine species and pass more easily through biological membranes. There is, however, a lack of validated research methodologies and data on environmental concentrations and impacts.

2.2. Distribution of Marine Litter in the Mediterranean (Regional, National, Local)

2.2.1 Beaches Regional surveys

78. Strandline surveys, cleaning, and regular surveys at sea are gradually being organized in many Mediterranean countries for the aim of providing information on temporal and spatial distribution. Various strategies based on the measurement of quantities or fluxes have been adopted for data collection purposes. However, most surveys are conducted by NGOs with a focus on cleaning. Moreover, small fragments measuring less than 2.5 cm, also referred to as mesodebris (versus macro debris), are often buried and may not be targeted by clean-up campaigns or monitoring surveys. Stranding fluxes are therefore difficult to assess, and a decrease in litter amounts at sea will only serve to slow stranding rates. They can comprise a large proportion of the debris found on beaches and very high densities have been found in some areas.

79. Standing stock evaluations of beach litter reflect the long-term balance between inputs, land-based sources or stranding, and outputs from export, burial, degradation and clean-ups. Recording the rate at which litter accumulates on beaches through regular surveys is currently the most commonly-used approach for assessing long-term accumulation patterns and cycles. The majority of studies performed to date have demonstrated densities in the 1 item/m2 range (Table 2.2.6) but show a high variability in the density of litter depending the use or characteristics of each beach. Plastic accounts for a large proportion of the litter found on beaches in many areas, although other specific types of plastic are widely-found in certain areas, according to type (Styrofoam, etc.) or use (fishing gear). For ICC (Table 2.2.2a), cigarette butts, plastic bags, fishing equipment, and food and beverage packaging are the most commonly-found items, accounting for over 80% of litter stranded on beaches.

Table 2.2.1a: Top ten items by country (International Coastal Clean-up, ICC 2014) expressed as number of items/100m of beach

	Number of items per 100 m									
COUNTRY	Cigarette butts	Food wrappers	Beverage bottles (plastic)	Bottle caps (plastic)	Straws Stirrers	Grocery bags (plastic)	Beverage bottles (glass)	Other plastic bags	Paper bags	Beverage cans
Croatia	1540	97	21	86	0	83	34	74	36	22
Egypt	1	2	40	18	1	15	33	6	0	6
Greece	116	6	11	15	13	4	3	3	2	5
Italy	0	0	2	0	0	4	14	0	0	7
Malta	0	15	22	40	13	0	7	3	0	0
Slovenia	21	5	3	6	6	1	1	2	0	2
Spain	79	9	15	23	57	13	5	9	4	8
Turkey	785	14	29	73	22	26	18	4	4	26

80. National Case Studies may provide more detailed information on local constraints and effective factors on the distribution of litter. It is important to note, however, that volunteer groups should be informed about the necessity to submit standardized research data for statistical purposes. Clean up actions by NGOs are usually organized to raise awareness and not so much for data collection, and cleanup programmes should increase public knowledge of the scientific relevance of information and information sharing.

81. Public participation in the cleaning campaigns is strong in the Mediterranean Sea. However, it is not constant; for example, there was a 50% decrease of volunteers between 2002 and 2007 (15,648 volunteers participating in 2002, 7,305 in 2006) and 70% between 2002 and 2013 (4830 volunteers in 2013). This may be interpreted as (i) a decrease in the environmental awareness and/or volunteer spirit of coastal inhabitants in the Mediterranean, (ii) a shift of focus of the general public's attention to other current environmental concerns such as global warming, and/or (iii) a reduced impact of environmental NGOs' action in the region. Due to this number of changing variables every year, it is difficult to draw conclusions regarding the overall increase or decrease of marine litter in the Mediterranean during the period under study. However, interesting observations have been made on the proliferation of lighter marine litter items in the Mediterranean (plastics, aluminum and smoking-related litter), as opposed to heavier items from basic use (bottles, cans, see figure 2.2.1a) or litter from dumping activities (household appliances, construction materials, tires, etc.) This could be related to the efficiency of preventive action (easier collection, recycling, adoption and/or implementation of stricter legislation with regards to dumping activities, etc.) for larger items and the difficulty to manage inputs from sources such as the general public.

82. Environmental awareness is also observed when this general public, conscious of the impact of their actions, do not use beaches as disposal sites for heavy garbage items as lightheartedly as they did in the past. The removal of these heavier items, combined with the persistent nature of plastics and other lighter marine litter items that can still be found in considerable numbers in the Mediterranean, has led to the changing nature of marine litter in the region.

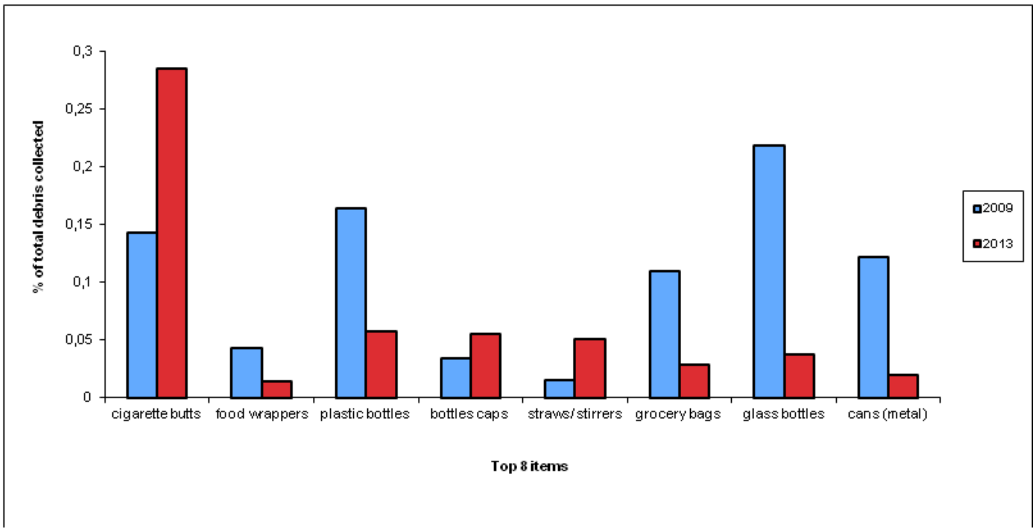
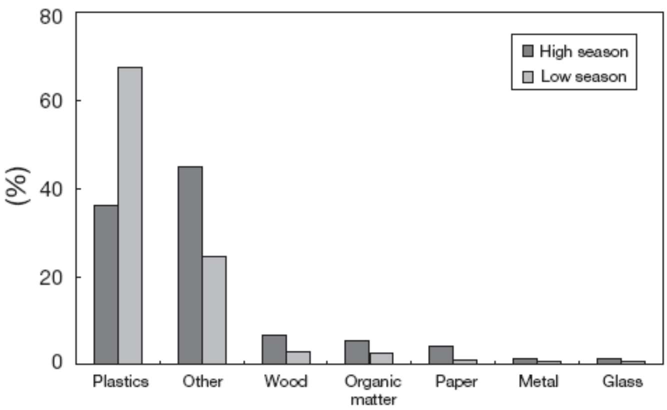


Figure 2.2.1a: Changes in percentages of the top 8 items in the Mediterranean Sea between 2009 and 2013. Data from Ocean Coastal Cleanup on types of debris of 303522 items and 110698 items collected in 2009 and 2013 respectively on beaches from Greece, Turkey, Egypt and Spain (data from http://www.oceanconservancy.org/)

83. Data from *Clean up Greece* between 2004 and 2008 indicated however the importance plastic and paper abandoned and wind born on island beaches. On isolated beaches, other visible and larger sized litter items (metal, rubber, glass, and textile) have increased due to illegal dumping. The abundance, nature, and possible sources of litter on 32 beaches on the Balearic Islands (Mediterranean Sea) were investigated in 2005 (Figure 2.2.1b). Mean summer abundance in the Balearics reached approximately 36 items per linear meter, with a corresponding weight of 32±25 g per m^{-1}, which is comparable to the results of other studies in the Mediterranean. Strong similarities between islands and a statistically significant seasonal evolution of litter composition and abundance were demonstrated. In summer (the high tourist season), debris contamination was double that in the low season and showed a heterogeneous nature associated with beach use. Again, cigarette butts were the most abundant item, accounting for up to 46% of the objects observed in the high tourist season. In contrast, plastics related to personal hygiene/medical items were predominant in wintertime (67%) and natural wood was the most important debris by weight (75%). In both seasons, litter characteristics suggested a strong relationship with local land-based origins. While beach users were the main source of summer debris, low tourist season litter was primarily attributed to drainage and outfall systems.



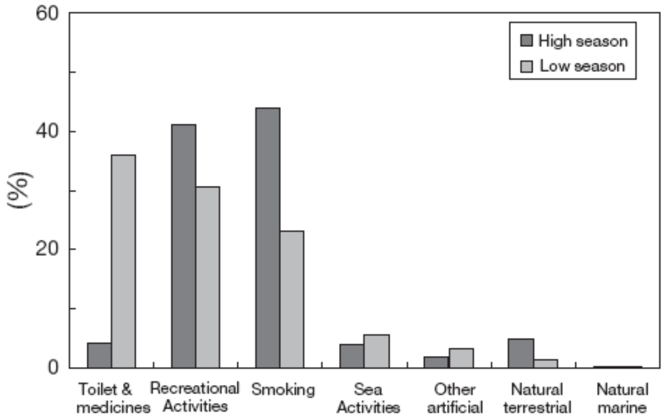


Figure 2.2.1b: Litter composition (A) and estimated origin (B) of the litter collected in low and high tourist season in Balearic Islands (source Martinez-ribes et al., 2007)

84. Finally, more recent data obtained within the Defishgear project (under press, See Table 2.2.6) indicated densities ranging from 0.715 items/m2 (range: 0.03 – 6.38) In Ionian Sea/South Adriatic Sea to 1.139 items/m2 (0.771 – 1.507) in North Western Adriatic.

2.2.2. Floating Litter on the surface of the Mediterranean Sea

85. Floating debris comprises the mobile fraction of debris in the marine environment, as it is less dense than seawater. However, the buoyancy and density of plastics may change during their stay in the sea due to weathering and biofouling (Barnes *et al.*, 2009). Polymers comprise the majority of floating marine debris, with figures reaching up to 100%. Although synthetic polymers are resistant to biological or chemical degradation processes, they can be physically degraded into smaller fragments and hence turn into micro litter, measuring less than 5 mm.

86. They can also be transported by currents until they sink to the sea floor, are deposited on the shore, or are degraded over time. A 30-year circulation model using various input scenarios showed the accumulation of floating debris in ocean gyres and closed seas, such as the Mediterranean Sea, made up 7-8% of the total debris expected to accumulate (Lebreton *et al.*, 2012).

87. Visual assessment approaches include the use of research vessels, marine mammal surveys, commercial shipping carriers, and dedicated litter observations. Aerial surveys are now being employed for larger items. Although the basic principle of floating debris monitoring through visual observation is very simple, particularly for beaches, there are few datasets available for the comparable assessment of debris abundance, and monitoring is only performed occasionally (Table 2.2.6). Only a few studies have been published on the abundance of floating macro and mega debris in Mediterranean waters (Aliani *et al.*, 2003; UNEP, 2009; Topcu *et al.*, 2010, Gerigny *et al.*, 2011, Suaria and Aliani, 2015), and the reported quantities measuring over 2 cm range from 0 to over 600 items per square kilometer. The Mediterranean Sea is often referred to as one of the places with the highest concentrations of litter in the world. For floating litter, very high levels of plastic pollution are found, but densities are generally comparable to those being reported from many coastal areas worldwide. In the Ligurian Sea, data was collected through ship-based visual observations in 1997 and 2000. 15-25 items/km² were found in 1997, which decreased to 1.5-3 items in 2000 (Aliani *et al.*, 2003).

88. Data may also be obtained from NGOs. HELMEPA, a Greek organisation of maritime stakeholders, invited its member managing companies with ships traveling in or transiting the Mediterranean to implement a programme for the monitoring and recording of litter floating on the sea surface. During the period February – April 2008, 14 reports were received by HELMEPA member-vessels containing information on litter observations from various sea

areas in the Mediterranean. In total, observations of 1,051.8 nautical miles (n.m.) of Mediterranean Sea resulted in the recording of 500.8 Kg of marine litter (Table 2.2.2a).

89. The total length of observation for floating marine litter carried out by HELMEPA member vessels was 1,051.8 nautical miles (1,947 kilometers), corresponding to an observation area of around 172.8 km^2. The width of observation depended on the weather conditions, the sea state, the position of the Observer, the use of binoculars, the freeboard and volume of marine litter, etc., and generally fluctuated between 22 and 150 meters. Observations were carried out mainly in the eastern Mediterranean (Aegean Sea, Libyan Sea and Eastern Mediterranean Levantine Sea), in the Alboran Sea between Spain and Morocco, and in the Adriatic Sea. The total of marine litter recorded was 366 items, corresponding to a concentration of one item per 3 n.m., or 2.1 items per km^2. The concentration of marine litter ranged from 0.08 to 71 items/nm. Relatively higher concentrations of marine litter were observed along routes close to coastal areas, while there were cases in which lengthy observations (more than 120 nm) revealed no existence of marine litter. Plastics accounted for about 83.0% of marine litter items, while all other major categories accounted for about 17%, as the following graph shows. Based on weight extrapolations, the average quantity of marine litter was estimated to be 230.8 kg/km2 ranging from 0.002 to 2,627.0 kg/km2. Relatively heavy items such as steel drums, wooden pallets, and crates observed on the sea surface were responsible for the majority of marine litter in certain routes. In terms of the length of observation, the average weight was 0.47 kg/n.m.

Table 2.2.2a: Marine Litter Survey by HELMEPA Member Vessels: Number of floating litter items collected in 2008 along a sampling area of 172.8 km^2

Sea area surveyed	Fishing Nets	Wooden Pallets	Plastic Packaging	Ropes	Plastic Bags	Clothing	Steel Drums	Wooden trace	Buoys	Paperboard boxes	Plastic bottles	Plastic containers
Mytilene sea (Northeastern Mediterranean)			**50**			**6**			**5**		**10**	
Saronikos Gulf (off Athens)			**25**		**30**						**8**	**4**
Mirtoon Sea (South Aegean)								**1**				
Off South Cyprus	**6**								**8**			**2**
East coast of Crete												**1**
Myrtoon Sea (South Aegean)	**3**											**2**
West Mediterranean		**2**	**3**	**1**	**10**		**1**		**8**			
Off Algeria				**5**					**6**			
Gibraltar					**30**							
Off Egypt	**3**	**2**			**1**		**1**		**3**			
Adriatic Sea					**9**	**6**			**5**	**12**	**9**	**6**
South Crete		**2**					**3**	**12**			**4**	

90. HELMEPA also provided data on the volume of marine litter recovered from the sea surface of the port of Piraeus for a two-year period (2006-2007), which it then processed and analyzed. The daily collection of floating debris from the port sea area (including the passenger and container port) was carried out by specialized skimmer vessels and/or manually from auxiliary boats. The volume of marine litter fluctuated from 1.47 m^3 per day to 3.46 m^3 per day, while the average volume was estimated to be 1.89 m^3 per day. During the summer season when the operation of the passenger port is extremely high (*it should be noted that Piraeus is the largest port in Europe and the third largest in the world in terms of passenger transportation, servicing 19,000,000 passengers annually*), the volume of marine litter is significantly higher, reaching an average of 2.96 m^3 per day. Although quantitative information regarding the origin of the debris does not exist, it appears that domestic garbage from passengers and litter ending up in the sea via urban sewers are the prevailing categories.

91. Debris was also quantified during marine mammal observation cruises in the northern western basin Mediterranean Sea in a 100 x 200 km offshore area between Marseille and Nice and in the Corsican channel. A maximum density of 55 items/km² was found, with a clearly discernible spatial variability relating to residual circulation and a Liguro-Provencal current vein routing debris to the West (Gerigny *et al.*, 2012 and Figure 2.2.2a).

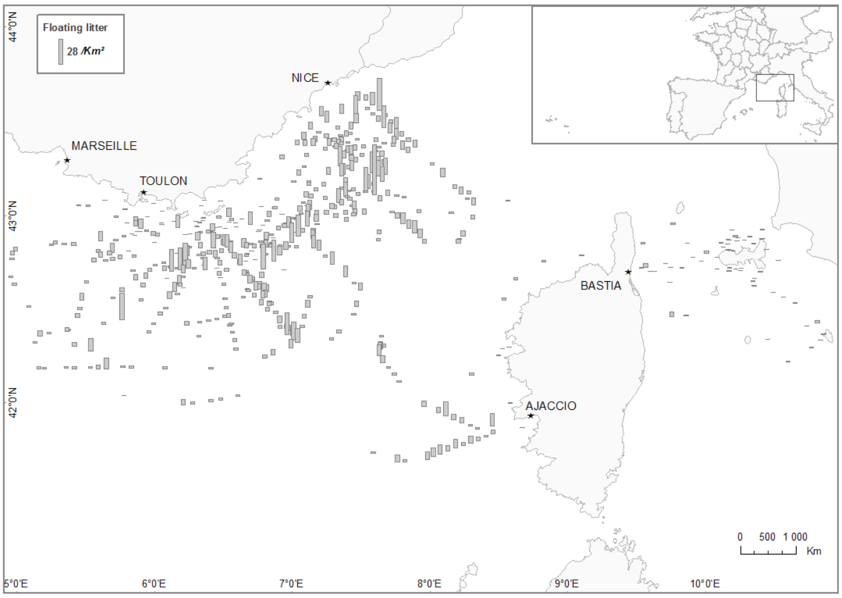


Figure 2.2.2a: *Distribution of floating litter in the northwestern Mediterranean Sea (2006-2008) (visual observations). IFREMER/SHOM map using data from the Ecocean/ParticipeFutur project for initial MSFD assessment (Gerigny et al., 2011).*

92. A subsequent survey made in the Eastern Mediterranean (Topcu *et al.*, 2010) reported densities of less than 2.5 items/ km2. It is important, however, to mention that surveys from ferries and commercial vessels show lower detection rates, especially for smaller objects. Therefore, comparisons among different regions or years are often altered by the diversity in counting protocols and viewing conditions encountered in the different surveys. Automated methods have been recently developed and tested in the Mediterranean Sea (Hanke and Piha, 2011), where data from ferry boxes uses cameras onboard regular shipping lines that are enabled to recognise floating or slightly submerged material of different colors and shapes, down to the size of a [few] centimeter[s]. These methods have also indicated larger quantities in coastal areas.

93. More recently, results from Suaria and Aliani (2014), dedicated to the first large-scale survey of anthropogenic debris (>2 cm) in the central and western part of the Mediterranean Sea (Figure 2.2.2b), demonstrated that 78% of all sighted objects were of anthropogenic origin, 95.6% of which were petrochemical derivatives (i.e. plastic and Styrofoam). Throughout the entire study area, densities ranged from 0 to 194.6 items/km2, with a mean abundance of 24.9 items/km2. The highest debris densities (>52 items/km2) were found in the Adriatic Sea and in the Algerian basin, while the lowest densities (<6.3 items/km2) were observed in the Central Tyrrhenian and in the Sicilian Sea. All of the other areas had mean densities ranging from 10.9 to 30.7 items/km2. The authors then evaluated the number of macro-litter items currently floating on the surface of the whole Mediterranean basin to be more than 62 million.

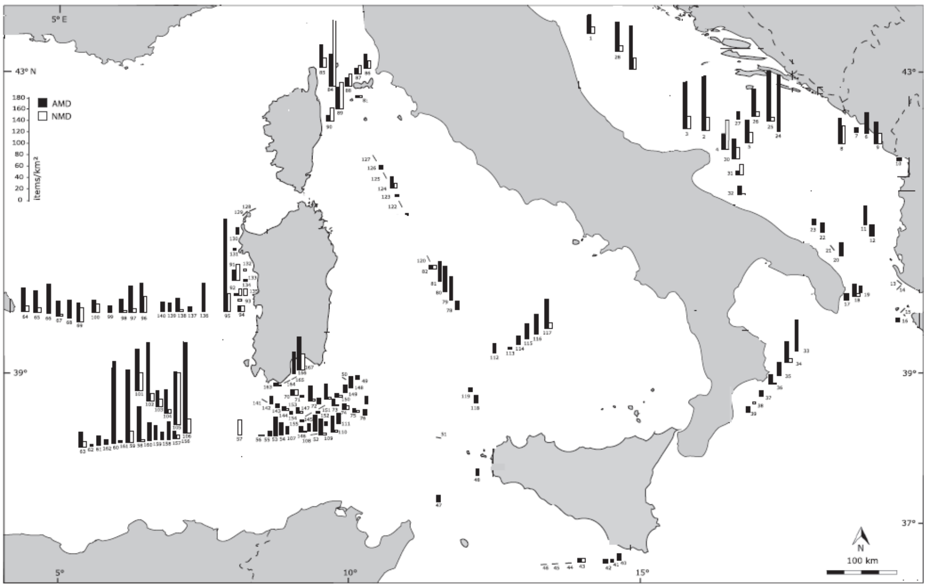


Figure 2.2.2b: Anthropogenic (black bars) and Natural (white bars) Marine Debris densities (items/km2) in the Western, Adriatic and Northern Ionian basins of the Mediterranean Sea (From Suaria and Aliani, 2014)

94. The highest densities found in the Adriatic Sea and along the North-western African coast are related to some of the heaviest densities in coastal population of the entire Mediterranean basin (UNEP/MAP (2012). North African countries in particular also have the highest rates of growth in coastal population densities, including touristic densities. Algeria, for instance, has a coastal population that has increased by 112% in the last 30 years, and it currently represents one of the most densely populated coastlines in the whole basin (UNEP, 2009). In addition, it should be noted that in some countries appropriate recycling facilities have not been fully implemented yet, and the cost of proper solid waste disposal is still often beyond their financial capacity (UNEP, 2009).

95. Once floating debris has entered into the marine environment, the hydrographic characteristics of the basin may play an important role in its transport, accumulation, and distribution. Atlantic surface waters enter the Mediterranean Sea through the strait of Gibraltar and circulate anticlockwise in the whole Algero-Provencal Basin, forming the so-called Algerian Current, which flows until the Channel of Sardinia and most often leads to the generation of a series of anticyclonic eddies 50–100 km in diameter wandering in the middle basin. Despite not being permanent, these mesoscale features could act as retention zones for floating debris and would help explain the high litter densities found in the central Algerian basin at around 80 nautical miles from the nearest shore. For the southern Adriatic Sea, it should be noticed that about one-third of the total mean annual river discharge into the whole Mediterranean basin flows into this basin, particularly from the Po River in the northern basin and the Albanian rivers (UNEP, 2012).

96. In addition, the shores of the Adriatic Sea are populated by more than 3.5 million people, and fisheries and tourism are significant sources, with 19 seaports handling more than a million tonnes of cargo per year and a considerable volume of passengers during the touristic season. Finally, significant cyclonic gyres are found also in the central and southern Adriatic Sea (Suaria and Aliani, 2014), favouring the retention of floating debris in the middle of the basin). This is also the Case in the Northeastern part of the Aegean Sea, where densities of floating litter are higher due to circulating waters and Black sea/Mediterranean sea water exchanges. As for anthropogenic debris accumulating in oceans gyres and convergence zones, the existence of Floating Marine Debris accumulation zones is a stimulating hypothesis, as their presence was supported recently (Mansui *et al.*, 2015). The existence of one or more ‘‘Mediterranean Garbage Patches’’ should be investigated in more detail, as there are no

permanent hydrodynamic structures in the Mediterranean Sea where local drivers may have a greater effect on litter distribution (CIESM, 2014).

2.2.3. Sea floor

97. Most litter is comprised of high-density materials and hence sinks. Even low-density synthetic polymers, such as polyethylene and polypropylene, may sink under the weight of fouling or additives. General strategies for the investigation of seabed debris are similar to those used to assess the abundance and type of benthic species. More than 50 studies were conducted worldwide between 2000 and 2015, but until recently very few covered extensive geographic areas or considerable depths. The Mediterranean Sea is a special case, as its shelves are not extensive and its deep sea environments can be influenced by the presence of coastal canyons. The geographical distribution of plastic debris is highly impacted by hydrodynamics, geomorphology, and human factors. Continental shelves are proven accumulation zones, but they often gather smaller concentrations of debris than canyons; debris is washed offshore by currents associated with offshore winds and river plumes.

98. Only a few studies have focused on debris located at depths of over 500 m in the Mediterranean (Galil, 1995; Galgani *et al.*, 1996, 2000, 2004; Pham *et al.*, 2014; Ramirez-Llodra *et al.*, 2013) (table 2.2.6). Galgani *et al.* (2000) observed decreasing trends in deep sea pollution over time off the European coast, with extremely variable distribution and debris aggregation in submarine canyons. Using a deep sea remote operated vehicle (ROV), video surveys concluded that submarine canyons may act as a conduit for the transport of marine debris into the deep sea. Higher bottom densities are also found in particular areas, such as around rocks and wrecks, and in depressions and channels. In some areas, local water movements carry debris away from the coast to accumulate in high sedimentation zones. The distal deltas of rivers may also fan out into deeper waters, creating high accumulation areas.

99. A wide variety of human activities, such as fishing, urban development, and tourism, contribute to these patterns of seabed debris distribution. Fishing debris, including ghost nets, prevails in commercial fishing zones and can constitute high percentages of total litter. More generally, accumulation trends in the deep sea are of particular concern, as plastic longevity increases in deep waters and most polymers degrade slowly in areas devoid of light and with lower oxygen content.

100. The abundance of plastic debris is very location-dependent, with mean values ranging from 0 to over 7,700 items per km² (table 2.2.6). Mediterranean sites tend to show the highest densities, due to the combination of a populated coastline, coastal shipping, limited tidal flows, and a closed basin with exchanges limited to Gibraltar. In general, bottom debris tends to become trapped in areas with low circulation, where sediments accumulate.

101. Counts from 7 surveys and 295 samples in the Mediterranean Sea and Black Sea (2,500,000 km², worldatlas.com) indicate an average density of 179 plastic items/ km² for all compartments, including shelves, slopes, canyons, and deep sea plains, in line with trawl data on 3 sites described by Pham *et al.*, 2014. On the basis of this data, we can assume that approcimately 0.5 billion litter items are currently lying on the Mediterranean Sea floor. Mapping the litter in the sea floor allows for the precise determination of the accumulation areas (Figures 2.2.3 a-c).

102. In a study on 67 sites conducted in the Adriatic Sea using commercial trawl analysis of Marine litter sorted and classified in major categories confirmed that plastic is dominant in terms of concentration by weight, followed by metal. The highest concentration of litter was found close to the coast, likely as a consequence of high coastal urbanization, river inflow, and extensive navigation.

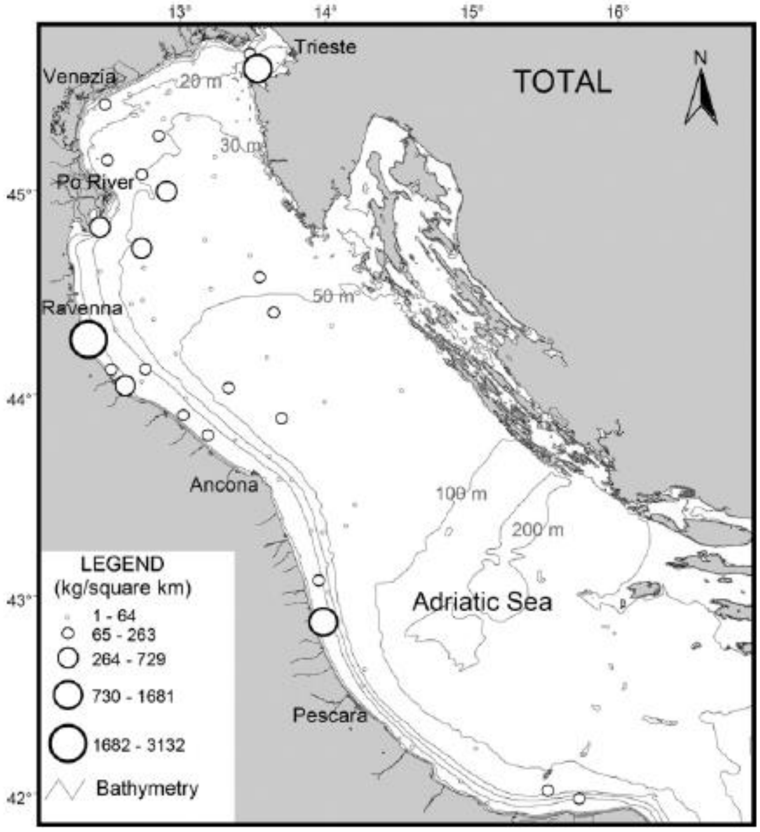


Figure 2.2.3a: Marine litter collected on seabed from the northern Adriatic (Solemon cruises, 2011-2012, Strafella et al., 2015).

103. Recently, benthic marine litter was investigated in 4 study areas from the Eastern Mediterranean (Saronikos; Patras and Echinades Gulfs; Limassol Gulf). Densities ranged from 24 to 1211 items/km^2, with the Saronikos Gulf being the most affected area. Plastics were predominant in all study areas ranging from 45.2% to 95%. Metals and Glass/Ceramics reached maximum values of 21.9% and of 22.4%, respectively.

104. In another example, the distribution and abundance of large marine debris were investigated on the continental slope and bathyal plain of the northwestern Mediterranean Sea during annual cruises undertaken between 1994 and 2009 (Galgani *et al.*, 2011). Different types of debris were enumerated, particularly pieces of plastic, plastic and glass bottles, metallic objects, glass, and diverse materials including fishing gear. The results showed considerable geographical variation, with concentrations ranging from 0 to 176 pieces of debris/ha. In most stations sampled, plastic bags accounted for a very high percentage (more than 70%) of total debris. In the Gulf of Lions, only small amounts of debris were collected on the continental shelf. Most of the debris was found in canyons descending from the continental slope and in the bathyal plain, with high amounts occurring to a depth of more than 500 m (figure 2.2.3c).

Table 2.2.3a: Distribution of debris in the gulf of lion in relation to the depth (Galgani *et al.*, 1996)

Depth (m)	Tows	Total area (km^2)	Total debris	Plastics	Debris (km^{-2})
<200	57	3.03	337	229 (68%)	111.2
200-1000	21	0.816	568	483 (85%)	696
>1000	10	0.17	631	537 (85%)	3712

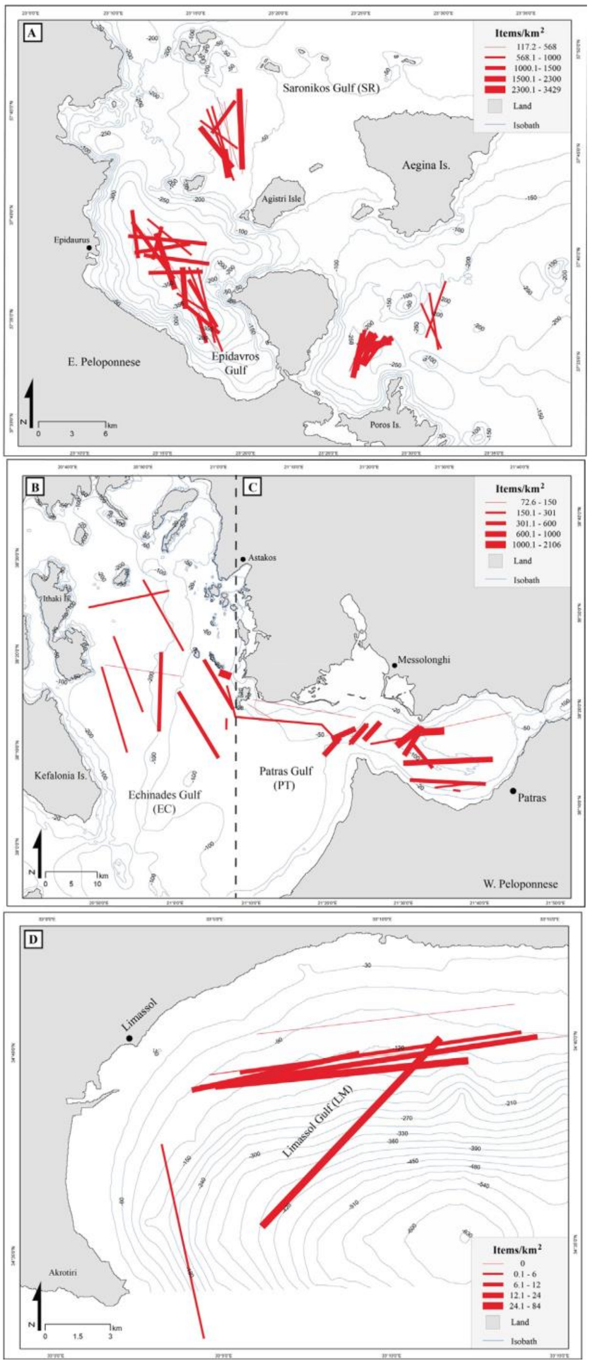


Figure 2.2.3b: Marine Litter density (items/km2) in Saronikos Gulf (Greece, Aegean Sea, A), Echinades Gulf (B), Gulf of Patras (Greece, Ionian Sea, C) and Limassol Gulf (Cyprus/ levantin basin, D.) Line positioning correspond to the trawling transect; line thickness relates to marine litter density. (After Ioakeimidis et al., 2014)

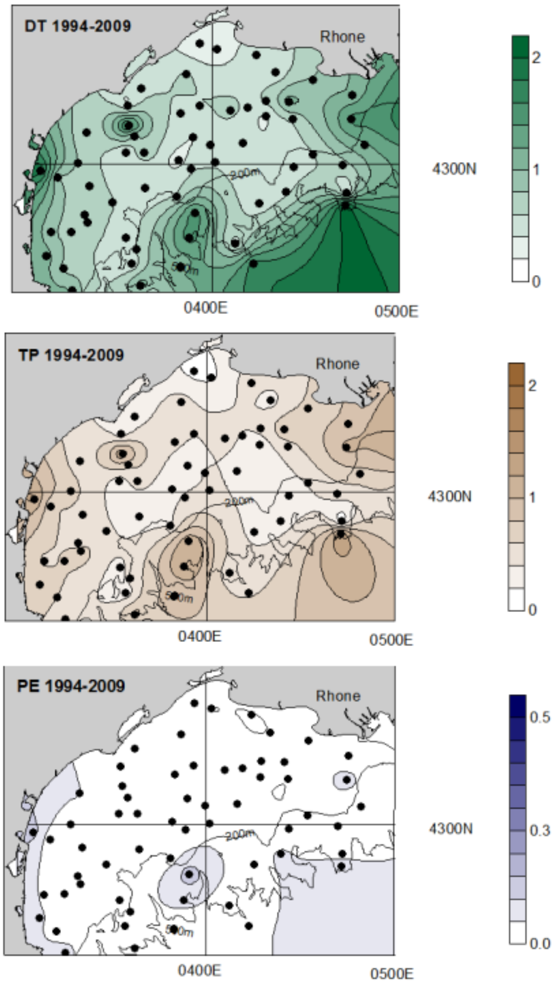


Figure 2.2.3c: Mean annual litter densities on the sea floor from the gulf of Lion for a period of 15 years of sampling (1994 –2009). Results are extrapolated densities expressed in items per hectare of the following categories total Debris (DT), Total plastics (TP) and fishing gears (PE). Data were from MEDITS cruises (Source: Galgani et al., 1996)

2.2.4 Derelict fishing gear

105. Damaged or worn out fishing gear **(**gillnets, trammel nets, wreck nets, pots, and traps) may be discarded or abandoned by fishermen at sea. Gillnets, driftnets, or other fishing gear may also be broken or dispersed by storms. Some of these can then continue to catch and kill marine organisms (fish and crustaceans, birds, marine mammals and turtles), commercial or not, for decades, until they are degraded (Bearzi, 2002; Brown and Macfayden, 2007). Work has been dominated, however, by biological and technical analysis, with very little attention to the socio-economic elements of either the impacts of ghost fishing or the management responses. The issue of 'ghost fishing' first gained global recognition at the 16th Session of the FAO Committee on Fisheries in April 1985. This is an important issue, since very high proportions of litter consist of net fragments. Some of the fragments may have food organisms growing on them and may occasionally attract other organisms that regard them as food.

106. Despite the International Maritime Organisation (IMO) Convention for the Prevention of the Pollution from Ships (commonly referred to as MARPOL 73/78) that specifically prohibits the abandonment/dumping of fishing gear (Annex V, Regulation 3), it has been estimated that

640,000 tons of such ghost nets are scattered overall in the world oceans, representing an incredible 10 percent of all marine debris (UNEP, 2009). The causes of the losses vary between fisheries and fishing "metiers," with some common features, particularly the conditions in which they occur. Factors, investigated under the FANTARED 2 project (2003), include, in decreasing order of relative importance, (i) conflict with other sectors, (ii) working in deep water, (iii) poor weather conditions and/or on very hard ground, (iv) working very long fleets, and (v) working more gear than can be hauled regularly. Thanks to improved communications between fishermen, losses have decreased in recent years. Moreover, there is generally a high economic motivation to retrieve lost fishing gears, in a short or long time, depending on the circumstances of the loss (depth and rougher ground conditions making the retrieval more difficult).

107. In a recent regional survey organized by UNEP/MAP-MED POL with support from MIO ECSDE (2015) through a questionnaire on derelict fishing gears addressed to various Mediterranean countries (Albania, Algeria, Croatia, Egypt, Israel, Lebanon, Morocco, Tunisia, Turkey, Syria, Palestine and Libya), results indicated that derelict fishing gear and ghost nets are considered to be a serious problem by 42% or a moderate one by 29% of the survey respondents. There was strong recognition of the marine litter problem among the fishermen and other fisheries related target groups, with 91% of the respondents considering marine litter to be a serious or moderate problem. Most fishermen, skippers, and sailors are well aware of the environmental damages and impacts of marine litter, and, to a lesser extent, of abandoned and lost fishing gear and are overwhelmingly positive regarding their cooperation in the effort to minimize these problems. The analysis of the survey results also clearly demonstrated that (i) Proper port and other facilities for effective management of derelict fishing gear, marine litter collected on board, etc. are insufficient; (ii) Relevant legislation exists but is not implemented or enforced; (iii) the problem with derelict fishing gear and marine litter is serious and that it is getting worse, particularly in connection to biodiversity; and finally (iv) The majority of Mediterranean fishermen claim to be willing to participate in “Fishing for Litter” schemes, if such scheme could be set in place. For the moment however, those vessels that do not have bins or bags on board to store litter items that are ‘fished’ or nets and other fishing equipment that are no longer useful end up throwing the litter and gear back into the sea. One of the main recommendations of all country surveys is the need for increased awareness-raising and educational activities calling for better waste management and disposal by the sector itself, which should go hand in hand with derelict fishing gear collection or recycling programs

108. The open ground fisheries usually account for the largest amount of fishing gear lost. Rates of permanent net loss in European waters appear to be low, with typically below 1% of nets deployed. Because their presence is not controlled, the available data for the Mediterranean do not allow evaluating precisely the relative importance of this threat, as compared to by catch in operating fishing gear. Bottom gillnet fisheries are very common throughout the Mediterranean basin, with more than 20,000 boats involved (http://firms.fao.org/firms/fishery/761/en). Target species are largely represented by demersal and bentho-pelagic fish and crustaceans. Although few entrapments in bottom gillnets have been documented (see table), this may be in part due to under-reporting as a result of the reluctance of fishers to report such incidents (Pawson, 2003).

109. In the Mediterranean, static gear is an important part of ghost fishing. Losses are often a result of a combination of rough bottom (rocks, wrecks) and strong currents complicating the retrieval of the gear and giving very variable results (pieces of netting and/or ropes, bundles of nets, etc.). Because of self-recovery favoured by GPS positioning and considerable efforts to avoid losses because of costs, the rate remains low when considering the total number of nets that are set. Finally, losses due to storms are less frequent, as usually fishermen are aware of bad weather conditions, leaving the lowest net retrieval rates as the nets are usually moved away from the place they were set.

110. The declining ghost catch rate over time is following a negative exponential function with rapidly declining ghost catch rates. On a daily basis, the catches are assumed to decline quickly with ghost catches at 5% of the active catches after 90 days (Browne *et al.*, 2007). After 90 days, the decline in catch rates slows down considerably, with catches continuing only at low levels. FANTARED (Fantared 2, 2003) showed, however, that gear in shallower, dynamic conditions tend to stop fishing earlier, sometimes after just a few months, while gear lost/discarded in deep water with little tidal/current activity can continue to fish for years rather than months. Ayaz *et al.* (2006) investigated and compared ghost fishing by monofilament and multifilament gillnets in Izmir Bay (eastern Aegean Sea). Gillnets were monitored every day by divers. After 106 days for the monofilament gillnets and 112 days for multifilament gillnets, a total of 29 species (22 fish, 5 crustaceans, 1 cephalopod, and 1 gastropod) were captured by the ghost gillnets and 17 specimens of the endangered species Pinna nobilis were killed during the study. Weekly fish catch rates of both gillnet types declined exponentially, decreasing by 55% (monofilament) and 63% (multifilaments) respectively. One year after deployment, all had completely collapsed and were excessively colonized by biota. On rocky bottoms, dependent on the level of exposure to the elements, gillnet catch rates can be near zero over an 8–11-month period. Fishing rates may nonetheless continue at rates of up to 15% of normal gillnet rates in some cases. While studies showed that nets set in very deep water may fish for many years, the effective fishing lifetime of nets studied in Europe was in most cases not more than 6–12 months (Brown and Macfayden, 2007), and in almost all bottom conditions, ghost catches initially showing a high percentage of fish before switch progressively to catches dominated by crustaceans.

111. Estimated ghost catches are generally believed to be well under 1% of landed catches. In the French Mediterranean Sea, an annual loss of hake was estimated at 0.27% and 0.54% of the total commercial landings (2072–4144 individuals), but there is no analysis beyond a biological quantification of ghost catch giving it value (Browne *et al.*, 2012).

112. In the studies that have been done in European fisheries, mortality rates from lost pots and traps are believed to be low due to escape of trapped organisms, low loss and high retrieval rates, and damage to the pots and traps. Mortality rates from lost demersal longlines, seine nets, and jigging gear are also usually low, as they stop fishing immediately or shortly after loss. Mortality levels from lost trawls are also believed to be low because these gear rely on their movement through water for their catching efficiency. Bingel (1989, in Golik, 1997) estimated the quantity of fishing gear lost to be between 2637 and 3342 tons in the Mediterranean Sea, based on an extrapolation of data from the Turkish industry losses. According to the targets species, FANTARED 2 (2003) estimated net losses in the French Mediterranean Sea at 6.25 km per boat and per year. With boats fishing different species, losses were estimated between 0.7 (red mullet) and 1.2 km (Sea Bream, Hake) per boat and per year, with percentages of total nets lost per boat between 0.2% (hake) and 3.2% (Sea bream) of nets lost per boat.

113. Modern gear is mostly made of non-biodegradable synthetic fibres and can persist for long periods. They can, therefore, theoretically continue to catch fish for long periods of time. Fish, dolphins, sea turtles, seabirds, crabs, and other animals swimming free in the water column or moving on the seabed may die once captured by nets. Alterations of the marine environment and its habitat functions, obstacles to navigation and possible damages to the vessels, and hazards for recreational and/or professional divers are all other risks caused by ghost nets.

114. While the environmental impacts of lost static gear may be considerable, these impacts must also be considered in the broader context as compared to the environmental impacts of other fishing methods. Mobile gear such as trawls generally have much greater impacts than static gear in terms of target catch, non-target catch, and discards, as well as habitat and biodiversity damage. The mortality rates attributed to lost fishing gear is dependent on the species present, species abundance, species vulnerability, and ghost gear status (Browne and Macfayden, 2007). However, since mortality rates associated with ghost fishing decline rapidly in most

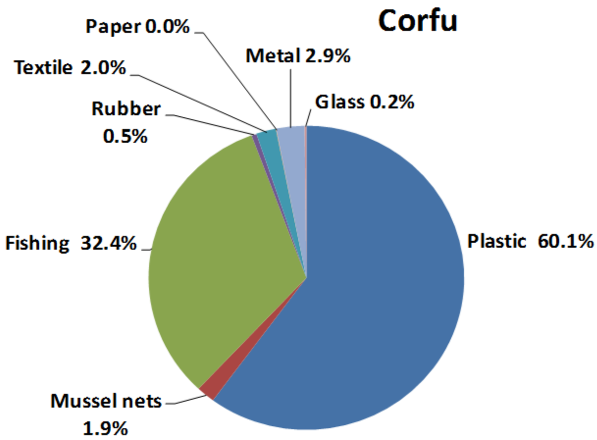
fisheries once nets/pots have been lost, the extent of ghost fishing in fisheries may be less interesting than expected, although there are gaps in our knowledge. Lost gear has a negative aesthetic impact as a source of litter at sea and on beaches and can potentially entangle active fishing gear and vessel propulsion systems. The significance of the aesthetic impact of fishing gear as a source of litter will vary by region. It may be particularly important mainly in areas where tourism is significant.

115. The causes of gear loss are important not only in terms of impacts but for developing appropriate management measures. The European Community banned netting below 200m from 1 February 2006 as a measure before long term management conditions could be developed. Curative measures in Europe often take the form of gear retrieval programmes. They are, however, limited in the Mediterranean Sea.

GHOST and DEFISHGEAR

116. The Adriatic region is facing a big gap when it comes to marine litter analysis, resulting in a lack of appropriate mitigation measures aimed at reducing pollution by ghost nets, evident in every country of the region. Through the implementation of various projects, marine litter in the Adriatic coastal waters will be reduced by involving fishermen as one of the key players in marine litter cause and solution. Pilot activities are underway, setting out a system for collection and recycling of derelict fishing gear, including the so called "ghost nets”. The EU project GHOST (http://www.life-ghost.eu/index.php/en/) was started to assess the impact of ghost nets on fish and benthic communities of the rocky outcrops located off the coast of Veneto, commonly known as *Tegnùe*.The mapping of these 20 rocky outcrops, which had been previously affected by ghost nets, has been completed. A 20 square kilometers area has been mapped through the acoustic instrument (High Resolution Scanning Sonar), providing images of each outcrop conformation with possible entangled ghost nets. Photo-surveys have showed that most of the outcrops are spoilt by Abandoned or Lost Derelict Fishing Gears (ALDFG). The project started to recover ALDFGs, which will be subsequently analyzed by type in order to identify the potential recyclable components. The project will then help to test the efficacy of the methods to map and remove ALDFG, in order to demonstrate its applicability in similar coastal habitats and to develop operative protocols for ALDFG management in coastal areas.

117. DeFishGear (http://www.defishgear.net/project/main-lines-of-activities) is addressing the wider context of the marine litter issue in the Adriatic. Part of the project deals with the implementation and management of preventive and mitigation actions such as (i) Fishing for litter, undertaken by fishermen while performing their daily fishing activities, leading to the removal of marine litter as well as awareness within the fishing sector, (ii) Targeted recovery of ‘ghost nets’ through a direct involvement of fishermen and divers, and (iii) Establishment of fishing gear management schemes to collect and recycle lost or abandoned fishing and other gear in the Adriatic region.



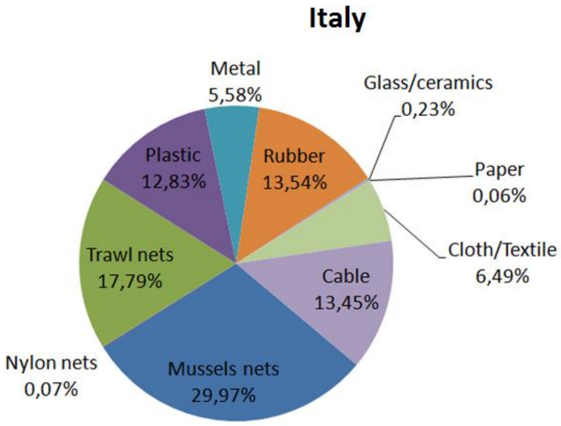


Figure 2.2.4a: Typology of Derelict Fishing Gears in the Adriatic. Preliminary analysis in Italy (Ronchi et al., ISPRA) and Corfu Island (Kaberi et al., HCMR) of 13 tons of DFG collected during an experiment started October 2014 in Corfu and February 2015 in Italy. (Source: Defishgear project in UNEP/MAP, in press)

118. More generally, the European projects FANTARED (1 & 2) classified the management options for addressing lost gear into two groups dedicated to methods used for reducing lost fishing gear and discarded fishing gear, respectively. For lost gears, the amount of time and effort spent retrieving gear is related to its value, the probability of recovery, and the opportunity cost of carrying on fishing. Abandoned or discarded fishing gear, on the other hand, has no financial value, and leaving it in the sea is a convenient means of disposal for the careless and irresponsible fisher.

119. Logistically, the management options for addressing lost gear can be however different with considerations to prevention, information and good practices (Macfayden *et al.*, 2009). Many of the current management responses to deal with ghost fishing feature gear retrieval programmes. However, a number of problems were identified, including (i) The precise information needed on location of gears, (ii) The reduced surface that can be covered in campaigns, (iii) The poor efficiency of recovery, (iv)The time when gears remain at sea, and (v) The cost. In some cases, especially when density of lost gears is low, there is then a question whether lost gears might be better left in the sea. For example, fouled ghost nets may better act as reefs rather than actively catching fish.

120. Strategies must then to be based on a quantification of the costs and benefits. Data, and costs, are however based on the areas where vessel numbers and patterns of activity will impact strongly on the percentage of total lost nets that are retrieved, and therefore the resulting benefits of a retrieval programme. In addition, in deeper water the costs of retrieval programmes could be considerably greater

121. Macfayden et al (2009) summarized some of the possible costs and benefits of reducing ghost fishing, related to prevention or curative measures. He noted that (a) gear retrieval programmes may only be cost effective in fisheries where the actual costs of ghost fishing are high; and (b) that preventative measures are likely to be preferable to curative ones. Key determinants of the economic viability of gear retrieval programmes are the number of vessels in the fishery; costs of the retrieval programme; number of nets lost; value of the gear lost; and the percentage of lost nets that can be successfully retrieved. Benefits include (i) a Reduced fish mortality of commercial/target species, marine mammals, birds, reptiles, etc., (ii) a reduced alteration of sea bed features, (iii) reduced littering of beaches, (iv) increasing catches and associated employment, and (v) Improved recreational, tourism and diving benefits

122. A broader management strategic approach implies to establish good practices and changing behaviour. Within FANTARED, specialists agreed on recommendations to be proposed to fishing industry. These include (i) A right amount of gear with restrictions on length, (ii) Marking gear properly (Transponders), (iii) Attention to weather and risks of conflict, and (iv) Better communicate and report losses, carrying net gear retrieving systems

123. As an example, the European Commission adopted a Regulation (Commission Regulation 356/2005) requiring passive gear (longlines, entangling nets, trammel nets and drifting gillnets) to be marked with the vessel registration numbers. In the project DEEPNET (Hareide *et al.*, 2005), geophysical and acoustic instruments were demonstrated to be the most appropriate methods for underwater detection when optical methods however had limited success. The project finally recommended the use of a miniature, codified passive-sonar transponder (microchip) to identify nets. However, an unfortunate implication of the requirements is that it may create an incentive for skippers to dump back at sea any abandoned gear that they may themselves retrieve in the course of fishing. Some technical measures have been also recommended to reduce the capturing possibilities of lost nets, such as the use of biodegradable thread for fixing the netting to the float line so that it will be released in the event of long submersion, or the use of lead-lines that break more easily, higher hanging ratios (over 50%) to reduce the looseness of the webbing, a major cause of tangling (Sacchi, 2012).

124. Mitigating the problem of ghost fishing also implies, above all, respect for elementary fishing regulations (for example, observance of regulations on gear marking systems). Interest in developing new management concepts based on Protected Marine Areas (MAPs) has risen over the past ten years, underscored by the feeling that it is possible to pursue commercial fishing activities while preserving threatened species at the same time. In such an example however, the benefits of a sustainable fishing may lead to more impacting fishing of ghost gears.

2.2.5 Microplastics

125. In addition to large debris, there is growing concern with regards to micro particles measuring less than 5 mm and particles measuring as little as 1 μm have already been identified (Carpenter *et al.*, 1972; Colton *et al.*, 1974; Thompson *et al.*, 2004). Most, but not all micro particles consist of micro plastics. Micro plastics comprise a very heterogeneous group, varying in size, shape, color, chemical composition, density and other characteristics. They can be subdivided by use and source as (i) 'primary' micro plastics, produced either for indirect use as precursors (nurdles or virgin resin pellets) for the production of polymer consumer products, or for direct use, such as in cosmetics, scrubs and abrasives and (ii) 'secondary' micro plastics, resulting from the breakdown of larger plastic materials into increasingly small fragments. This is the result of a combination of mechanisms, including photo, biological, mechanical and chemical degradation.

126. To date, only a limited number of global surveys have been performed in the aim of quantifying micro plastic distribution. The majority of existing surveys is localized and

concentrated on specific areas around the world, such as regional seas, gyres or the poles. Most of these studies focus on sampling the sea surface and/or water column and intertidal sediments (Hidalgo-Ruz *et al.* 2012). Mean sea surface plastic was found in concentrations up to 115,000 -1050000 particles / km² in the NW Mediterranean Sea (maximum 4860000 particles per km2) (Collignon *et al.*, 2012, Da Lucia *et al.*, 2014, Faure *et al.*, 2015, Suaria *et al.*, 2015), giving an estimated weight over 1000 tons for the whole basin. Recently (Cozar *et al.*, 2015), an evaluation provided an estimation based on samples collected with a 200µm mesh in the whole basin at 423 g km-2 (243,853 items km-2), then between 756 to 2,969 tons for the basin. At this scale, the spatial distribution of plastic concentrations is irregular, with a patchy pattern that may be related to the variability in the Mediterranean surface circulation disabling the formation of permanent accumulation areas. The highest micro plastic concentrations in sediment (Claessens *et al.*, 2011) were found in beach and harbour sediments, not in the Mediterranean Sea but Belgium, with concentrations of up to 391 micro plastics/kg of dry sediment. Similarly, a beach survey on the Mediterranean island of Malta revealed an abundance of pellets on all of the studied beaches (Turner and Holmes, in Cole *et al.* 2011), with the highest concentrations reaching 1,000 pellets/m2 along the high-tide mark. In Slovenia (Bajt *et al.*, 2015), concentrations were found between 3 and 87 particles per 100g generally with offshore areas less contaminated. Finally, on Kea Island in the South Aegean Sea, microplastics abundance reached the 977 items/m2 with a highly variable abundance of virgin pellets (7-560 pellets/m2) (Kaberi *et al.*, 2013). Micro plastic pollution has also spread throughout the world's seas and oceans, into sediment and even deep Mediterranean Sea (Van Cauwenberghe *et al.*, 2013).

127. After a large scale study in the Mediterranean Sea, five different types of plastic items were identified (pellets/granules, films, fishing threads, foam, fragments), with the majority of items being fragments of larger rigid objects (87.7%, e.g. bottles, caps) and thin films (5.9%; e.g. pieces of bags or wrappings) (Cozar *et al.*, 2015)

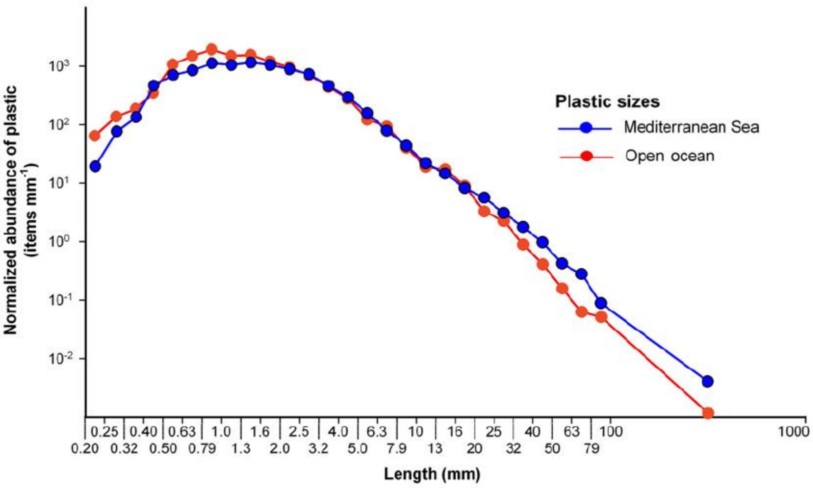


Figure 2.2.5 a: Size distribution of the floating plastic debris collected in the Mediterranean Sea (n = 3,901 plastic items) compared to those measured for plastic accumulation regions in the open ocean (n = 4,184 plastic Items). Note the logarithmic scale of the axis (After Cozar et al., 2015).

128. Time trends relating to the composition and abundance of micro plastics are scarce and lacking information in the Mediterranean Sea. However, available long-term trend data suggests various patterns in micro plastic concentrations. A decade ago, Thompson (2004) revealed a significant increase in plastic particle abundance over time in Atlantic Ocean. More recent evidence indicates that micro plastic concentrations in the North Pacific Subtropical Gyre have increased in the last four decades (Goldstein *et al.* 2013), whereas no changes have been observed on the surface of the North Atlantic gyre over a 20-year period (Law *et al.*, 2010)

2.2.6 Summary of litter data in the Mediterranean Sea

Table 2.2.6: Comparison of mean litter densities from recent data (from 2000) in the Mediterranean Sea. Intervals of values are given in parentheses.

Location	Environmental compartment	Date	Sampling	Depth	Density (min-max)	% plastics	References
Slovenia	Beaches, Macro litter	2007	3 beaches, 150 m-2 per transect	0	12158/km	64	Palatinus, 2009
Slovenia	Macro/Beaches	2007-2013	6 beaches, all litter items >2cm collected on 3x150m per location	0	1.9 litter items / m	74	National Report for MSFD Article 8, 9 and 10, Peterlin *et al.*, 2013
Slovenia	Macro/Beaches	2014-2015	2 samplings, 3 beaches, 1 beach with 2X100mX10m transects, 2 beaches with 100mX10m transects; all litter items >2cm collected	0	3.95 litter items / m	70	DeFishGear/ Institute for Water of the Republic of Slovenia/in press
Balearic	Beaches, Macro litter	2005	32 beaches	NA	36000/ km (high season)	75 (46% cigarette butts)	Martinez *et al.*, 2009
France /Marseille	Beaches, Macro litter	2011-2012	10 beaches (30 in winter)	NA	0,076 m-3/day/100m (stranding rates)	80-94	MerTerre 2013 - (www.mer-terre.org)
Turkey	Beaches, Macro Litter	2008-2009	10 beaches	NA	0.085 to 5.058 items m2	91	Topçu *et al.*, 2013
Spain	Beaches, Macro litter	2013-2014	12 beaches, 100m transects, 4 surveys/year	NA	11-2263 items/100 m (2013) 27-1955 items/100 m (2014)	66% (2013) 62% (2014)	Ministerio de Agricultura, Alimentación y Medio Ambiente (http://www.magrama.gob.es/es/costas/temas/proteccion-medio-marino/actividades-humanas/basuras-marinas/)
Spain-Mediterranean Sea	Beaches, Macro litter	2013-2014	27 beaches	NA	11-2137 items / 100 m	48.6%	MARNOBA Project (http://vertidoscero.com/Marnoba_AVC/result.htm)
Croatia (Mjet island)	Beaches, Macro litter	2007	NA	NA	NA	80	Cukrov & Kwokal, 2010
Greece, Ionian Sea	Beaches, Macro litter	2014-2015	6 beaches	NA	Mean: 0.715 items / m^2 (range: 0.03 – 6.38)	84.6 %	DeFishGear/ MIO-ECSDE/in press
Italy, North-western Adriatic coast	Beaches, Macro litter	2015	2 beaches	NA	Mean: 1.139 items/m^2 (range: 0.771 – 1.507)	95%	DeFishGear / ISPRA /in press
Mediterranean sea (15 countries)	Beaches, Macro litter	2002-2006	Beaches	0	NA	>60	ICC, in Unep, 2011
Greece	Beaches, Macro litter	2006-2007	80 Beaches	0	NA	43% (2006) 51% (2007)	Kordella *et al.*, 2013

Spain (Murcia)	Micro plastics Beach	2012	1 Beach	0	2245 microplastics/m2	100	http://surf-and-clean.com/microplasticos/
France	Micro plastics Beach	2011	15 beaches	0	2920 microplastics/m2 (10cm layer, 0-8000)	100	Klosterman *et al.*, 2012
Greece	Micro plastics Beach	2012	12 beaches	0	10-977 items/m2 (2-4 mm) 20-1218 items/m2 (1-2 mm)	100	Kaberi *et al.*, in preparation
Slovenia	M Micro plastics Beach	2014-2015	2 samplings, 1 beach, large (1-5mm) on 3 x 0,25 m2 and small (<1mm) microplastic particles (3x 250 ml)	3-5 cm	Large: 516±224 items/ kg Small: 616±325 items/ kg	> 90%	DeFishGear/ Institute for Water of the Republic of Slovenia/in press
Slovenia	Micro plastics Sediments	2014	27 stations	50 m Maximum	3-80/100g		Bajt *et al.*, 2015
Location	**Environmental compartment**	**Date**	**Sampling**	**Depth**	**Density (min-max)**	**% plastics**	**References**
Kerch Strait/Black Sea	Macro/Sea surface	Before 2008	Visual	Vidual/Aerial	66 / km^2	nd	BSC, 2007
Ligurian coast	Macro/Sea surface	1997-2000	Visual	Surface	1.5-25/ km^2	nd	Aliani et al., t, 20031
North western	Macro/Sea surface	2013	Waveglider	0-4,5m	40,5/ km^2	100	Galgani *et al.*, 2013)
Slovenia	Macro/Sea surface	2011	Visual	Surface	1.98 /km2	90	Vlachogianni & Kalampokis, 2014
Slovenia	Macro/Sea surface	2014-2015	2 samplings, 5 transects, visual observation of floating litter >2.5cm, constant speed 3knots for 60 mins	Surface	. 0.0013 items / m2	100	DeFishGear/ Institute for Water of the Republic of Slovenia/in press
Adriatic sea	Macro Litter (>20cm), Sea surface (high sea)	winter 2015	Fixed Line Transect (FLT), repeated, samples (n=7). 1.600 km surveyed in total	NA	3.79± 0.71 items/ km^2	87,6%	DeFishGear/ MIO-ECSDE & Accademia Leviatano/in press
Ionian Sea	Macro Litter (>20cm), Sea surface (high sea)	Winter 2015	Fixed Line Transect (FLT), repeated, samples (n=7). 1.200 km surveyed in total	NA	2.53± 1.01 items/ km^2	89,2%	DeFishGear/ MIO-ECSDE & Accademia Leviatano/in press
Adriatic/ Greek waters	Macro/Sea surface	Since 2008	Visual	Surface	5.66 /km2		Vlachogianni & Kalampokis, 2014
Aegean/ Levantine	Macro/Sea surface	Since 2008	Visual (172.8 km2)	Surface	2.1/ km2	83	Unep, 2011
North western	Floating Macro/Sea surface	2006-2008	Visual	Surface	3,13 / km^2	85	Gerigny *et al.*, 2012 and Unpublished data (Ecoocean.org)
Greece	Macro/Sea surface		Visual	Surface	2.1 items/km^2	83	HELMEPA (Greece) in UNEP, 2011
NW Mediterranean	Floating Micro plastics	2011-2012	41 samples/Manta/330μm mesh	Surface	130000 / km^2		Faure et al., 2015

NW Mediterranean	Floating Micro plastics	2010	40 samples/Manta/330µm mesh	Surface	115000 / km^2	> 90%	Collignon *et al.*, 2012
West Sardinia	Floating Micro plastics	2012	30 samples/Manta/500µm mesh	Surface	150 000 items/ km^2		Da Lucia *et al.*, 2014
Mediterranean sea	Floating Micro plastics	2015	39 samples/Manta/200µm mesh		243,853 items/ km^2 (423 g km-2)		Cozar *et al.*, 2015
Slovenia	Floating Microplastics	2012-2014	17 samples/Manta / 300µm	Surface	471900 items / km^2 (13900-3098000)	80% polyethylene	Palatinus *et al.*, 2015
Slovenia	Micro/Sea surface	2014-2015	2 samples river outflow/Manta/308µm mesh 4 samples sea surface/Manta/308µm mesh	Surface	River outflow: Av. 228046±30060 items / km2 Sea surface: Av. 287924±52979,5 items / km2	> 90%	DeFishGear/ Institute for Water of the Republic of Slovenia/in press
Italy/ North Adriatic	Floating Microplastics	2014	11	Surface	63175 items / km^2 (27.3 g / km^2, max at 128800)		Mazziotti *et al.*, 2015
Italy/South Adriatic	Floating Microplastics	2013	29	Surface	1050000 items / km^2 (100000-4860000), 442g / km^2	41% polyethylene	Suaria *et al.*, 2015
Location	**Environmental compartment**	**Date**	**Sampling**	**Depth**	**Density (min-max)**	**% plastics**	**References**
Malta	Shelf	2005	Trawl (44 hauls, 20 mm mesh)	50-700	102	47	Misfud *et al.*, 2013
Sicily/ Tunisian channel	Shelf	1995	Trawl (fishermen)	0-200 m	401/km^2	75	Cannizarro *et al.* (1995)
Adriatic Sea	Shelf	1997	12 hauls (trawling, 20 mm mesh)	0-200 m	378 +/- 251 / km^2	69,5	Galgani *et al.*, 2000
Northern & central Adriatic	Shelf	2005-2010	trawling	0-200m	5-34 kg/ km^2	NA	From Vlachogianni & Kalampokis, 2014
Montenegro	Shelf/ slopes	2009	trawling	48 - 746 m	6-59% of total catches	NA	Petrovic & marcovic, 2013,
Slovenia	Shallow waters	2013	diving	0-25m	Na	55	From Vlachogianni & Kalampokis, 2014
France- Mediterranean	Seabed, slopes	2009	17 canyons, 101 ROV dives,	80-700m	3.01 /km survey (0-12)	12 (0-100)	Fabri *et al.*, 2013
Thyrenian sea	Seabed, Fishing grounds	2009	6 x 1.5 ha samples, trawl, 10mm mesh	40-80m	5960±3023/ km^2	76	Sanchez *et al.*, 2013
Spain-Mediterranean	Seabed, Fishing grounds	2009	Trawling (fishermen)	40-80m	4424±3743/ km^2	NA	Sanchez *et al.*, 2013
Mediterranean sea	Seabed, Bathyal/abyssal	2007-2010	292 tows, Otter/agasiz trawl, 12 mm mesh	900-3000m	0.02- 3264.6 kg/ ·km^2 (including clinkers)	nd	Ramirez- Llodra, 2013
Slovenia	Macro/Sea floor	2014-2015	2 samplings, 5 locations, each location has transects of 100mx8m	2-17m	0 – 7500 items / km^2	67%	DeFishGear/ Institute for Water of the Republic of Slovenia/in press
Turkey/ Levantine basin,	Seabed, Bottom/Bathyal	2012	32 hauls (trawl, 24 mm mesh)	200-800m	1150 -2762/ / km^2 (max at 2, 186)	81.1	Güven *et al.*, 2013
Turkey/ North eastern basin,	Shelf	2010-2012	132 hauls (2.5kts)	20-180	72(1-585 kg)/ hour	73	Eryasar *et al.*, 2014
Mediterranean, Southern France	Shelves & canyons	1994-2009 (16 years study)	90 sites (trawls, 0.045 km2/tow)	0-800 m	76-146/ km^2 (0-2540)	29.5 -74	Galgani *et al.* 2000 & unpublished data
Greece	Shelf	Before 2004	59 sites	30-200	4900 /km^2	55.5	Katsanevakis & Katsarou (2004)
Greece	Shelf	2000-2003	54 hauls (trawl, 1,5 mm mesh)	30-200	72–437 / km^2	55,9	Koutsodendris *et al.* (2008)
Greece	Seabed (fishing ground)	2013	69 hauls (50mm mesh)	50-350	1211±594 items/km2 (Saronikos Gulf)	95,0±11,9 (Saronikos	Ioakeimidis *et al.*, 2014

						Gulf)	
Levantine basin (Cyprus)	Seabed (fishing ground)	2013	9 hauls (50mm mesh)	60-420	24±28 items/km2	67,4±7,7	Ioakeimidis *et al.*, 20143
Black sea (Constanta bay)	Seabed (fishing ground)	2013	16 hauls (20mm mesh)	30-60	291±237 items/km2	45,2±4,8	Ioakeimidis *et al.*, 20143
Italy (North Thyrrenian)	Shelf	2010-2011	69 dives (26 areas, 6.03 km2)	30-300	90 debris items/ km² (0- 160)	92% (89% from fishing)	Angiolillo *et al.* (2015)
Italy (Tyrrhenian)	Fishing Grounds (Rocky banks)	2010-2011	ROV observations	70-280 m	0.0029 / km^2	-	Bo *et al.* (2014)
Italy, North-western Adriatic Sea	Seabed	2014	16 x 5.7 ha samples, trawl, 24 mm mesh opening	20-30 m	Mean: 721 items/km^2 (range: 99 – 3,036)	92%	DeFishGear / ISPRA /in press
Italy, North-western Adriatic Sea	Seabed	2011-2012	67 hauls,	1 – 260 M	85 721 kg/km^2	34%	Strafella et al . 2015

3. IMPACT OF MARINE LITTER IN THE MEDITERRANEAN

129. Litter affects marine life at various organizational levels and its impact varies according to the target species or population, environmental conditions, and the considered region or country.

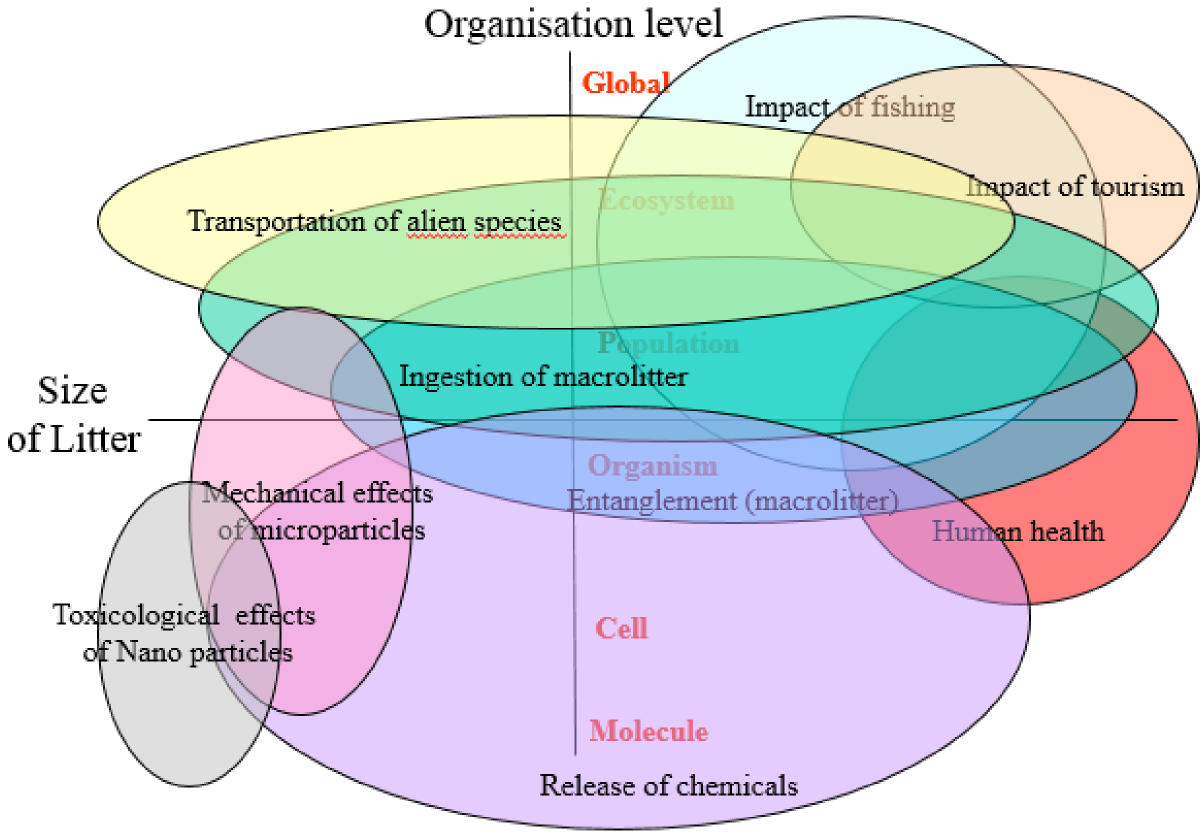


Figure 3: Schematic representation of different types of impacts in relation with size of marine litter and biological organization level.

130. The concept of harm itself is not obvious, as no acceptable units of measure have been defined. Even the most remote part of the Mediterranean is affected by marine litter, with various impacts on the environment and coastal communities. It constitutes a major source of aesthetic pollution and may affect ecologically the marine ecosystem but also may affect chemically and socio-economicly, the tourism and fishing activities. Marine litter may also endanger human health and safety.

131. The problem is compounded by the fact that a very high percentage of marine litter does not degrade quickly in the environment (metal, plastic) and therefore it also contributes to marine environmental pollution with secondary pollution (release of chemicals).

3.1. Impacts on wildlife

132. As marine litter affects different ecological compartments, the study of its impact on marine biota of all trophic levels on the same temporal and spatial scale is of increasing importance. With regard to biodiversity, it is essential to focus research on sensitive species such as turtles, marine mammals, seabirds, and filter feeders, invertebrates or fish that may be ingest micro plastics. Protocols also have to be developed in order to assess early warning effects on key species and key habitats (Deudero & Alomar, in CIESM, 2014). Moreover, the identification

of interactions between litter and fauna strongly depends on data collection methods. For example, most data on fish, turtles, and cetaceans are provided by stomach contents analyses, stranded individuals, or bycatches reflecting only a small snapshot of actual interactions which can be expected. The effect of litter on marine populations is difficult to quantify, as an unknown number of marine animals die at sea and may quickly sink or be consumed by predators, eliminating them from potential detection. New methods for the unbiased estimation of mortality rates and the effects on the population dynamics of many affected species are urgently needed.

133. So far, 79 studies have investigated the interactions of marine biota with marine litter (mainly plastics) in the Mediterranean basin (Deudero & Alomar, in CIESM, 2014). These studies cover a wide range of depths (0 m to 850 m) and a large temporal scale (1986 to 2014), unveiling a vast array of species that are affected by litter, ranging from invertebrates (polychaetes, ascidians, bryozoans, sponges…), fish, and reptiles to cetaceans. Effects from the studies were classified into entanglement, ingestion, and colonization and rafting.

3.1.1 Entanglement / impact of derelict fishing gears

134. In 2015, 340 original publications reported encounters between organisms and marine debris, and 693 reported species with entanglement as the most important consequence (Gall and Thompson, 2015). Birds represented nearly 35% of entangled wildlife followed by fish (27%), invertebrates (20%), mammals (almost 13%), and reptiles (almost 5%). Discarded monofilament fishing line is perhaps the single most dangerous litter item, accounting for 65% of entanglements found during the ICC campaign in 2007. In fact, derelict fishing gear, which includes fishing line, nets, rope, lures, light sticks, and crab/lobster/fish traps, represented 72% of all entanglements. Lost fishing gear may impact the environment in a large number of different ways, including (i) continued catching of target species, (ii) capture of non-target fish and shellfish, (iii) entanglement of sea turtles, marine mammals, sea birds, and fish in lost nets and debris, (iv) ingestion of gear-related litter by marine fauna, (v) physical impact of gears on the benthic environment, and (vi) the ultimate fate of lost gear in the marine environment with degradation products being introduced to the food chain. Factors complicating the analysis of entanglement were demonstrated within the project FANTARED (table 3.1.1a).

Table 3.1.1a: Factors complicating the analysis of marine entanglement trends

Detection	Sampling and reporting biases
Entanglement occur as isolated events scattered over wide range	Virtually no direct, systematic at-sea sampling has been done and there are few long-term surveys.
Entangling debris is not easily seen on live animals at sea because animals may only be partially visible at great distances	Sampling methodologies are inconsistent
Dead animals are difficult to see because they float just beneath the surface and may be concealed within debris masses	Stranding represent an unknown portion of total entanglements
Dead entangled animals may disappear quickly because of sinking or predation.	Shore counts of live entangled animals are biased toward entanglement of survivors carrying small debris
	Entangled animals spend less time ashore and more time foraging at sea
	Some entanglements reflect interactions with active rather than derelict fishing gear
	Many unpublished or anecdotal results
	Recent data only

135. There is a general lack of available data on marine wildlife in the Mediterranean. For cetaceans, factors that may contribute to the entrapment of organisms in ghost gears (Bearzi, 2002) include (1) the presence of organisms in the nets or in their proximity, (2) the water turbidity, making the fishing gear less visible; (3) the capability of cetaceans to detect the net filaments by means of echolocation, and (4) the ambient noise, for cetaceans, in the marine environment that may mask or confuse the echoes produced by fishing gear . Moreover, lack of experience by juvenile or immature individuals may make them more vulnerable to entrapment in gillnets. Types of impacts vary, including ingestion of lost pieces of net (Alon *et al.*, 2009)

136. In the Mediterranean Sea, monk seals also interact with static fishing gear (Cedrian, 2008). In the Northern Ionian Sea, Zakynthos fishers endured an overall damage rate of 4.96% out of 1632 net settings. Entanglement in ghost nets is then a probable impact, even not described for now, especially in very coastal waters. Ghost gears may also damage benthic habitats and can potentially pose safety risks for fishers if they become entangled with active fishing gear.

137. More generally, proven harm may not be useful for monitoring purposes as organisms may continue to travel over considerable distances after becoming entangled in ropes, net and lines, hence transforming active fishing gear into marine debris. As a consequence, monitoring of impacts mainly record ingested litter, due to difficulties in distinguishing between entanglement in litter and active fishing gear. The current difficulties in interpreting data, together with the low reported numbers of entangled beached animals and the problems associated with large-scale harm assessment due to the rarity of stranding, mean this approach can only usefully be applied to specific areas and on the basis of national decisions (Galgani *et al.*, 2013 and 2014). Research may contribute to the development of new, more specific entanglement indicators. (Votier *et al.*., 2011). For example, guidelines are currently being developed for litter in seabird nest structures as a source of entanglement as the litter found

there cannot originate from active fishing gear. Even with some research needed to define behaviours, breeding seasons, and the types of litter brought into seabird nests, the monitoring of species in the Mediterranean Sea such as shags (Phalacrocorax aristotelis) is promising. This particular species is very common throughout the whole basin and nests on coastal areas in most European and North African countries, as well as on the Black Sea coast.

1.2.Ingestion

138. More than 62 million of debris items are estimated to be floating in the Mediterranean (Suaria and Aliani, 2014), and these may affect marine organisms through indirect health effects such as after ingestion. Moreover, some species that are feeding on bottom may also ingest litter directly from the sea floor. Beyond the direct impact on survival, debris ingestion causes sub-lethal effects related, for example, to the decrease of natural food inside the organisms' stomachs, and therefore a change in the amount of absorbed nutrients, or the ingestion of toxic substances adsorbed on or released directly from the plastic (Gregory 2009). They may act as endocrine disruptors and therefore can compromise the fitness of individuals (Teuten *et al.*, 2009; Rochman *et al.*, 2013 and 2014).

139. More than 180 marine species have been documented as having absorbed plastic debris, among these various different species of sea birds (Van Franeker *et al.*, 2011), fish (Boerger *et al.*, 2010), and marine mammals (de Stefanis *et al*. 2013), including plankton species (Cole *et al*. 2013). All species of turtles living in the Mediterranean Sea are listed as globally vulnerable or endangered (IUCN, 2013) and have been found to ingest debris. Except in the case of occlusions (Sea turtles, mammals, etc.) or storage by some species (Procellariforms), excretion of ingested indigestible particles with feces is very common for all kinds of organisms. Nevertheless, a number of harmful effects of ingested litter have been reported; the most serious effects are the blockage of the digestive tract (occlusion) and internal injuries by sharp objects, which may be a cause of mortality (Katsanevakis, 2008).

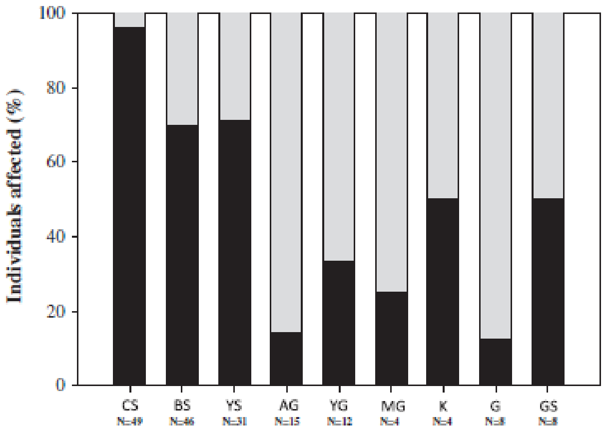


Figure 3.1.2a: In a first assessment of plastic ingestion in Mediterranean seabirds (Codina et al. 2013), plastics were quantified and measured in the in the stomach of 171 birds from 9 species accidentally caught by longlines in the western Mediterranean from 2003 to 2010. Without differences in Plastic characteristics and sex, Cory's shearwaters Calonectris diomedea) showed the highest occurrence (94%) and large numbers of small plastic particles per affected bird, followed by Yelkouan shearwaters (Puffinus yelkouan, 70%), and Balearic shearwaters (Puffinus mauretanicus, 70%). Other species (Audouin's gull, Ichthyaetus audouini; Mediterranean gull, Ichthyaetus melanocephalus; yellow-legged gull, Larus michahellis; black-legged kittiwake, Rissa tridactyla and great skua, Catharacta skua)were below 33%.

140. Sub-lethal effects caused by marine litter ingestion may greatly affect populations in the long term. One potential sublethal effect is diminished feeding stimulus and nutrient dilution, i.e. reduced nutrient gains from diets diluted by consumption of debris. This may have serious implications on the population level because of possible reduced growth rates, longer developmental periods at sizes most vulnerable to predation, reduced reproductive output, and decreased survivorship (McCauley and Bjorndal, 1999). Such sub-lethal effects of marine litter and their impacts on the population level need to be further investigated.

141. Impacts on fish have been found to vary greatly as a function of their ecological compartments. Highly affected species include *Boops boops*, myctophids, *Coryphaena hippurus, Seriola dumerilii, Schedophilus ovali,* and *Naucrates ductor* (Deudero & Alomar, 2014). Recently (Romeo *et al.*, 2015, in press), tunas and swordfish from the Mediterranean Sea were identified as targets species with occurrence of micro, meso, and larger plastics in more than 18% of the samples. Spot-scale bioindicators of micro-plastics in Mediterranean Sea bottom ***(****Mullus barbatus, Solea sp.)* and coastal shores *(Mytilus galloprovincialis, Arenicola marina, holothurids)* are a better indicator of harm due to their feeding habits as detritivorous or filter feeders. Typically, high rates of filtration in mussels support high ingestion rates of microplastics *(Van Cauwenberghe et al., 2014).* Dolphins and whales are also known to ingest litter. Although known rates of incidences of ingested litter are generally low, in the percent range, except in some cases when accidental ingestion may be related on feeding on the sea floor. As a counterpart, large filtrating marine organisms, such as baleen whales and sharks, which ingest microplastics by filter feeding, are present in the Mediterranean Sea and, due to large amounts of water filtrated at each mouthful (approximately 70,000 L of water for *Balaenoptera physalis*), they could face risks caused by the ingestion and degradation of microplastics as suggested through the detection of plastic additives (e.g. phthalates) in tissues from stranded animals and from skin biopsies (Fossi *et al.*, 2012).

142. The loggerhead sea turtle (*Caretta caretta*) is the most abundant chelonian in the Mediterranean (Camedda *et al.,* 2014; Casale and Margaritoulis, 2010) and may ingest plastic bags mistaken for jellyfishes (Mrosovsky *et al.*, 2009) when they feed in neritic and offshore habitats. This is a very sensitive species to marine litter and one of the most studied. Despite the fact that the loggerhead is able to ingest any kind of waste, plastic items seem to be more significant than other kinds of marine litter. Different studies in the Mediterranean Sea (Lazar and Gracan, 2011; Campani *et al.*, 2013, Camedda *et al.*, 2014), as well as for other seas and oceans, demonstrated that plastic is the most frequently ingested anthropogenic debris. There is no difference in litter found in stranded sea turtles when compared with those excreted by hospitalized ones (Cameda *et al.*, 2014), with analyses showing homogeneity in relation of the total abundance, weight, and composition among alive and dead individuals.

143. Plastic fragments and other anthropogenic materials may be directly responsible for the obstruction of digestive tracts (Bugoni *et al.,* 2001; Di Bello *et al.,* 2006) and even death (Bjorndal *et al.*, 1994). Furthermore, long retention times of plastic debris in the intestine may cause the releasing of toxic chemicals (e.g. phthalates, PCBs) that may act as endocrine disruptors and therefore can compromise the fitness of individuals (Teuten *et al.*, 2009).

144. Sea turtle species have different lifestyles at various stages of their lives; they can frequent disparate areas, feeding on epipelagic or benthic prey in oceanic and neritic zones. At the early stage of their lives, individuals are mainly inactive and gradually begin to swim against the tide reaching shallow water. Then adults start to use the sea bottom and the water column as a feeding compartment (Casale *et al.* 2008, Lazar *et al.* 2010). Adult loggerheads have been found to show fidelity to their neritic feeding grounds, which may be the same ones they traveled to as juveniles (Casale *et al.*, 2012). For these reasons, they are likely to ingest waste in different habitat types during their lives.

145. The transition from the pelagic stage to the neritic one occurs at different range sizes, when the curved carapace length is around 40 cm (Casale *et al.* 2007). While some studies reported that smaller oceanic turtles are more likely to ingest debris than larger turtles, most results in the Mediterranean Sea showed adult specimens of loggerhead with higher values of marine litter as compared with the juvenile specimens (Campani et., al., 2013). Adult individuals are able to discriminate colors to find food, but both adults and juveniles ingest plastic materials “preyed” on the sea surface and in the water column.

146. The loggerhead sea turtle, *Caretta caretta*, demonstrates great tolerance of anthropogenic debris ingestion, and the species is generally able to excrete these items (Casale *et al.*, 2008; Frick *et al.*, 2009). Camedda *et al.*, 2014 observed that sea turtles released anthropogenic materials in feces for longer than a month of hospitalization, with most of the litter expelled within the first 2 weeks. Studies about transit time of substances in gastro-intestinal tracts of loggerhead sea turtles demonstrated that materials (as polyethylene spheres) are expelled in about 10 days (Valente *et al.*, 2008). Therefore, they conclude that, considering the mean distance covered in 10 days by *C. caretta*, the litter defecated during the hospitalization into the tanks is likely to be a sample of debris present at a distance of less than 120 km (Camedda *et al.*, 2014).

Table 3.1.2a: Ingestion rates of Litter in Mediterranean Sea turtles. Size is given in carapce length.

Area	Date	size	Individuals/ dead	With ingested litter (%)	live individuals	With ingested litter (%)	Total	With litter (%)	References
Sardinia (E&W)	2008-2012	21-73	30	20	91	12	121	14,04	Camedda *et al.*, 2013
Tuscany	2010-2011	29-73	31	71			31	71	Campani *et al.*, 2013
Adriatic	2011-2004	25-79	54	35,2			54	35,2	Lazar & Gracan, 2011
Spain	nd	34-69	54	79,6			54	79,6	Tomas *et al.*, 2012
Lampedusa	2001-2005	25-80	47	51,5	33	44,7	79	48,1	Casale *et al.*, 2008
Malta	1988	20-69			99	20,2	99	20,2	Grammentz, 1988
France	2011-2012	nc	2	0	54	24	56	19,6	Dell'Amico & Gambaiani, 2012
France	2003-2008		20	36			20	36	Claro & Hubert, 2011
Balearic islands	2002-2004	36-57	19	37,5			19	37,5	Revelles *et al.*, 2007
Linosa	2006-2007	26,7-69					32	93,5	Botteon *et al.*, 2012
Italy/Spain (Murcia)	2001-2011				155	50	155	50	Casini *et al.*, 2012

3.1.3 Transport of species/ New habitats.

147. In most cases, organisms are shown to utilize the debris items in oceans as habitats to hide in, adhere to, settle on, and move into new territories (Barnes, 2002; Gregory, 2009). This type of dispersion is not really new as dead woods, ash, coconuts, or other floating fruits are debris that have promoted colonization by sea for millions of years. This, however, has become a real problem because of the recent proliferation of floating particles, most of which are plastic. The 250 billion microplastics floating in the Mediterranean Sea (Collignon *et al.*, 2012) are all also potential carriers for alien, harmful species and so-called "invasive" species (Maso *et al.*, 2003).

148. As described by Katsanevakis *et al.* (in CIESM, 2014), the first animals colonizing plastic surfaces at sea after biofilm made of microorganoisms are suspension feeders (polychaetes, bryozoans, hydroids and barnacles). Unicellular organisms are also present on floating debris. Foraminifera, diatoms, dinoflagellates, including harmful species (Maso *et al*, 2003), coccolithophorids, radiolarians, and ciliates are frequently seen, as well as many species of algae that are widely described (Carson *et al.*, 2013, Collignon *et al.*, 2014) as having a distribution "in patches" that is affected by factors such as location, temperature, salinity, plankton abundance, and plastic concentration (Carson *et al.*, 2013). The abundance of some species may increase with the roughness and size of fragments, especially on polystyrenes, and they may benefit from local conditions such as light or the presence of food. Mobile scavengers and predators, such as Peracarid crustaceans and crabs, gradually join these organisms, and ultimately there can be a wide variety of other animals. The plastic may be entirely covered in just a few months. Most, if not all, of the colonisers grow to become adults and, under proper conditions, can reproduce – so the raft becomes a source of larvae (eg which may colonise other nearby plastic). This can drastically change the directions, spread, and chance of success for aliens to spread and establish. As an example, among the rich fauna found on floating plastics sampled in the north western Mediterranean Sea, substantial specimens of a single species of benthic foraminifer, *Rosalina globularis,* were found (Jorissen *et al.*, in CIESM, 2014). This is very rare foraminiferal taxa with a planktonic (*Tretomphalus*) stage, enabling the colonization of floating plastics during sexual reproduction and dispersion of gametes at the surface that is only possible part of the time when temperature is above 18°C.

149. Although there are many studies on the colonization of fixed plastic panels, the colonization process of floating marine litter and the relevant ecological succession needs further research, as it is inherently different when compared to fixed submersed plastic panels (interaction with the atmosphere, effects of weather conditions, direct sunlight etc.).

150. The large availability of floating litter can assist in the transport of species beyond their natural boundaries and in their introduction to environments in which they were previously absent (Ciesm, 2014). Barnes and Milner (2005) estimated that human litter more than doubles the rafting opportunities for biota, assisting in the dispersal of alien species. This role is not well understood, especially in the Mediterranean Sea at a point where marine litter has not been included as a potential vector of introduction of alien species in any of the recent assessments on primary pathways for introduction (Katsanevakis *et al.*, 2013), where shipping, corridors (Suez Canal and inland corridors), aquaculture, and aquarium trade have been identified as the most important pathways. However, as stated by CIESM (2014), thirteen species alien to the Mediterranean are known to colonize floating litter elsewhere in the world. Furthermore, more than 80% of the known alien species in the Mediterranean might have been introduced by colonizing marine litter or could potentially use litter to further expand their range (secondary invasion). In many cases, plastic can be colonized more easily than vessel hauls (metal), and litter may arrive in the Mediterranean through the Suez Canal with a non-negligible potential to raft Red Sea organisms (Galil *et al.*, 1995).

151. By sinking, debris may also have an impact on the deep sea environment. These areas may be affected with dumped waste and deep currents sometimes subject to significant intensity. Litter, then, by providing solid substrates and new habitats, may impact the distribution of benthic species even in remote areas (Katsanevakis *et al.*, 2007; Pham *et al.*, 2014).

152. There was an increasing trend in both total abundance and the number of on the impacted surfaces, because the litter provided refuge or reproduction sites. A marked change in the community structure of the impacted surface and a clear successional pattern of change in this community composition were demonstrated (Katsavenakis *et al.*, 2007).

153. More than 40% of the plastics on trawling grounds from the Mediterranean were colonized by biofilms of micro-organisms, and, in some areas, up to 12% of plastics were totally covered by larger organisms, suggesting indirect effects on benthic communities (Sanchez *et al.*, 2013).

154. To date, incrustation of nano- and micro-planktonic or benthic organisms on marine litter has not been described in the deep, but sponges, sea anemones, hydroids and Scleractinian corals, Polychaetes, Bryozoa, Molluscs, Echinoderms, Tunicates and rockfishs were all found fixed on litter from ultradeep areas (Ramirez lodra, 2011, 2012 and 2013, Fabri *et al.*, 2013, Sanchez *et al.*, 2013), most of which are suspension feeders. As a consequence, the presence of marine litter may alter biodiversity as it increases habitat heterogeneity.

155. A field experiment on shallow soft substrata (Katsanevakis *et al.*, 2007) found a marked gradual change in the community structure due to marine litter, with a clear successional pattern of change in the mega-fauna community composition, the establishment of new intraspecific and interspecific competition for hard substratum and shelter, and new predator-prey interactions.

156. Overall, the Mediterranean Sea is a receiver rather than an original source of species (Katsavenakis, In CIESM, 2014). Plastic litter provides more opportunities, both in number and surface area, better surface characteristics, lower speeds that favour settlement, and a larger dispersion than ships travelling port to port. The secondary dispersion after primary invasion that is then favourable is a path mainly through Gibraltar and the Suez Canal. As a consequence, dispersion to multiple locations decreases options for containing or removing any alien species, thereby increasing risks of significantly impact on fisheries, aquaculture, tourism, water treatment, etc.

3.2 Marine litter and human health

157. Marine litter, both stranded and floating, is considered a public health issue (Sheavily & Register, 2007). Typically, large sized debris may affect humans from molecular (toxicity) to individual levels. Pieces of glass, discarded syringes, and medical waste all present possible harms to beach users. In some UK beaches, up to 4% of injuries by needles are observed on beaches (Anonymous, 2012). However, evaluating harm is difficult, as most incidents are unrecorded, and measures such as cleaning, ruling, and public information may prevent from litter associated risks. Entanglement can also pose a threat to swimmers and divers, who can become entangled in submerged or floating debris such as fishing nets and ropes. Although this is uncommon, it is regularly reported for monofilament nets (Mouat *et al.*, 2010). Because of the toxicity of heir components to human, especially plasticizers and additives (Flint *et al.*, 2012; Oellman *et al.* 2009), and because of the possible leaching of poisonous chemicals (Thompson *et al.*, 2009; Andrady, 2011), plastics may be considered as potential biohazards. To date, concentrations at sea remain very low (Flint *et al.*, 2012) and may not be relevant in terms of chronic contamination. The risk to humans is, however, important when considering accidental inputs of debris, from containers for example, with a massive presence of toxic compounds or harmful debris.

158. Microplastic-related harm to humans is still under discussion. From an individual to a population level, magnification of ingested litter or microlitter trough the food chain and the consumption of sea food has not been demonstrated as harmful. While recent studies have demonstrated the injury of digestive gland cells after litter ingestion in *et al.*(Von Moos *et al.*, 2012), the excretion of feces containing styrofoam litter in various planktonic species is well documented (Cole et al, 2013), and one may expect an intestinal transit to decrease potential risks of litter bio magnification.

As a counterpart, the introduction of vast quantities of plastic debris, both micro and macro, into the ocean environment over the past half-century has massively increased the amount of raft material and consequently increased the opportunity for the dispersal of many and various marine organisms. Plastic debris is now an abundant substrate for microbial colonization, physically and chemically distinct from natural substrates, and could support distinct microbial communities. Different types of substrates, including fishing lines, hooks, plastic bottles, and metal cans, were shown to deliver pathogens to fish, in vitro (Pham *et al.*, 2012). Bacteria, which play an important role in the formation of primary biofilms, are also transported (Zettler *et al.*, 2013; Carson *et al.*, 2013), a "plastisphere" ecosystem whose consequences are not controlled (Zettler *et al.*, 2013), even when the question of the transport of pathogens has now become crucial and may potentially support impact on human health.

3.3. Secondary pollution from marine litter

159. In recent years, secondary pollution from the leaching of pollutants from litter has been extensively studied, including in the Mediterranean Sea, to estimate the contribution by marine litter in the pollution of the sea by metallic or organic chemicals (Chalkiadaki, 2005, Rochman et *al*., 2013) and to understand if litter, beyond its unfavorable effects as debris, acts as secondary sources of pollutants, particularly over the long periods of time that it takes to decompose. The results of the studies showed that marine litter indeed acts as a secondary source of pollutants. Plastic additives (PAs) can leach out of the matrix over time and exert toxic and endocrine disruptive effects on marine organisms when plastics are ingested (Oehlmann *et al.*, 2009), and the transfer or enhanced bioaccumulation of persistent organic pollutants (POPs) may also occur as a consequence of the high sorption capacity of many plastics for lipophilic compounds (Rochman *et al.*, 2013).

160. Phthalates generally do not persist in the environment, but they may leach from plastic debris on a fairly steady basis. Di-(2-ethylhexyl) phthalate (DEHP) is the most abundant phthalate in the environment, but is metabolized in its primary metabolite, MEHP (mono-(2-ethylhexyl) phthalate), which can be used as marker of exposure to DEHP (Barron *et al.*, 1989). High concentrations of these plastic-associated contaminants and nonylphenol have been measured in small planktivorous fish, and recent laboratory experiments (Rochman *et al.*, 2014) indicated that they might alter the endocrine system function of fish. In large filter-feeding organisms (basking shark and fin whale) of the Mediterranean Sea, Fossi *et al.*, (2014), showed that the presence of harmful chemicals may be linked to the intake of plastic derivatives by water filtering and plankton ingestion. There is also an increased concern regarding persistent, bioaccumulative, and toxic (PBT) chemicals such as polycyclic aromatic hydrocarbons (PAH) and pesticides adsorbed onto plastics, which then become vectors for the bioaccumulation of these highly toxic pollutants in fatty tissues (Rochman *et al*., 2013), posing a long term risk to the environment. The most common synthetic polymers in beached samples were found to be polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyurethane (PU).

161. Beaches located downstream from industries and/or port facilities showed higher quantity of plastic debris and microplastics as well as higher concentrations of POPs (PAH, PCB and DDT). PCBs and DDE attach to debris with a partition coefficient, Kd of approximately 100,000-1,000,000 over seawater. Similarly, phenanthrene, a PAH, affixes to plastic debris 13,000-fold over seawater (Engler, 2012). Most of these chemicals can potentially affect organisms having endocrine disruptors potency and affect population viability (Teuten *et al.*, 2009). Based on data from beaches on the Greek coast (Karapanagioti *et al.*, 2011), pellets near port facilities may reach PAH concentrations as high as µg g^{1} exhibiting congener patterns from petrogenic sources. PCB contamination is higher in aged pellets than in any of the other type, and the more chlorinated congeners recorded higher concentrations in the proximity of urban areas. The highest total DDT levels are found near industrial sites and port facilities. Though there are no defined levels of toxicity for persistent organic pollutants adsorbed to plastic particles, it is probable that effects may exist, as these pollutants are known to desorb in certain conditions (Endo *et al.*, 2013). Nevertheless, modelling studies by Koelmans *et al.* (2013) showed that ingestion of contaminated plastics does not necessarily lead to increased bioaccumulation in organisms. One of the reasons is the limited retention

time of the material which prevents complete desorption of co-transported contaminants during gut passage. Finally, relationships between harm (at a specific endpoint) and particle size are still to be determined, especially for nanoparticles below 30 – 100 nm in size due to a possible uptake (Von Moos, in CIESM, 2014).

162. In an example of litter collected around Athens (Chalkiadaki, 2005, Table 3.3a), the various categories of litter containing metal contamination in different percentages on the various beaches was examined, with Zn as the most important metal found on debris.

Table 3.3a: Heavy metals in mixed waste collected on beaches from Greater Metropolitan Area of Athens (2007-2008). Data are expresses as mg/kg (After UNEP, 2011)

	Zn mg/kg	**Cr mg/kg**	**Cu mg/kg**	**Ni mg/kg**	**Pb mg/kg**	**Cd mg/kg**
Plastic packaging	191± *99*	11.6± *7.9*	32.4± *22*	3.67± *0.85*	33.7± *49.0*	1.*52*±*3.79*
Other plastics	637± *816*	32.4± *78*	237± *757*	3.35±*1.95*	193± *332*	7.51±*15.4*
Textiles	150±*88.1*	39.8±*92.7*	35.4±*29.1*	2.73±*2.44*	68.3±*106*	0.22±*0.19*
Paper packaging	102±*37.9*	13.87±*14*	25.2±*8.38*	6.43±*9.73*	13.4±*0.44*	1.43±*4.39*
Printed paper	68.0±*28.4*	12.7±*6.22*	35.7±*26.6*	3.61±*1.34*		0.08±*0.12*
Other categories of paper	97.9±*49.5*	11.6±*5.75*	10.9±*5.95*	4.33±*2.58*		0.08±*0.06*
Composite	34.9±*21.2*	6.18±*1.41*	13.3±*7.01*	1.96±*1.88*	1.05±*0.74*	0.06±*0.01*
Organic	412± *562*	52.5± *39.3*	625±*1428*	12.4±*9.61*	15.5±*22.6*	0.92±*1.53*

In another experiment, leaching from plastic bags and cigarette butts was evaluated, measuring desorption of metals extracted using sea water for 3 months. Data indicated a possible release of 0.8 kg of Zn per km of beach. (Table 3.3b).

Table 3.3b: Metal content (mg/km) measured on plastic bags and cigarette butts (3 months extraction using seawater) collected on a Greek beach (Unep, 2011). Samples consisted of 1,170 plastic bags and 14083 cigarette tips collected on the 16,200 m beaches that were cleaned by HELMEPA in 2002

	Cd	**Cu**	**Pb**	**Zn**
Plastic bags	0.027-0.54	0.068-.220	0.300-1.390	6.70-9.70
Cigarettes butts	2.50-10.3	156-234	49-87	451-838

3.4. Socio-economic impacts

163. The collection, treatment, and disposal of solid waste involve considerable economic and environmental costs. Generating less waste would therefore be better both for the economy and the environment of the region.

164. Litter in the marine environment gives rise to a wide range of economic and social impacts and negative environmental effects are often also interrelated and frequently dependent upon one another (Ten Brink *et al.,* 2009). Ghost fishing, for example, can result in harm to the environment, economic losses to fisheries, and reduced opportunities for recreational fishing (Macfayden *et al.,* 2009). Our understanding of these impacts remains limited, particularly for socio-economic effects. For the European commission, the total costs of marine litter is estimated at 263 million euros (Arcadis, 2014), with a value for the closed Mediterranean Sea likely even more important due to the population in the region, maritime traffic, and tourism. The social impacts of marine litter are rooted in the ways in which marine litter affects people's quality of life and include reduced recreational opportunities, loss of aesthetic value, and loss of non-use value (Cheshire *et al.*, 2009).

165. In the Mediterranean, there is little or no reliable data on what the exact costs are. Furthermore, the loss of tourism and related revenues due to marine litter both on the beaches and in the sea, although recognized and considered, has not been quantified in detail. Economic impacts are most often described as including the loss of aesthetic value and visual amenity, discouraging users in polluted areas (Ballance *et al.*, 2000), the loss of non-use value (Mouat *et al.,* 2010), public health and safety impacts (extent and frequency of incidents), navigational hazards (fouling and entanglement in derelict fishing gear, burnt out water pumps, collisions with large marine litter can damage, etc.) that are often unreported, and impacts on fishing, fishing boats, and fishing gears (cleaning), as well as the costs that burden local authorities and other bodies for monitoring and clean-ups.

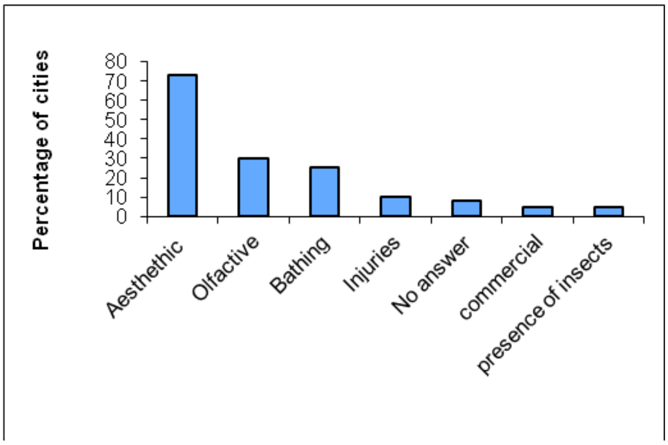


Figure 3.4a: Impacts of marine litter as perceived by 40 different towns/cities managers along the coasts of France (37), Monaco (1) and Italy (2). Data was collected through a questionnaire, and results are expressed as % or towns/cities citing a type of impact as significant (data from Cedre, 2000, in Galgani et al., 2011).

166. In practice, the wide diversity of impacts makes measuring the full economic cost resulting from marine litter extremely complex (Mouat *et al.*, 2010). Direct economic impacts such as increased litter cleansing costs are clearly easier to assess than the economic implications of ecosystem degradation or reduced quality of life due to the wide variety of approaches for valuing the environment and detrimental anthropogenic impacts.

167. The economic impacts of marine litter are most often small-scale, rely on anecdotal evidence, and focus on particular aspects of the marine litter problem such as ghost fishing. Any understanding of the economic significance of marine litter therefore remains relatively limited (Ten Brink *et al.*, 2009).

Main costs are related to:

(i) Litter cleansing costs: Removing marine litter (and further disposal, management costs, etc.) is a necessary task. For example, the town Nice (France) have 40 persons a year, 5 boats and 1 plane to locate and collet litter from beaches and adjacent waters, with associated costs of more than 2 million euros each year (Galgani *et al.*, 2011) to ensure that beaches remain aesthetically attractive. In Spain, more than 60,000 € are spent annually to remove litter from harbours.
(ii) Losses to tourism: Marine litter can reduce tourism revenue and consequently weaken coastal economies. It remains unclear at what density litter starts to deter tourists but it has been shown outside the Mediterranean Sea that a drop in beach cleanliness standards could reduce revenue by up to more than 50% (Ballance *et al.*, 2000). It was found that 85% of beach users would not visit a beach with 2 or more large debris items per meter. In extreme cases, such as urban beaches, marine litter can also lead to the closure of beaches.
(iii) Losses to fisheries. Marine litter has a twofold impact on fisheries by increasing costs to fishing vessels as well as reducing potential catches and revenue through ghost fishing (see paragraph 2.2.4). The direct costs include repairing damage to the vessel and equipment, disentangling fouled propellers, replacing lost gear, lost earnings from reduced fishing time, restricted and/or contaminated catch, and cleaning of nets. Studies in Northern Europe demonstrated experienced losses reaching 25-40000 € per vessel/year (Mouat *et al.*, 2010).
(iv) Losses to aquaculture: Entangled propellers and blocked intake pipes present the most common problems for aquaculture operators and can result in costly repairs and lost time (UNEP 2009). In addition, the time required to remove debris floating in or around stock cages and to clean nets can represent a significant cost to aquaculture organisations, ranging around 1 hour per month for cleaning , with a cost of up to 1500€ per incident (Hall, 2000)
(v) Costs to shipping: Costs from marine litter are a result of vessel damage and downtime (Ten Brink *et al.*, 2009), litter removal (manual or not) and management in harbours and marinas (UNEP 2009), and emergency rescue operations to vessels (pleasure or commercial) stricken by marine litter (Macfayden *et al.*, 2009). However, the vast majority of incidents are unreported.
(vi) Costs to power stations: The effects of marine litter on power stations can include the blockage of cooling water intake screens, an increased removal of debris from screens, and additional maintenance costs (Mouat *et al.*, 2010).
(vii) Ecosystem degradation: The potential for marine litter to contribute to ecosystem deterioration is a critical concern. However, damage is extremely complex to evaluate and has not been addressed by research. Establishing what the long-term effects of marine litter will be on the environment is similarly highly complex and difficult to translate in terms of costs.

Table 3.4a: A summary of impacts of marine Litter on economic sector with estimated importance in the Mediterranean Sea. (Derived from Mouat et al., 2010) (+= low ; ++= moderate ; +++= high ; ?= unknown)

SECTOR	IMPACT	IMPORTANCE IN THE MEDITERRANEAN
MUNICIPALITIES	Health risks	++
	Legal action	+
	Hidden costs	?
	Disposal	++
	Beach cleaning	+++
	negative publicity	++
	Beach awards	+
TOURISM	Beach awards	+
	negative publicity	++
	Area promotion	++
	Reduced revenue	+++
	Reduced recreational opportunities	++
	Loss of aesthetic amenity	++
INDUSTRY	Damage to equipment	+
	Increased maintenance	+
	Plant/ staff downtime	+
	Removal of litter	+
AQUACULTURE	Manual removal of litter	+
	Vessel damage and staff downtime	+
	Net cleaning	+
SHIPPING	Vessel damage	+
	Costs of rescue	+
	Statutory duty	+
	Negative publicity	+
	Harbors cleaning and dredging	+
	Harbors awards	+
NGOs	Operational costs	++
	Financial assistance	++
	Volunteer's time	+++
FISHING	Repairing damage to fishing gear	++
	Replacement of lost gear	++
	Reduced and/or contaminated catch	++
	Reduced fishing time	+
	Gear cleaning	+
ECOSYSTEM SERVICES	Degradation costs	+

4. MARINE LITTER MONITORING PROGRAMS IN THE MEDITERRANEAN

4.1 Monitoring

168. Monitoring is an important part of any management strategy, as no strategy can be evaluated without monitoring data. The relative success of different tactics also cannot be determined, and monitoring is also necessary for the setting of targets.

169. Without some degree of information on trends and amounts across all compartments, a risk-based approach to litter monitoring and measures is impossible. In the Mediterranean Sea, countries must draw up their monitoring programmes in a coherent manner by ensuring monitoring methods are consistent across the region. This will facilitate the comparison of results and take into account relevant transboundary impacts and features.

170. Marine debris monitoring generally consists of various approaches, such as beach surveys, at-sea surveys, and estimates of the amounts entering the sea and impacts. Beach surveys are widely viewed as the simplest and the most cost effective, but they may not relate to true marine pollution and, because they may be affected by weather, the stranded debris may not necessarily provide a good indicator of changes in overall abundance.

171. Buried litter is usually not sampled, though it may be a considerable proportion of beach litter. Some beaches will better indicate specific sources of debris than others due to their location (remote beaches or urban beaches tracking ship and urban pollution respectively).

172. Despite more intensive sampling required to assess spatial scale, at-sea surveys probably reflect overall debris abundance best (CMS, 2014). Surveys can also only assess stock and not accumulation, From-deck observation, trawl surveys, and aerial surveys are the most accepted methods, depending on the size of litter, but the recent development of floating drones (Galgani *et al.*, 2013) will support large scale automated monitoring in the future. Seabed surveys are also conducted with divers, submersibles, and remote-operated vehicles. It is thus possible to obtain both accumulation and stock data in this marine compartment.

173. There is actually no regular monitoring of micro particles in the Mediterranean Sea. Another approach to monitoring is to look at impacts directly. Entanglement data does suffer from not always being expressed as a proportion of the population, due to a lack of population estimates, and can wrongly be conflated with within-species prevalence. Moreover, the distinction between active gears and litter when sampling stranded organisms is too difficult to enable regular and consistent monitoring. Ingestion sampling provides consistent data but is restricted to deceased and stranded individuals as opposed to a sample from the population at large. Moreover, species that can be considered for monitoring purposes must meet a number of basic requirements, like (i) sample availability (adequate numbers of beached animals, by-catch victims or harvested species), (ii) regular plastic consumption (high frequency and amounts of plastic over time in stomachs), and (iii) feeding habits (stomach contents should only reflect the marine environment).

174. The last approach for monitoring marine debris is at-source input monitoring. This may concern ship inputs (records from port waste reception facilities and garbage log books) or land based sources (inputs from rivers), and both are considered to be the most indicative of changes related to reduction measures.

175. In the Mediterranean Sea, there is very little coverage of any other marine compartment other than beach and stranded debris, the most mature indicator and the one for which most data is available.

176. As major future decisions within the Mediterranean will be based on measures, monitoring efforts should be shouldered by quality control/quality assurance (training, inter-comparisons, use of reference material for microplastics, etc.) to assist survey teams. Protocols do exist (UNEP, 2009, MSFD/Galgani *et al.*, 2013, UNEP/MAP, 2014) that take into consideration a standard list of categories of litter items in order to enable the comparison of results. Items may be attributed to a given source e.g. fisheries, shipping etc., or a given form of interaction (ingestion), thus facilitating identification of the main sources of marine litter pollution and the potential harm caused by litter. This will also enable a targeted implementation of measures.

177. Comprehensive and regular surveys of marine litter on beaches have been made in many areas, often over a number of years, by various NGOs in the Mediterranean region. Valuable information about the quantity and composition of marine litter found on beaches has been available in most of the countries, and the statistic sheets give an overview of debris found in the Mediterranean countries. However, there is a lack of official statistics for most of the Mediterranean countries. The challenges in dealing with this problem are not due to lack of awareness or the lack of data from various regions but rather are due to the lack of standardization and compatibility between methods used and results obtained in these projects. This makes it difficult to compare data from different regions and to make an overall assessment of the marine litter pollution situation for the entire Mediterranean region. This problem will be solved in the years to come with the implementation of the Marine Litter Regional Action Plan committed to coordinate and harmonize monitoring. Nevertheless, the existing programs are indicators of approaches that could be used to address the problem of Marine Litter in the Mediterranean.

178. Most programmes that exist or have existed in most Mediterranean countries involve(d) NGOs with various objectives such as cleaning or educating local/regional/national authorities, industry stakeholders, and the wider public. Helmepa, MiO-esdce, and MEDASSET in Greece, Legambiante and Acadomia Leviatano in Italy, EcoOcean in France, Vertidoscero in Spain, Clean Coast in Israel, and Ocean Conservancy (International Coastal Cleanup) are some indicative examples of successful Marine Litter monitoring programmes that have taken place in the Mediterranean. Some of them are cooperating together and are interrelated.

179. The “Clean Coast” programme (Alkalay *et al.*, 2007, in UNEP, 2011) shows that the litter problem can only be solved by the introduction of a holistic mechanism, backed up by a measurement index and applied long-term. Some argue that a country should not embark toward a solution to the marine litter problem until the sources of the litter have been analyzed and identified. However, the programme shows that “Action First” by countries may be the key. A strategy pursued for a long enough time will create a self -perpetuating mechanism that will generate success, not only for the residents of a country, but for neighboring countries as well. A combined international action of such kind may be the beginning of a turnover in reducing marine and coastal litter. Science-based coordinated monitoring is not organized at the basin scale but, its implementation is in progress within the UNEP/MEDPOL regional Action plan.

180. The MEDITS survey programme (International Bottom Trawl Survey in the Mediterranean, http://www.sibm.it/SITO%20MEDITS/principaleprogramme.htm) intends to produce basic information on benthic and demersal species in terms of population distribution as well as demographic structure, both on the continental shelves and along the upper slopes (80-800m), at a global scale in the Mediterranean Sea, through systematic bottom trawl surveys and with a common standardized sampling methodology and protocols. The last version (7) of the protocol is incorporating a common procedure for the voluntary collection of data on marine litter in agreement with the requirements of the MSFD. It will enable the organization of the collection of data on a regular basis and will provide assessments at the basin scale. To date 1280 sampling stations are being considered, some only on an irregular basis, covering mainly the European coasts with a strong potential to extend to the wider basin. As an example, figure 4.1a gives results from the Gulf of Lion, where monitoring was started in 1994 to enable the consistent evaluation of trends. The analysis of results demonstrated the absence of change for quantities of plastic during the period.

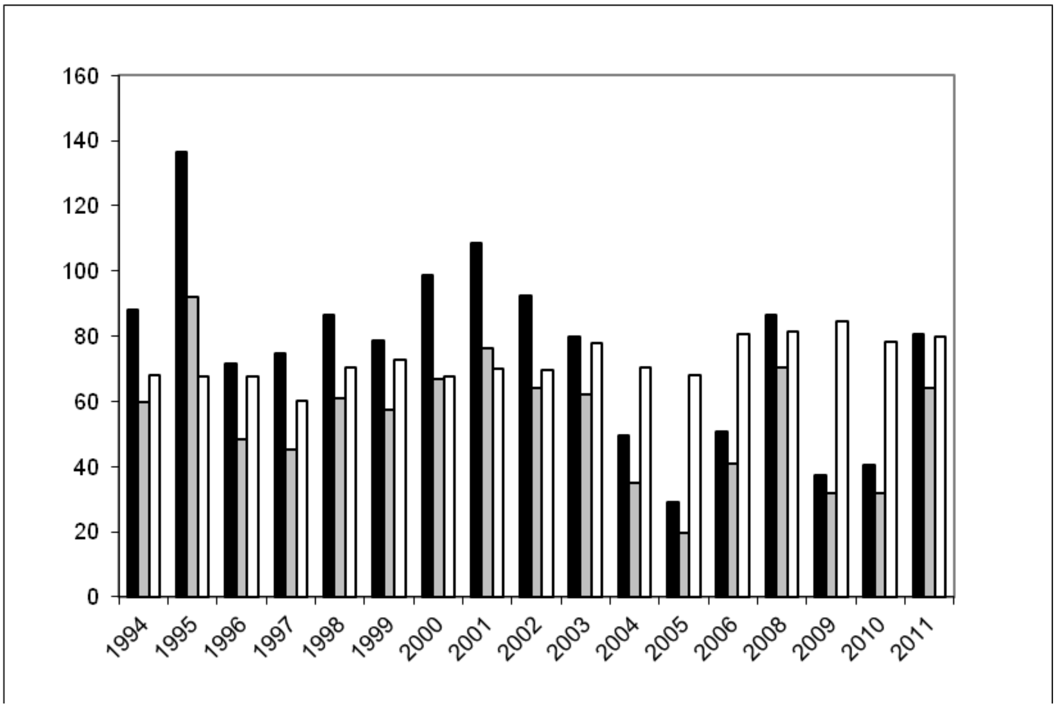


Figure 4.1a: *Evolution of seabed litter densities in the Gulf of Lion (France) between 1994 and 2011. Data was collected from MEDITS cruises and expressed as Total Items/km2 (black), Plastic items/ km2 (Grey) and percentage of plastic (White).* *(http://www.sibm.it/SITO%20MEDITS/principaleprogramme.htm)*

181. There is no monitoring of impacts in the Mediterranean Sea, but there is a good scientific and technical basis to start it. The loggerhead turtle, classified worldwide as “endangered” (IUCN, 2013), is adopted worldwide as a bio-indicator of environmental conditions, particularly pollution contamination. The use of sea turtles for monitoring ingested litter in the Mediterranean Sea was first suggested in 2010 by a MSFD task group (*Galgani et al.*, 2010) after many years of research. Protocols were then implemented (Matiddi *et al.*, 2011; Galgani *et al.*, 2013) providing support to monitoring. The loggerhead turtle’s extended spatial distribution in the Mediterranean Sea (Casale and Margaritoulis, 2010, Oliver, 2014; Darmon *et al.*, 2014), and the regular occurrence of anthropogenic waste in the stomach contents of the turtles (Tomas *et al.*, 2002; Lazar and Gracan 2011; De Lucia *et al.*, 2012; Bentivegna *et al.*, 2013; Travaglini *et al.*, 2013; Camedda *et al.* 2013 and 2014) are interesting criteria for using this species as an assessment and monitoring tool for marine litter in biota. Monitoring remains yet to be implemented and will need reinforced coordination, capacity building, quality assurance, and harmonization.

182. There is a potential for using litter ingested by other species as indicator of harm. In the North Sea, an indicator using fulmar (*Fulmarus glacialis*) to assess temporal trends of ingested litter has already been established (OSPAR EcoQO, Van Franeker *et al.*, 2011). However, alternative species for the Mediterranean Sea, such as shearwaters, have limited distribution indicating local interest only. Other species, such as fish with higher incidence of ingested debris (Boops sp. for example, Deudero *et al.*, 2014), Crustacea (Nephrops nephrops, Murray and Cowie, 2011), echinoderms, or mollusks, may also be considered as target species for microplastics but need more research to justify a standard for monitoring recommendation at this point, as information is fragmented and incidence is generally low.

183. The known incidence of ingested plastic is too low in the percentage range mammals to use this group for ingestion monitoring, or else it concerns species that occur in too low frequencies in the Mediterranean sea or that are ttoo difficult to collect (Cuvier´s beaked whales, MacLeod, 2009; Sperm Whales, Jacobsen *et al.*, 2010) to be used in a monitoring

system. Studies of litter in stomach contents of marine mammals are then certainly recommended, also from the viewpoint of knowledge of harm, but not as a monitoring tool.

4.2 Baselines and targets in the context of Monitoring Marine Litter in the Mediterranean Sea

184. There is currently no accepted Mediterranean or sub regional baseline against which to measure progress. Due to the poor differences between the Mediterranean sub-regions in terms of litter densities, the unequal spread of available data-sets, and some countries belonging to two or more sub-regions (Italy, Greece), it was recommended recently (UNEP/MAP/CORMON, 2015) that common baselines for the various litter indicators (beaches, sea surface, sea floor, microplastics, ingested litter) must be considered at the level of the entire basin (Mediterranean Sea) rather than at the sub-regional level (Table 4.2a).

Table 4.2a: Proposed baselines for monitoring marine litter in the Mediterranean Sea (UNEP /MAP, 2015)

Indicator	minimum value	maximum value	mean value	Proposed baseline
16. beaches (items/100 m)	11	3600	920	450-1400
17. Floating litter(items/km2)	0	195	3.9	3-5
17. sea floor(items/km2)	0	7700	179	130-230
17 Microplastics (items/km2)	0	4860000	340 000	200000-500000
18 (Sea Turtles)				
Affected turtles (%)	14%	92.5%	45.9%	40-60%
Ingested litter(g)	0	14	1.37	1-3

185. The amount of existing information may be limited, but set, definitive baselines may be adjusted after monitoring programmes could provide additional data. It is quite important to harmonize the monitoring programs with other Regional Seas Conventions (e.g. OSPAR) as much as possible. Each Region should then adopt a common master list, including the more frequent items, in order to produce harmonized shorter lists, which would be more useful and practical for field work.

186. Environmental targets are qualitative or quantitative statements on the desired condition of the different components of marine Mediterranean waters. They are important for management as they will enable regions to (i) link the aim of achieving objectives such as Good Environmental Status (GES) to the measures and effort needed, (ii) measure progress towards achieving the objective by means of associated indicator(s), and (iii) assess the success or failure of measures enacted to prevent marine litter from entering the seas and to support management and stakeholder awareness (Interwies *et al.*, 2013).

187. Broad based targets (maintain the level of Marine litter, reduce the amount of litter at sea, etc.) and "trend-based" targets (e.g. reduce the amount of litter transported by rivers, decrease the number of visible litter items on beaches) are possible options. Typically, broad targets will have many advantages such as a common concern enabling harmonized actions, political commitment, coordinated actions, and cooperation. Another approach would be to provide some flexibility in the extent of reductions towards a common goal. Our current lack of

knowledge with regards to metrics to be used is such that absolute targets are difficult to set;

188. The design of most protocols enables regional adaptation and the discrimination of litter items; they are therefore likely to detect changes in litter types and enable a proper assessment of the various measures implemented. Interwies *et al.* (2013) provided an overview of potential aspects to set targets on marine litter. They may consider (i) Location (Beaches, floating, estuaries, marine life, etc.), (ii) Composition or type (Plastic bags, cigarette bugs, microparticles, sanitary wastes, etc.), (iii) Sources and pathways (Rivers, ship-based litter, landfills, etc.), (iv) Sectors (Fisheries, recreation, industrial pellets, etc.), and (v) Measures (Reduce urban waste production, improve waste collection of land-based sources/sectors, improve collection of ship-based waste in the port reception facilities, improve waste water treatment, reduce consumer littering, and improve inspections at sea, etc.). These kinds of knowledge gaps lead to problems when trying to determine the relative importance of different sources and pathways globally and regionally, which are important for devising management strategies and tactics. Subsequently, they lead to difficulties in setting quantitative targets on marine litter at any level, whether global, regional, or by sector.

189. It may be possible to circumvent some of these issues by using trend targets and 'operational' measures. In December 2013, the Contracting Parties of the Barcelona Convention adopted the MLRP that defined general objectives and targeted measures and timetables for their implementation. The general objectives are (i) The prevention and reduction of marine litter pollution in the Mediterranean and its impact on ecosystem services, habitats, species, particularly the endangered species, public health, and safety, (ii) The removal to the extent possible of already existing marine litter using environmentally respectful methods, (iii) Improved knowledge on marine litter, and (iv) A management system that is in accordance with accepted international standards and approaches and which is in harmony with programmes and measures applied in other seas.

190. The MLRP also provides for strategic and operational objectives and lists a series of prevention and remediation measures that should be considered and implemented by the concerned actors. The establishment of both "state" and "pressure" complementary targets can then better reflect and support the effectiveness of specific operational objectives.

191. It is clear that there is more data on beach debris than for debris in the water column, even though there is not so much information available in Mediterranean marine waters to set quantitative thresholds related to the reduction of marine litter stranded on beaches.

192. Quantitative reduction targets for beach/floating/seabed litter and microplastics should nevertheless be considered. In this respect, higher targets will be easier to determine through monitoring than if weak targets had been set. It may not be technically possible, or only possible at higher cost, to measure a slight (few %) change that could just reflect a "background noise". Moreover, an apparent failure to achieve a modest target may be cited by some as evidence that more ambitious targets are not feasible and should not be pursued (CMS 2014).

193. There is quite a wide diversity of targets that may be defined by Mediterranean countries in terms of nature, ambition, and measurability, even between neighboring countries. Most countries involved in reduction plans have defined targets as a reduction in the overall amount of litter present in the marine environment or in any of its compartments (coast, seafloor, or water column) or biota. Within the context of various management schemes, reviewed by Arcadis (2014) some contracting parties have proposed various targets such as (i) Reduction of litter from beaches based on a five year moving average, (ii) Negative annual trend in beach litter, (iii) Reduction in litter on sea surface, water column and seabed, (iv) Reduction towards zero over the long term of harmful litter, (v) Entanglement and strangulation reduced towards a minimum, (vi) Less than X% of sea turtles having more than Xg of plastic in their stomachs, (vii) Various targets regarding better waste collection in coastal regions, (viii)

Reduced inflow from rivers and sewers, and (ix) Targets dedicated to education, as related to changes in behaviour (littering, etc.).

194. Where Contracting Parties are hesitant about establishing quantitative state targets, pressure/operational-oriented targets can complement their efforts, as they refer to human processes and activities, which are easier to monitor and influence. Formulating a sub-set of targets for specific sources of marine litter (e.g. litter generated by fisheries) or even particular types of items (e.g. reduce the average occurrence of the top identifiable items found on reference beaches) should facilitate breaking down such a complex issue into more quantifiable and complementary elements. Most actors may use beach litter as an indicator to assess the reduction of marine litter or directly relate beach litter to a target formulated. This is quite positive, as it reflects the intention to implement beach litter monitoring programs widely in the Mediterranean. If done in line with a common protocol, it will constitute a cost-effective methodology and a critical step towards a harmonized and comparable monitoring approach across the region. Further specification and harmonization are now needed in terms of how trends and reductions are to be determined (time scales for example) and have comparable reference periods. This may enable comparability, and, for this reason, other countries should be encouraged to consider beach litter as a common indicator to be adopted.

195. The setting of marine debris targets will encourage the implementation of monitoring programmes, and different types of targets are relevant to different types of information gaps (at-sea targets for improving the state of information about abundance, operational targets such as estuarine monitoring for improving information on pathway, source, and regional differences). However, due to a large set of factors affecting the quantities and distribution of marine litter in a certain area, it can be very challenging to detect clear reduction trends in the sea that can be associated to the implementation of measures in a particular area.

196. A proposal of a headline reduction target for marine litter on beaches was proposed by Arcadis (2014), based on (i) the targets already in use at the level of Europe, Contracting Parties, or UNEP/regional seas, (ii) the expectations of the general public and the stakeholders concerning an effective marine litter policy, (iii) the analyzed occurrence of key marine litter types, loopholes and pathways retrieved from 343 recent beach screenings in the four European regional seas, (iv) the modelled impact of the different policy options on marine litter, and (v) the assessed impact on marine litter that dedicated policy measures for specific litter items could have.

197. In September 2014, an aspirational target of reducing marine litter by 30% by 2020 compared to 2015 for the ten most common types of litter found on beaches, as well as for fishing gear found at sea, was established, with the list adapted to each of the four EU regions (EU communication 2014/398). As stated by Arcadis (2014), for European regional seas, measures targeting cigarette butts have resulted in reductions of the total number of beach litter items of up to 18%, reductions in plastic carrier bags of up to 13%, bottle caps up to 7%, cotton buds up to 2% and deposit refund systems for beverage packaging up to 12%, depending on the specificities of the regional sea concerned. The level of ambition of the proposed target remains high, as depending on the litter management policies from Contracting Parties may not fit for indicator EI 17. Floating litter may be transported from one country/sub basin to another, and sea bed litter is accumulating for long periods, with low degradation rates. Moreover, sources of microplastics cannot be distinguished by uses or other characteristics, and it will be difficult to relate targets with measures. In regards to the coordinated monitoring strategy in the Mediterranean sea and technical or scientific considerations, accessible targets were proposed UNEP/MAP,, 2015 and Table 4.2b) considering baselines that may be optimized after the 2015 first results from monitoring. Targets may focus on the total amount of marine litter first, with some specific targets on individual items after impacts of reduction measures can be evaluated. For floating and sea floor litter, a significant decrease in amount requires overcoming the constraints of diffuses and uncontrolled sources (tranboundary

movements, influence of currents) and permanent accumulation processes on the sea floor. Targets on ingested litter in sea turtles will then focus on the number of affected animals and the amount of ingested debris by number or weight.

Table 4.2b: Operational targets for the Mediterranean Sea as proposed within the Unep/MAP Marine Litter Regional Action Plan (2015)

ECAP INDICATORS	TYPE OF TARGET	MINIMUM	MAXIMUM	RECOMMENDATION	REMARK
BEACHES (EI16)	% decrease	significant	30	20% by 2024 or [2030]	Not 100% marine pollution
FLOATING LITTER (EI 17)	% decrease	-	-	Statistically Significant	sources are difficult to control (trans border movements)
SEA FLOOR LITTER (EI 17)	% decrease	stable	10% in 5 years	Statistically Significant	15% in 15 years is possible
MICROPLASTICS (EI 17)	% decrease	-	-	Statistically Significant	sources are difficult to control (trans border movements)
INGESTED LITTER (EI 18)					Movements of litter and Animals to be considered
Number of turtles with ingested litter (%)	% decrease in the rate of affected animals	-	-	Statistically Significant	
Amount of ingested litter (g)	% decrease in quantity of ingested weight	-	-	Statistically Significant	

5. MANAGEMENT AND REDUCTION MEASURES

198. Attempts to prevent marine litter require the inclusion of a vast amount of activities, sectors, and sources that cannot be addressed by a single measure. The Mediterranean MLRP and , the Berlin Conference on Marine Litter, 2013, Berlin, Germany (http://www.marine-litter-conference-berlin.info/) provided the following guiding principles as well as an umbrella structure that serves as a guiding framework for any of the following marine litter measures:

- The principle of prevention establishes that any marine pollution measure should primarily aim at addressing the prevention at the source, as removal of already introduced waste is very costly and labour intensive, especially compared with prevention measures.
- The polluter-pays principle has a preventive function in that externalities from polluting activities should be borne by the polluter causing it, which puts more pressure on potential polluters to make better attempts to avoid polluting. However, the application of this principle is limited by the difficulty in determining the polluter and also the extent of (environmental) damage.
- The precautionary principle is based on the understanding that measures must not be postponed in the light of scientific uncertainties. This principle plays an important role in setting targets and addressing the issue of micro-particles, despite an incomplete scientific knowledge on the specific sources and consequences of marine litter.
- The ecosystem-based approach is an approach that ensures that the collective pressures of human activities are considered.

- The principle of public participation is an important aspect of creating awareness for the problem of marine litter
- The principle of integration means that environmental considerations should be included in economic development. This principle constitutes a key element of the Protocol on Integrated Coastal Zone Management in the Mediterranean.

199. Implementing measures to reduce marine litter is a real challenge, as most sources are diffuse and cannot be easilycontrolled and managedt. Then, measures and actions taken should respond to the major sources and input pathways, but they should also take into consideration feasibility and the specificity of this pollution in the Mediterranean Sea. The main groups of items found on beaches in the Mediterranean are sanitary items (mostly cotton bud sticks), cigarette butts, and cigar tips, as well as packaging items and bottles, all related to coastal-based tourism and recreation. This indicates direct disposal, intentionally or negligently, on the beaches or inland (river banks, dumpsites, etc.) as the main input pathways.

200. The fishing and shipping industries are also considered major sources of marine litter. In the Mediterranean Sea, the following measures were seen to be most effective in tackling the problem (Table5.3a)

Table 5.3a: Main measures for the reduction of Litter in the Mediterranean Sea (after the Mediterranean expert meeting held during the Berlin Conference (2013, http://www.marine-litter-conference-berlin.info/)

TYPES	MEASURES
Sea based litter	Port reception facilities; No-special-fee system (also for marinas); Fishing for Litter; Removal of Abandoned & Lost & Discarded Fishing Gear.
Land-based litter	The inclusion of marine litter as an integrated part of municipal solid waste management; An improved waste management system, including the ban on illegal dumping, especially in tourism hotspots; The upgrade, redesign and improved maintenance of sewage system, including the storage of wastewater; The establishment of "Guidelines for Management of Coastal Litter"); The transfer of skills/knowledge to Mediterranean countries in the South and East; Education and outreach on marine litter impacts; Incentives/disincentives for littering; Bans on smoking on beaches and the introduction of dissuasive taxes (tax on plastic bags, a “tourist tax", etc.) .
Clean-up measures	Compulsory cleaning of inland pathways (rivers, near landfills etc.), beach cleaning by local communities and/or private companies (i.e. of the tourism sector); Incentives for beach cleaning (e.g. awards, like the “Blue flag award”).
Production	Smart production (Ban on single-use plastic bags, packaging guidelines; Elimination of certain products (microbeads); Use of paper/carton made cotton swabs; Extended producer responsibility measures and voluntary agreements with plastic industry for return and restoration integrated management systems.
Knowledge and data	Standard monitoring programme(s) that consistently describe the litter, their sources, and quantities; Information sharing around the Mediterranean.

201. In comparison, a meeting of stakeholders held in the Mediterranean within the European project Marlisco (Poitou and Poulain, 2015) concluded that the most promising measures in terms of reduction of marine litter were (i) a great national cause with an action plan, (ii) a deposit system for bottles, (iii) public awareness at the national level, (iv) collection and processing of Marine Litter at sea by fishermen, (v) the development of a litter collection in rain sewers, (vi) the optimization of the waste collection system, (vii) the reduction of waste at its source, and (viii) a tax for plastic producers.

202. Focus should also be directed toward management strategies that deal with debris known to have a high impact on marine species, such as fishing gear, soft plastic, and microplastic fragments. The numbers available on debris abundance also suggest that prevention must be addressed before removal can be effective.

203. Fishing for Litter is one of the most important measures that would lead to the reduction and removal of marine litter from sea. It has become one of the most successful concepts by involving one of the key stakeholders, the fishing industry. The initiative not only involves the direct removal of litter from the sea but also raises awareness of the problem inside the industry

as a whole. All types of marine litter are targeted, depending on the gear type used. Most are from the seafloor, collected with bottom-contacting gear. Filled bags of litter are deposited on the quayside, where the participating harbours monitor the waste before moving the bag to a dedicated skip for disposal. This reduces the volume of debris washing up on beaches and also reduces the amount of time fishermen spend untangling their nets. The objectives and aims of the scheme can gain the support of the fishing industry, port authorities, and local authorities. Furthermore, it can contribute to changing practices and culture within the fishing sector, provide a mechanism to remove marine litter from the sea and seabed, and raise awareness among the fishing industry, other sectors, and the general public. Fishermen are usually not financially compensated for their engagement, but the disposal logistics are free.

204. The best environmental practices and techniques should be used for this purpose, due to the fact that such interventions may also have a very negative impact on marine environment and ecosystems. Mouat *et al.* (2010) suggested that the health and safety aspects of implementing these types of initiatives would be the same as normal fishing activities (operations) and, therefore, there would likely not be any additional implications with regard to hazardous and other substances that might be caught in trawls and collected on board vessels. Moreover, the experience of Fishing for Litter projects in the North Sea since 2000 indicates that there have been no instances of accidents or injuries directly related to the collection, storage, or transfer to shore of marine litter collected as part of these projects.

205. Fishing for Litter projects are recent to the Mediterranean Sea, where four main projects are being developed currently (Zorzo Gallego, 2015), including (i) *Contrats Bleus, started in 2008* (3 French Mediterranean harbors, with financial compensation and best practices), (ii) Ecological bags on board (38 vessel Spanish East Coast collecting floating and seabed litter), (iii) *Ecopuertos* (Andalusian Coast, Spain, 5 trawlers collecting sea bed litter), and (iv) DeFishGear (seven participating Adriatic countries during one year targeting seabed litter and fishing gear (http://www.defishgear.net))**.** Since the participation of fishermen in the projects is voluntary, costs such as waste management, mainly litter collection at harbour and litter disposal, and coordination and data recording works need to be not covered by fishermen. Further implementation is being considered within the Mediterranean Regional Action Plan, developing best practices adapted to the context of the basin (Zorzo Gallego, 2015).

206. Additional work was started recently involving various NGOs such as Healthy Seas (http://healthyseas.org), Medasset (http://www.medasset.org/en/), ECNC (ecncgroup.eu), and private companies such as Nofir (Nofir.no) or Aquafil (http://www.aquafil.com/en/). These organizations are conducting underwater clean-ups and are also collecting nets from fishing and aquaculture industries for regeneration and recycling, turning them into high quality materials and textiles products. Operations were conducted in three Mediterranean regions (Turkey, Spain, and the Northern Adriatic) and provide background knowledge and skills for the sustainable valorization of collected materials.

207. Given the complexities of environmental problems and the impact of environmental policies on social and economic activities, specific environmental problems are usually addressed by employing a "policy mix," consisting of various command and control instruments, economic instruments, and persuasive instruments. Using economic instruments alone usually is not the only or ideal solution. Regulation or voluntary agreements may also be appropriate where there are a limited number of polluters, as the costs of setting up a scheme based on an economic instrument may outweigh the benefits (http://www.unep.org/regionalseas/marinelitter/other/economics/default.asp).

208. Oosterhuis *et al.* (2014) analysed the possible economic instruments to reduce marine litter. Poor waste management, limited awareness of the public, and inadequate interventions from industry and policy-makers are the main causes of the presence of litter at sea. There is very sparse information about the links between the amount of overall polluting material (e.g. plastic bags) and the extent to which this becomes marine litter (e.g. plastic in the sea). There are, though, a

few studies that have attempted to attribute marine litter to particular sectors and economic activities. In the Mediterranean, recreational and beach-related tourism activities account for a large part of all litter found on the beach, while the shipping industry contributes another large part, with sewage related debris comprising a minor part (see paragraph 2.1.1). The cost of cleaning marine litter can be significant, with municipalities spending millions of euros each year on removing beach litter. Marine litter also negatively impacts the fishing industry by causing a few percentage decrease of total revenue. As a result of the complexities caused by the diverse origin of marine litter, a wide range of instruments have been proposed to deal with it across multiple sectors. Some of them are regulatory policy instruments that focus on adopting relevant legislation to help minimise marine litter, such as the EU Directive 2000/59/EC on port reception facilities for ship-generated waste and cargo residues. Other instruments more economic in nature influence the amount of marine litter through taxes, charges, or subsidies.

209. There is no market to determine the desired level of marine litter, and any transaction costs would render them prohibitively expensive as a result of time-consuming procedures involving large number of individuals and firms. Policy instruments to limit marine litter include direct regulation of activities that contribute to marine litter by legislation (increase of standards for port facilities, ban of plastics bags, etc.) or economic instruments that provide (dis)incentives that allow firms and individuals greater flexibility in their approach to pollution management.

210. Command-and-control measures may be preferred when there is an urgent need, but economists argue that economic instruments are more cost efficient as means to reduce and prevent marine litter. Moreover, economic instruments can stimulate gradual changes in the behaviour of users by allowing environmental costs or benefits to be internalised into the prices of products or activities that reduce litter (Lanoie *et al.*, 2011, cited by Oosterhuis *et al.*, 2014).

211. Effectiveness is a key determining factor for economic instruments. The cost of implementation is another important factor that influences which instrument to opt for, and it focuses on how to allocate scarce resources (e.g. public funds) to meet a certain environmental objective. This is the case in the cost of ghost gears.

212. There is a wide range of economic instruments that can make use of either positive or negative financial incentives in order to tackle the marine litter problem. Financial disincentives (penalties, taxes, and charges) are applied to discourage behaviour that may contribute to the problem of marine litter. Charges and taxes can be seen as price tags on economic activities and may be collected on consumptive or productive activity that contributes to marine litter. Financial penalties however do not recognise a “pollute and pay”. The challenge for policymakers is then to set taxes and penalties at an appropriate level in order to enable certain targets of marine litter reduction to be met.

213. Financial incentives (deposit-refund schemes, subsidies, direct payments, price differentiation, and preferential treatments) are applied to stimulate behaviour in the form of encouraging recycling and reuse of materials and proper waste disposal. Subsidies and fiscal incentives are remunerations (Engel *et al.*, 2008), and deposit-refund schemes reward those consumers who return packaging material. Price differentiation can be used to encourage consumers to choose products and services that lead to less environmental damage. Preferential treatment is often a government-supported scheme that positively discriminates in favour of companies that are more environmentally friendly. Economic instruments that have been identified in the literature as a means to reduce marine litter are more or less effectives (Table 5.3b).

Table 5.3b: Effectiveness of economic instruments to reduce marine litter as evaluated from real experiments/situations worldwide (after Oosterhuis et al., 2014).

ECONOMIC INSTRUMENT	TYPE OF LITTER	EFFECTIVENESS	COSTS	REMARKS
Penalties	General	Limited, weak political support, conditional on the ability to identify the polluter	high	
Taxes on tourists	General	High in areas where tourism is prominent activity but may be Limited by opposition with the tourism sector and inadequate infrastructures	high	loss of competitiveness, less tourist arrivals
Taxes	Plastic bags	High (reduction in plastic bag use by 90% in Ireland since 2002), effective for limiting the demand but less for recycling	low	possible losses of jobs in plastic industry
Deposit refund schemes	General	More effective than environmental but may be limited by corruption in some countries	high	
Deposit refund schemes	Bottles	Limited by consumer preferences	high except when using containers	higher demand for non-refillable containers, cleaner public areas, job creation
Deposit refund schemes	Plastic bottles	Limited by consumer demand		
Subsides	General	Conditional to political support	high	
Direct payment awards	General	Conditional to political support, may be limited by local corruption in some countries	high	
Direct payment awards	Plastic bags	Low		
Direct payment awards	Fishing gears, bottles (to fishermen)	High with increased rate of participation	low when compared to litter removal	additional income for fishermen
Price differentiation	Plastic bags	Low		

214. Unfortunately for the Mediterranean Sea, there is no unique economic instrument, and the choice of an appropriate intervention is case specific, largely depending on the source and nature of pollution, the country's institutional characteristics and infrastructure, consumer preferences, perception and habitual behavior, and the economy's overall sectorial composition.

215. From non-Mediterranean experiences, it appears that (i) Taxes and charges can be very successful in reducing their use at a relatively low cost, (ii) The collection of tourist taxes, although there is a high risk these might be used for other purposes, can further support waste collection and treatment in coastal areas, (iii) Deposit-and-refund schemes can achieve high return rates in some countries, especially for bottles and cans, but they depend on the cost of

implementation, and (iv) Rewards for fishing vessels that return waste to shore have been shown to both reduce marine litter and complement fishermen's income.

6. RESEARCH GAPS, KNOWLEDGES NEEDS, AND PROPOSALS AS BASIS FOR SETTING PRIORITIES

216. Both the implementation of the management schemes and the improvement of knowledge on marine litter are long-term processes. Research and monitoring have become critical for the Mediterranean Sea, where not so much information is available. UNEP/MAP-MEDPOL,, 2013, MSFD (Galgani *et al.*, 2011), the European project STAGES (http://www.stagesproject.eu), and the CIESM (Ciesm, 2014) recently reviewed the gaps and research needs of knowledge, monitoring, and management of marine litter. This requires scientific cooperation among the parties involved prior to reduction measures due to complexity of issues.

217. Accumulation rates vary widely in the Mediterranean Sea and are subject to factors such as adjacent urban activities, shore and coastal uses, winds, currents, and accumulation areas. Additional basic information is still required before an accurate global debris assessment can be provided. For this, more valuable and comparable data could be obtained by standardizing our approaches. In terms of distribution and quantities, identification (size, type, possible impact), evaluation of accumulation areas (closed bays, gyres, canyons, and specific deep sea zones), and detection of litter sources (rivers, diffuse inputs), are the necessary steps that would enable the development of GIS and mapping systems to locate hotspots.

218. An important aspect of litter research to be established is the evaluation of links between hydrodynamic factors. This will give a better understanding of transport dynamics and accumulation zones. Further development and improvement of modelling tools must be considered for the evaluation and identification of both the sources and fate of litter in the marine environment. Comprehensive models should define source regions of interest and accumulation zones, and backtrack simulations should be initiated at those locations where monitoring data are collected.

219. The project STAGES (http://www.stagesproject.eu) stated that a better understanding of rates of degradation of different types of litter (plastics, degradable materials, bio plastics, etc.) and related leachability of pollutants is needed. At present, the lower limit of detection for plastic particles is around 1µm. It seems likely that even smaller particles of litter (nanoparticles) may exist, however we need to develop appropriate methodology to quantify these. We also need a better understanding of the potential areas/types and habitat where this material is most likely to accumulate, as the knowledge of the accumulation and environmental consequence of microplastic/nanoplastics particles is relatively limited.

220. Biota indicators provide possible signs of harm. Pilot-scale monitoring is therefore an important step towards monitoring litter harm in terms of determining baselines and/or adapting the strategy to local areas. A better understanding of entanglement (lethal or sub lethal) under different environmental conditions and of how litter is ingested by marine organisms is key. For ingestion of litter by sea turtles, the precise definition of target (GES) and the identification of Parameters/biological constraints and possible bias sources to be considered when defining the good environmental status are the priority research needs. Work on other "sentinel" species (fishes and invertebrates) is also important, as it may provide additional protocols supporting the measurement of impacts, especially for microplastics. Finally, the use of new approaches and the development of new metrics to assess entanglement in, or ingestion of, Marine Litter may open new perspectives in the context of monitoring.

221. With regards to the transport of species, many questions remain open and need to be further studied (Katsavenakis, CIESM, 2014). The (i) increase in the probability of translocation of species due to floating litter, (ii) the identification of species (including pathogens for both marine organisms and human) in the Mediterranean that settle on marine litter, (iii) the nature of constraints for the colonization of floating plastic, which Mediterranean alien or native species colonize floating litter, and (iv) the identification of Red Sea species that enter the Mediterranean via floating litter are key questions to consider for a better understanding of harm.

222. For monitoring, there is often a lack of information needed to determine the optimum sampling strategy and required number of replicates in time and space. This is an even bigger problem for microplastics, for which there is additional uncertainty about the optimal sampling scheme. Since the study of microplastics in the Mediterranean Sea is still in an early stage of development, a harmonization of sampling protocols for the water surface is highly recommended. Moreover, the comparability of available data remains highly restricted, especially with respect to different size class categories, sampling procedures, analytical methods, and reference values. Actual categorization probably needs to be amended by a further subdivision of the smallest size class of microplastics to include nanoplastics (Van Moos, CIESM 2014).

223. From the economic/management point of view (Unep, 2011), the problem of marine litter has not been successfully addressed in the Mediterranean because of (i) the lack of international legal instruments (except for IMO/MARPOL Annex V) or Global Programmes, (ii) the lack of coordination between actors, (iii) the poor regulatory framework for organizing the management of coastal waste (bad practices, poor classification of waste, no monitoring of production, lack of penalties and application of laws) and (iv) the problems that are encountered in the application of economic instruments (inconsistent information, lack of tools, little information on social and economic consequences, need for transparency, isolated awareness and educational campaigns).

224. An evaluation of direct costs and loss of income to tourism and fishery (incomes and stock losses, including protected/endangered species), an evaluation of costs due to clogging of rivers, coastal power plant cooling systems, and/or wastewater purification systems, the effectiveness of market based instruments related to marine litter, and the development of common methodologies to evaluate the costs of removal (collection and elimination of marine litter) are key elements that require further study.

225. Aside the implementation of the the Mediterranean MLRP and requiring integration within the development of national and local strategies, the support of a better management through (i) the development of common methodologies to collect social and economic data, (ii) an assessment of socially acceptable levels of marine litter to the public and industry, (iii) the development of social and economic impact indicators (aesthetic impact, effects on fishing industry/maritime sector and human health), and finally (iv) the education of the public (tourists, fishermen, general public) has now become critical. A prerequisite to these is the consideration of laws with a harmonization of national Mediterranean systems (jurisdictional measures and institutional structures), with conventions to support management schemes dedicated to marine litter.

226. In terms of measures, the development of tools to assess the effectiveness of monitoring, the implementation of measures intended to reduce the amount of marine litter and/or effectiveness programmes, the development of port reception facilities (taking into consideration the Mediterranean maritime traffic), and the consideration/elimination of transborder marine litter, including the intervention in case of critical situation (ex. Concordia), are the main priorities in the management of marine waters that have to complement management measures to reduce inputs.

227. Knowledge about the extent of ghost fishing is still very limited due to the costs and practical difficulties of underwater survey work and partial knowledge about fish stocks losses. There are actually no overall estimates of the extent of the problem for the Mediterranean as a whole. Research will have to first assess the presence of DFG in fishing areas and on fishing grounds, including deep-water fisheries, especially in areas where there is no information (Eastern and southern Mediterranean Sea). Evaluating the interest of retrieval for each area/sub-region is also an important point before taking on "cleaning". Finally, there are also research gaps on the environmental impacts of ghost gear, including the impacts of management responses, notably gear retrieval programmes. Research on economic impacts, such as the costs of gear loss and ghost fishing, or the relative costs and benefits of different management responses, will also be a necessary step before effective reduction measures can be implemented.

228. Macfayden (Unep, 2009) identified more specific gaps. They include rates of gear losses, ghost fishing mortality rates, measures of the extent to which entanglement occurs or affects species at the population level, incidence and aesthetic impact of ghost fishing nets as a source of marine litter, the ultimate fate and impact of lost gear (particulate matter), the impact, feasibility, and costs/benefits of different management measures tailored to particular fisheries, the economic valuation of net loss and ghost fishing impacts, the environmental impacts of management responses, the specification of Codes of Practice for minimising gear loss in particular fisheries, and some technical issues related to different management measures (marking of gear, new materials).

229. Outputs from European projects also provided key messages and questions, such as the extent to which lost nets continue to catch fish, the importance of studies in those fisheries for which there is virtually no information, the estimation of total ghost fishing catches in the basin, the assessment of the different types of environmental impacts of ghost fishing and management responses, and the collection of data on ghost fishing and management responses.

230. Appropriate management responses are likely to vary for different fisheries, as are the research gaps, but prevention methods based on Codes of Practices and improved communication between active and passive gear users is almost certainly better than retrieval programmes.

231. In conclusion, marine litter in the Mediterranean has become a critical issue. Management and reduction still need to be developed, implemented and coordinated. However, a number of points need to be addressed in order to better understand the issue. A number of key issues will have be considered in order to provide a scientific and technical background for a consistent monitoring, a better management system, and science based reduction measures. The following points are relevant for the near future, with a list of actions and research to be initiated in order to improve basic knowledge and to support both monitoring and management:

1) Develop a basin scale model with consideration to sources (rivers, cities, maritime routes, tourism, fishing, etc.) and pathways in order to follow the transport of marine litter.

2) Map the hot spots (accumulation areas, areas at risk) of marine litter (beaches, floating, sea bed, impact of litter) at the basin scale.

3) Determine the sinks for marine litter (budgets, fluxes, etc.) and better understand degradation.

4) Define a GIS platform to support the integration and the analysis of all monitoring data.

5) Develop an Ecological Quality Objective (ECOQ) for the ingestion of litter in indicator species suitable for monitoring (sea turtles) and support implementation of the monitoring of this indicator (capacity building, technology transfer).

6) List (inventory) species (also biofilms) settled on litter in the Meditrranean Sea, with consideration to the development of standardised protocols and the assessment of species at risk (pathogens, toxic species, etc.).

7) Develop a database on rafted species to better explain the risk of dispersion and the possible colonisation of new areas, focusing on a better understanding of the ecology of microorganisms living on/with litter, their role in the degradation of microplastics, identification of species involved and populations/assemblages in coastal waters, and finally developing strategies, methods and standards to approach this issue.

8) Evaluate the distribution and changes of microplastics from beaches to the seafloor/deep seafloor and quantify ingested microplastics in key species, from coastal epipelagic to demersal species.

9) Support the rationalisation of monitoring (i.e. common and comparable monitoring approaches (standards/baselines, inter calibration, data management system and analysis/quality insurance)). This must include the definition of specific baselines and targets for important litter categories that may individually targeted by reduction plans or measures by the Mediterranean countries (cigarette butts, plastic bags, cotton buds, etc.).

10) Identify new indicator species for impact (entanglement, ingestion, microplastics, and rafted species) through laboratory and field evaluation, and define thresholds for harm.

11) Evaluate the quantity and localization of lost fishing gears.

12) Evaluate the potential loss of fish stocks due to the main types of abandoned/lost fishing gears.

13) Focus on integration and cooperation among the various sectorial branches of the administration (fisheries, tourism, environment, industry, port activities etc.).

14) Harmonize clean ups to favor a common science-based protocol that enables the collection of relevant scientific information.

15) Ensure the involvement and cooperation of administrative stakeholders at different levels and regional/national scales.

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