

# Chapter 15

## Regulation and Management of Marine Litter

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**Abstract** This chapter aims to provide an overview of the regulation and management instruments developed at international, regional and national levels to address marine litter problems, put forward the potential gaps in the existing management body and suggest solutions. While not covering the gamut of all relevant instruments, a number of existing instruments, including specific management measures contained therein, were profiled as illustration. The management measures illustrated are either on a mandatory or voluntary basis and provide a general, snapshot picture of the management framework of marine litter. They can be broadly divided into four categories: preventive, mitigating, removing and behavior-changing. The preventive and behavior-changing measures are particularly important in addressing marine litter at its root. The former schemes include source reduction, waste reuse and recycling, containing debris at points of entry into receiving waters and land-based management initiatives (e.g. restriction of the use of plastic bags, establishment of extended producer responsibility). The latter schemes aid people's engagement in the other three types of measures, including education campaigns and activities raising awareness (e.g. Fishing for Litter). The potential gaps include limits of existing instruments in addressing plastic marine litter, deficiencies in the legislation and a lack of enforcement of regulations, poor cooperation among countries on marine litter issues and insufficient data on marine litter. To fill these gaps, recommendations are proposed, including establishment of a new international instrument targeted to the plastic marine litter problem, amending existing instruments to narrow exceptions and clarify enforcement standards, establishing national marine litter programme, enhancing participation and cooperation of states with regard to international/regional initiative, and devising measures to prevent marine litter from fishing vessels.

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## 15.1 Introduction

Marine litter (also called marine debris) has long been on the political and public agenda. It is recognized as a worldwide rising pollution problem affecting all the oceans and coastal areas of the world (Galgani et al. 2015; Ryan 2015; Thompson 2015). The increasing production and use of durable synthetic materials such as plastics<sup>1</sup> has led to a gradual, but significant accumulation of litter in the marine environment, making it ever more difficult to tackle (Barnes et al. 2009; Kühn et al. 2015). Moreover, the high-profile reports of garbage patches found in the North Pacific and North Atlantic regions (Pichel et al. 2007; Law et al. 2010; Howell et al. 2012) further propel an intensified international drive to address the ongoing problem of marine litter. Indeed, the model simulations suggest that debris accumulates in a number of convergence zones or gyres where they remain for many years (UNEP 2013).

Marine litter is defined as “any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment” (UNEP 2005, 2009). It is largely associated with diverse human activities occurring both on land and at sea, and is concomitant with the increasing use of synthetic materials, industrialization and urbanization of coastal areas, and inadequate disposal practices. Generally it can be said that the problem of marine litter is rooted in the prevailing production and consumption pattern and the way we dispose of and manage waste. Marine litter originates from three main sources: land-based, riverine and ocean-based sources (Galgani et al. 2015; Browne 2015; Jambeck et al. 2015). The former include public littering, poor waste management practices, industrial activities, sewage related debris and storm water discharge, all of which can be transported via rivers (Morritt et al. 2014; Free et al. 2014; Hoellein et al. 2014). The latter include fishing activities, shipping, marine leisure industry, and offshore oil and hydrocarbon industries (Mouat et al. 2010). In particular, derelict fishing gear<sup>2</sup> has become a serious concern with the intensified fishing effort in the world’s oceans and the increasing durability of fishing gear (Macfadyen et al. 2009; Bilkovic et al. 2014).

It is widely documented that marine litter has a wide range of adverse environmental, economic, social and public health and safety impacts (Newman et al. 2015). They are illustrated by marine litter injuring or killing wildlife by ingestion and/or entanglement (Jones 1995; Bugoni et al. 2001; Donohue et al. 2007; Allen et al. 2012; Bond et al. 2013; Baulch and Perry 2014; Kühn et al. 2015), altering ecosystems by introducing non-native species (Barnes 2002; CBD 2012; Kiessling et al. 2015),

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<sup>1</sup>Since 1950, global plastics production has continued the growth pattern by 9 % per annum. From 1.7 million t in 1950, total global production reached 288 million t in 2012 (PlasticsEurope 2013).

<sup>2</sup>Derelict fishing gear is often referred to ALDFG, which is a collective term for fishing gear that has been abandoned, lost or otherwise discarded (Macfadyen et al. 2009).

threatening sensitive habitats (e.g. corals, salt marsh) by moving along the seabed (derelict fishing gear) (Donohue et al. 2001; Arthur et al. 2014), posing risks to human health and safety (e.g. hazards to navigation) (Taylor et al. 2014), entailing economic costs to coastal towns/communities, fisheries, tourism, and other maritime industries (Ballance et al. 2000; Mouat et al. 2010; Jang et al. 2014; Newman et al. 2015). For instance, the total number of turtles entangled by the 8,690 derelict fishing nets sampled in northern Australia was estimated to be between 4,886 and 14,600 (Wilcox et al. 2014). The estimate of damage cost from marine litter across the 21 Pacific Rim economics is €949 million annually in total, €273 million for the fishing industry, €209 million for the shipping industry and €467 million for marine tourism (McIlgorm et al. 2011). In addition to these negative impacts, there is a growing concern about microplastics as they increase the risk of plastics entering food webs (Lusher 2015). If ingested microplastics have the potential to transfer toxic substances to the food chain, posing a threat to the health of humans and ecosystems (Teuten et al. 2009; Thompson et al. 2009; Rochman 2015).

To minimize the negative impacts, a plethora of instruments has been developed at international, regional and national levels to prevent, reduce and manage marine litter. They represent a wide range of international, regional and national efforts devoted to combat marine litter. The goal of this article is to provide an overview of these instruments, to identify the potential gaps in the existing management body and suggest solutions.

As it is impossible and impractical to cover the gamut of all relevant instruments in detail within the scope of this chapter, I will first consider the general mechanisms of the instruments and refer to specific ones as illustration when appropriate. This approach has the advantage of providing a general, snapshot picture of the management framework of marine litter, while also laying out the specifics of certain instruments, including the management measures contained therein. It should also be noted that marine litter is an issue of, or related to, broader topics, such as marine environmental protection, changes in biodiversity, rafting of invasive species, water quality and hazardous waste, waste and sewage water management as well as eco design and producer responsibility. The instruments addressing these broader issues would also be applicable to marine litter, although not specifically mentioned. However, as such instruments are large in scope and may not encompass the specifics of marine litter management, I will focus on those that specifically address marine litter.

## **15.2 Instruments of Marine Litter at International, Regional and National Levels**

### ***15.2.1 General Mechanisms of Instruments***

As previously mentioned, a large number of instruments at international, regional and national levels have been adopted to tackle marine litter problems. These instruments comprise conventions, agreements, regulations, strategies, action

plans, programs and guidelines. They contain specific management measures that are either compulsory or voluntary.

There are two basic types of instruments at the international level, in terms of their connection with regional or national instruments. The first comprises those, which are explicitly transposed into regional or national ones, usually in the form of regional agreements or national legislations. Similar texts can also be found in the instruments at the regional or national level. Examples include international instruments such as Annex V<sup>3</sup> of MARPOL 73/78,<sup>4</sup> the London Protocol and the Action Plan on tackling the inadequacy of port reception facilities (PRFs). The corresponding regional or national instruments transposed from international ones include: the European Union (EU) PRF Directive, the Annex IV of the Helsinki Convention, the United States (US) Marine Plastic Pollution Research and Control Act, the United Kingdom (UK) Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008, and various other national legislations. The second type comprises instruments, which are not explicitly transposed into regional or national schemes. These instruments mostly serve as global guiding instruments encouraging regional bodies or countries to follow the actions proposed therein, or as a platform for the states concerned to engage in coordination and cooperation in marine litter issues. The most prominent examples are perhaps a series of initiatives developed by the United Nations Environment Programme (UNEP), including the Regional Sea Programme (RSP), Guidelines on survey and monitoring of marine litter, Guidelines on the use of market-based and economic instruments and the Honolulu Strategy.

As for the instruments at the regional or national level that lack a clear link traced back to international instruments, they are devised by their own respective regional bodies or nations to deal with marine litter problems. These instruments usually consist of regional agreements, regional or national programs, legislations, or activities dealing with specific aspects of marine litter problems. Examples include the Barcelona Convention, the Guideline for monitoring marine litter on the beaches in the OSPAR<sup>5</sup> Maritime Area, the EU Marine Strategy Framework Directive, the CCAMLR<sup>6</sup> Marine Debris Program, the US National Marine Debris Program, numerous coastal cleanup activities, and various national legislations relevant to marine litter.

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<sup>3</sup>Regulations for the Prevention of Pollution by Garbage from Ships.

<sup>4</sup>International Convention for the Prevention of Marine Pollution from Ships, 1973 as modified by the Protocol of 1978, known as MARPOL 73/78.

<sup>5</sup>Commission for the Protection of the Marine Environment of the Northeast Atlantic.

<sup>6</sup>Commission for the Conservation of Antarctic Marine Living Resources.

## 15.2.2 *Examples of Instruments on Marine Litter*

This section presents examples of instruments at international, regional and national levels to illustrate the current regulation and management of marine litter.

### 15.2.2.1 International Instruments

United Nations Convention on the Law of the Sea (UNCLOS)

The UNCLOS is one of the most important agreements related to the use of the oceans. The convention entered into force in 1994 and comprises 320 articles and nine annexes. It established a comprehensive regime for the law of the sea by governing all aspects of the oceans from geopolitical delimitations to environmental control, scientific research, economic and commercial activities, technology and the settlement of disputes relating to ocean matters (Roberts 2010). In particular, articles 192–237 of Part XII are dedicated to the protection and preservation of the marine environment. While the provisions do not explicitly refer to marine litter, they place a general obligation on states to protect and preserve the marine environment, which can be used in the context of marine litter regulation.

Annex V of MARPOL 73/78

Annex V of MARPOL 73/78 is the major international instrument addressing ocean-based litter pollution from ships and was developed under the auspices of the international Maritime Organization (IMO). Annex V was recently revised in 2011 and came into force in 2013. The revised Annex V provides an updated framework for the control of garbage generated by ships. It imposes a general ban on discharges of all garbage from ships at sea, except for a few clearly defined circumstances.<sup>7</sup> These circumstances are associated with the types of garbage that can be disposed of, specifications of the distances from the coast, discharge of garbage within or outside special areas,<sup>8</sup> the manner in which they may be disposed of, and en route requirements for allowable discharge.<sup>9</sup> The updated disposal regulations

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<sup>7</sup>Revised Annex V, reg. 3.

<sup>8</sup>Revised Annex V, reg 1: Special areas refer to a sea area where for recognized technical reasons in relation to its oceanographic and ecological condition and to the particular character of its traffic the adoption of special mandatory methods for the prevention of sea pollution by garbage is required. The special areas of Annex V are the Mediterranean Sea, the Baltic Sea, the Red Sea, the Gulfs area, the North Sea, Antarctica and the Wider Caribbean.

<sup>9</sup>Revised Annex V, reg 1.: En route means that the ship is underway at sea on a course or courses, including deviation from the shortest direct route, which as far as practicable for navigational purposes, will cause any discharge to be spread over as great an area of the sea as is reasonable and practicable.

are summarized in Table 15.1. Other major changes include expanding the requirements for placards and garbage management plans to fixed and floating platforms,<sup>10</sup> and reduction of the minimum tonnage limit for garbage management plans from 400 gross tonnage (GT) to 100 GT.<sup>11</sup>

Major provisions remaining unchanged include: the obligation to provide a Garbage Record Book (GRB) for ships  $\geq 400$  GT or ships certified to carry  $\geq 15$  persons,<sup>12</sup> and the provision of adequate reception facilities at ports without causing undue delay to ships.<sup>13</sup> A GRB is to record each discharge made at sea or a reception facility, or a completed incineration, including date, time, ship position, category of the garbage and the estimated amount discharged or incinerated.<sup>14</sup> The GRB is subject to inspection by the competent authority of a party to MARPOL 73/78 when the ship is in port.<sup>15</sup>

## London Protocol

The London Protocol (LP) is a major instrument dealing with dumping of wastes and other matter at sea. The discharge of garbage during normal operations as regulated in the Annex V of MARPOL 73/78 is not considered as dumping.<sup>16</sup> In 1996, the protocol was adopted to further modernize the 1972 London Convention<sup>17</sup> and eventually replace it. The protocol entered into force in 2006. While the goal of the 1972 convention is to regulate pollution by dumping, the goal of the Protocol is to stop waste dumping at sea (Louka 2006). Namely, the protocol is more restrictive in regulating wastes dumping than the 1972 convention by introducing a reverse listing approach. This approach is, in essence, to prohibit the dumping of any wastes or other matter except for the materials listed in Annex I.<sup>18</sup> Dumping of these materials (such as dredged material, sewage sludge, fish wastes, vessels and platforms, inert, inorganic geological material) requires a permit and parties shall adopt measures to ensure that the issuance of permits and permit conditions comply with Annex II.<sup>19</sup> In addition, the protocol prohibits incineration of wastes at sea and the export of wastes to countries for dumping or

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<sup>10</sup>Revised Annex V, reg. 10.1.

<sup>11</sup>Revised Annex V, reg. 10.2.

<sup>12</sup>Revised Annex V, reg. 10.3.

<sup>13</sup>Revised Annex V, reg. 8.1 The relevant regulations on port reception at ports are also seen in Annex I, II, IV, and VI.

<sup>14</sup>Revised Annex V, reg. 10.3.1 and 10.3.2.

<sup>15</sup>Revised Annex V, reg. 10.5.

<sup>16</sup>LP, reg. art. 1.4.2.

<sup>17</sup>Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.

<sup>18</sup>London Protocol, art. 4.1.1.

<sup>19</sup>London Protocol, art. 4.1.2.

**Table 15.1** Summary of discharge provisions of the revised MARPOL Annex V

Type of garbage	Ships outside special areas <sup>a</sup>	Ships within special areas <sup>a</sup>	Offshore platforms and all ships within 500 m of such platforms
Food wastes comminuted or ground <sup>b</sup>	Discharge permitted $\geq 3$ nm from the nearest land and en route	Discharge permitted $\geq 12$ nm from the nearest land and en route	Discharge permitted $\geq 12$ nm from the nearest land
Food wastes not comminuted or ground	Discharge permitted $\geq 12$ nm from the nearest land and en route	Discharge prohibited	Discharged prohibited
Cargo residues <sup>c</sup> not contained in wash water	Discharge permitted $\geq 12$ nm from the nearest land and en route	Discharge prohibited	Discharge prohibited
Cargo residues <sup>c</sup> contained in wash water		Discharge only permitted in specific circumstances <sup>d</sup> and $\geq 12$ nm from the nearest land and en route	Discharge prohibited
Cleaning agents and additives <sup>c</sup> contained in cargo hold wash water	Discharge permitted	Discharge only permitted in specific circumstances <sup>d</sup> and $\geq 12$ nm from the nearest land and en route	Discharge prohibited
Cleaning agents and additives <sup>c</sup> contained in deck and external surfaces wash water		Discharge permitted	Discharge prohibited
Animal carcasses	Discharge permitted as far from the nearest land as possible and en route	Discharge prohibited	Discharge prohibited
All other garbage including plastics, domestic wastes, cooking oil, incinerator ashes, operational wastes, and fishing gear	Discharge prohibited	Discharge prohibited	Discharge prohibited
Mixed garbage	When garbage is mixed with or contaminated by other substances prohibited from discharge or having different discharge requirements, the more stringent requirements shall apply		

Source Resolution MEPC.201(62) Amendments to the Annex of MARPOL 73/78 (entered into force on 1 January 2013)

*Note*

<sup>a</sup>According to reg. 1.14, special areas are the Mediterranean Sea area, the Black Sea area, the Red Sea area, the Gulf of Mexico, the North Sea area, the Antarctic area and the Wider Caribbean Region

<sup>b</sup>According to reg. 4.1.1, 5.2, 6.1.1, comminuted or ground food wastes shall be capable of passing through a screen with openings no greater than 25 mm

<sup>c</sup>These substances must not be harmful to the marine environment

<sup>d</sup>According to reg. 6.1.2, the discharge shall only be allowed if: (a) both the port of departure and the next port of destination are within the special area and the ship will not transit outside the special area between these ports; and (b) if no adequate reception facilities are available at those ports

incineration at sea.<sup>20</sup> The protocol is to supersede the convention for the state parties that ratified it and will eventually replace the convention as more and more parties ratify.

### Action Plan on Tackling the Inadequacy of PRFs

In 2006, the Marine Environment Protection Committee of the IMO approved the Action Plan on tackling the inadequacy of PRFs. The plan was developed to contribute to the effective implementation of MARPOL 73/78 and to promote quality and environmental consciousness among administrations and the shipping industry. It covers standardized reporting, information on PRFs, equipment technology, types and amount of wastes, regulatory matters, technical cooperation and assistance.<sup>21</sup>

### UNEP Regional Sea Programme

The UNEP Regional Sea Programme and Global Programme of Action (GPA<sup>22</sup>) embarked in 2003 on the development of a Global Initiative on Marine Litter. This initiative has succeeded in organizing and implementing regional activities on marine litter around the world. Activities focusing on managing marine litter were arranged through individual agreements in 12 Regional Seas.<sup>23</sup> The main activities include: a review and assessment of the status of marine litter in the region, organization of a regional meeting of national authorities and experts on marine litter, preparation of a regional action plan for the management of marine litter, and participation in a regional cleanup day within the framework of the International Coastal Cleanup Campaign.<sup>24</sup> This regional initiative also provides a platform for the establishment of partnerships, cooperation and coordination of activities for the

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<sup>20</sup>London Protocol, art. 5 and 6.

<sup>21</sup>Further information on this Plan is available at [www.imo.org/ourwork/environment/pollutionprevention/portreceptionfacilities](http://www.imo.org/ourwork/environment/pollutionprevention/portreceptionfacilities).

<sup>22</sup>Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities. The GPA, adopted in 1995, is a programme that addresses the impacts of land-based sources and activities on coastal and marine environment and human well-being. Litter is one of nine source categories of the GPA and as such is important for its implementation (UNEP 2009).

<sup>23</sup>Baltic Sea, Black Sea, Caspian, East Asian Seas, Eastern Africa, Mediterranean, Northwest Pacific, Northeast Atlantic, Red Sea, Gulf of Aden, South Asian Seas, Southeast Pacific and Wider Caribbean.

<sup>24</sup>International Coastal Cleanup (ICC) is the world's largest volunteer effort to clean up beaches and waterways, with its many global public and private partners. The ICC is organized by Ocean Conservancy (a US-based NGO) and has been operating since 1986. It annually hosts cleanup activities around the world. In 2012, the ICC mobilized >560,000 volunteers to clean coastal beaches and inland waterways in 97 countries and locations, and a total of 4.5 million kg of trash were collected on the shoreline of 28,485 km (Ocean Conservancy 2013).

control and sustainable management of marine litter. The main partners include Regional Sea Conventions and Action Plans, government representatives, UN agencies, relevant bodies, donor agencies, the private sector and NGOs (UNEP 2009).

### UNEP/IOC Guidelines on Surveying and Monitoring of Marine Litter

The UNEP developed, in cooperation with the intergovernmental Oceanographic Commission (IOC), guidelines on surveying and monitoring of marine litter in order to provide a long-term platform for scientific monitoring. Four sets of operational guidelines were developed: comprehensive assessments of beach, benthic and floating litter, and rapid assessments of beach litter. The first three sets target the collection of highly resolved data to support the development and/or evaluation of mitigation strategies, while the last aims to raise public awareness of and educate about marine litter issues (Cheshire et al. 2009).

### UNEP Guidelines on the Use of Market-Based and Economic Instruments

The UNEP developed guidelines on the use of market-based and economic instruments. This report serves as a practical reference to decision makers on how to select, apply and implement related economic tools. Tools include deposit-refund programs on plastic and glass bottles, plastic bag tax, incentives to fishers for reporting and removing debris, subsidies, tourist taxes, car park fees, and waterfront business charges (Ten Brink et al. 2009; Newman et al. 2015).

### UNEP/FAO Abandoned, Lost or Otherwise Discarded Fishing Gear

A report commissioned by the UNEP and Food Agriculture Organization (FAO) identified reasons for fishing gear being abandoned, lost or otherwise discarded, reviewed existing measures to reduce derelict fishing gear, and proposed recommendations for future action (Macfadyen et al. 2009). A variety of existing measures have been presented, including gear marking, port-state measures,<sup>25</sup> onshore collection, payment for retrieved gear, better locating and reporting lost gear, disposal and recycling, and awareness raising schemes.

### Honolulu Strategy

The UNEP and the US National Oceanic and Atmospheric Administration (NOAA) co-organized the Fifth International Marine Debris Conference in 2011, where the Honolulu Strategy was formulated. This strategy can be regarded as a global

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<sup>25</sup>Port state measures help to address illegal, unregulated and unreported (IUU) fishing, which is a significant contributor to derelict fishing gear problems.

framework on possible actions to combat marine litter. It contains three goals, 19 strategies and numerous specific actions, serving as a useful and practical reference for concerned parties to take actions at national levels (UNEP/NOAA 2011).

### UNEP Global Partnership of Marine Litter

The most recent initiative was to establish a Global Partnership of Marine Litter (GPML) in June 2012 by the UNEP. The GPML builds on the Honolulu Strategy. It is a global partnership, acting as a “coordinating forum” for all stakeholders (international, regional, national and local organizations) working in the area of marine litter prevention and management. The forum assists stakeholders to complement each other’s efforts, to avoid duplication and to optimize the efficiency and efficacy of their resources.<sup>26</sup>

#### 15.2.2.2 Regional Instruments

##### EU PRF Directive

In response to MARPOL 73/78, which requires party states to ensure the provision of adequate PRFs, the EU adopted the Port Reception Facility (PRF) Directive aimed at reducing the input of ship-generated waste to the sea. The directive came into force in 2002 and key requirements include: member states are obliged to ensure the availability of PRFs to meet the needs of ships, ports to develop and implement a waste reception and handling plan, a reporting requirement for the master of a ship regarding the delivery of waste, implementation of a cost-recovery system, and establishment of an enforcement scheme (EU 2000). A study by the European Maritime Safety Agency (EMSA) shows that there was an increase in the total delivery from 2004 to 2008 for oily waste and from 2004 to 2009 for garbage for European ports and the decrease, experienced in 2009 and 2010, for oily waste and garbage, respectively, is thought to be a result of the financial crisis and thus a decrease in the number of calls to the ports (ship/cargo traffic) (EMSA 2012).

##### EU Marine Strategy Framework Directive

Multiple initiatives exist to tackle marine debris in the EU. Among them, perhaps the most relevant is the Marine Strategy Framework Directive (MSFD) (EU 2008), the environmental pillar of the EU Integrated Maritime Policy. This directive is an integral policy instrument for the protection of the marine environment for the European Community, following an ecosystem-based, adaptive and integrated

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<sup>26</sup>Further information on the GPML is available at [www.gpa.unep.org/index.php/global-partnership-on-marine-litter](http://www.gpa.unep.org/index.php/global-partnership-on-marine-litter).

approach to the management of human activities, which have an impact on the marine environment. The directive establishes a framework, within which member states shall take necessary measures to achieve or maintain good environmental status (GES) in the marine environment by 2020.<sup>27</sup> Marine litter is listed as the tenth of 11 qualitative descriptors for determining GES, which states that the properties and quantities of marine litter do not cause harm to the coastal and marine environment.<sup>28</sup>

To achieve GES, each member state should define GES as well as environmental targets and put in place its own marine strategy to protect its waters. In relation to this, two criteria and associated indicators for marine debris that define GES have been identified, serving as a reference for member states to follow. One criterion is characteristics of litter in the marine and coastal environment, and the associated indicators are trends in the amount of litter on beaches, in the water column and on the seafloor as well as trends in the amount, distribution and where possible, composition of microparticles (particularly microplastics). The other criterion deals with the impacts of litter on marine life, and the associated indicator is marine litter taken up by marine organisms (EU 2010). Furthermore, the Technical Group on Marine Litter was established to support member states by providing technical and scientific recommendations for the implementation of MSFD requirements with regard to marine litter. The group continues to work on, among other concerns, harmonizing monitoring tools (protocols) and strategies, defining and quantifying harm to the marine environment, assessing land- and sea-based sources from which marine litter enters the sea including riverine inputs, and developing a common understanding of appropriate operational/environmental targets (Galgani et al. 2013).

## EU Initiatives on Land-Based Waste Management

The EU has a wide range of initiatives on land-based waste management, which could have a significant impact on the amount of waste in the marine environment. For example, the Packaging and Packaging Waste Directive outlines a range of requirements to reduce the impact of packaging waste on the environment. It contains provisions on the prevention of packaging waste, on the re-use of packaging and on the recovery and recycling of packaging waste (Interwies et al. 2013). Other initiatives include the Waste Framework Directive, the Landfill Directive and the Urban Waste Water Directive.

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<sup>27</sup>The MSFD, art. 1.

<sup>28</sup>Annex I of the MSFD. The remaining descriptors include, to name a few, biological diversity, non-indigenous species, populations of commercially exploited fish and shellfish, eutrophication, introduction of energy.

## Helsinki Convention and Its Associated Initiatives

The 1992 Helsinki Convention<sup>29</sup> is a regional instrument aimed at protecting the marine environment of the whole Baltic Sea area, including inland waters as well as the seawater itself and the seabed. Its Annex IV (Prevention of Pollution from Ships) contains Regulation 4 (Application of the Annexes of MARPOL 73/78) and Regulation 6 (Mandatory discharge of all wastes to a port reception facility), which can be used in the context of marine litter. According to Regulation 4 contracting parties shall apply the provisions of Annexes I–V of MARPOL 73/78. According to Regulation 6 ships shall discharge all ship-generated wastes before leaving port, which are not allowed to be discharged into the sea in the Baltic Sea in accordance with MARPOL 73/78 and the convention. In relation to this, the Commission (HELCOM<sup>30</sup>) has approved the strategy for PRFs for ship-generated wastes (also known as the Baltic Strategy). This strategy comprises a set of measures and regulations with the main goals to ensure ships' compliance with global and regional discharge regulations and to eliminate illegal discharges of all wastes from all ships. Over 210 PRFs are provided in ports located around the Baltic Sea. To encourage their use, a “no-special-fee” system has been designed, by which disposal fees are included in port charges (HELCOM 2012).

In addition, the Baltic Sea Action Plan adopted by the HELCOM includes an agreement to raise awareness of the negative environmental and economic effects of marine litter in the marine environment, including effects of “ghost fishing” of derelict fishing gear (BSAP 2007).

Recently, Ministerial Declaration 2013 was adopted at the HELCOM Copenhagen Ministerial Meeting. It was agreed to prevent and reduce marine litter from land- and sea-based sources, causing harmful impacts on coastal and marine habitats and species, and negative impacts on various economic sectors, such as fisheries, shipping or tourism, and decided to develop a regional action plan by 2015 at the latest with the aim of achieving a significant quantitative reduction of marine litter by 2025, compared to 2015, and to prevent harm to the coastal and marine environment (HELCOM 2013). It was specifically agreed that the regional action plan on marine litter should allow to, among others, carry out concrete measures for prevention and reduction of marine litter from its main sources, develop and test technology for removal of microplastics and nano-particles in municipal waste water treatment plants by 2020, develop common indicators and associated targets related to quantities, composition, sources and pathway of marine litter.

## OSPAR Initiatives on Monitoring Marine Litter

Since 1998, OSPAR has monitored levels of beach litter (OSPAR 2010a). A pilot project (2000–2006) on monitoring marine beach litter in the OSPAR region

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<sup>29</sup>Convention on the Protection of the Marine Environment of the Baltic Sea Area, known as Helsinki Convention.

<sup>30</sup>HELCOM is the governing body of the Helsinki Convention.

using the standardized method was conducted (OSPAR 2007). The guideline for monitoring marine litter on the beaches in the OSPAR Maritime Area was further adopted in 2010, providing practical advice, especially with standardized methodology and a photographic guide, for determining the nature and amount of litter (OSPAR 2010b).

In addition, monitoring of plastic ingestion by northern fulmar (*Fulmarus glacialis*) has been implemented by OSPAR (van Franeker et al. 2011). An Ecological Quality Objective (EcoQO) has been established that <10 % of northern fulmars should have >0.1 g plastics particles in the stomach samples of 50–100 beach fulmars from each of the 4–5 areas of the North Sea over a period  $\geq 5$  years (OSPAR 2010a). Meeting this objective would indicate a reduction of litter at sea. Between 2002 and 2006, the stomachs of 1090 beached fulmars from the North Sea were analyzed. The proportion of fulmars with >0.1 g plastic in the stomach ranged from 45 to >60 %. To meet the EcoQO, refinements may be needed on the implementation of the EU Directive on Port Reception Facilities and MARPOL Annex V, as well as specific measures on lost fisheries materials (OSPAR 2010a).

### OSPAR Fishing for Litter

In 2007, OSPAR published Guidelines for the implementation of Fishing for Litter (FFL) projects in the OSPAR area. FFL has two main aims: first the physical removal of marine litter from the seabed (Fig. 15.1) and, second, to raise awareness within the fishing industry that it is not acceptable to throw litter overboard. Participating vessels are given large bags to store marine litter that collects in their nets during normal fishing activities. The concept of FFL has received support within the fishing industry with increasing numbers of vessels participating in this activity over the past seven years (OSPAR 2010a). Indeed, the 210 vessels registered for the FFL initiative in Scotland landed >700 t of marine litter at the participating harbors between 2011 and 2014 (KIMO 2014).



**Fig. 15.1** OSPAR Fishing for Litter program. From left to right: catch with litter from a *Nephrops* trawler in the Clyde Sea(U.K.) (Photo: M. Bergmann); fisher from *FV Andrea* sorting litter from catch (Photo: G. Lengler, NABU, DSD); disposal of litter collected by fisher into portside Fishing for Litter container (Photo: K. Detloff, NABU)

In the light of recent weight estimates of 268,940 t of litter adrift in the oceans (Eriksen et al. 2014) this initiative could significantly help to reduce marine litter (although this figure did not include litter on the seabed). FFL initiatives are currently also realized in The Netherlands, Belgium, Germany, England, Ireland, Italy and Sweden.

### Barcelona Convention

The Barcelona Convention<sup>31</sup> is a regional instrument aimed at protecting and promoting sustainable development of the Mediterranean marine and coastal environment. It was adopted in 1976 and amended in 1995 by the parties to the Mediterranean Action Plan (MAP).<sup>32</sup> Seven protocols to the convention establish the MAP legal framework and address specific aspects of conservation. The one most relevant to marine litter is the Land-based Sources and Activities Protocol (LBS Protocol). It states that parties undertake to eliminate pollution deriving from land-based sources and activities, in particular to phase out inputs of the substances that are toxic, persistent and liable to bioaccumulate listed in its Annex I,<sup>33</sup> including litter. In addition, the Dumping Protocol has relevance to marine litter. It states that dumping of wastes and other matter is prohibited, except for dredged material, food waste, platforms and other man-made structures, and inert geological materials.<sup>34</sup>

### CCAMLR Marine Debris Program

The Commission for the Conservation of Antarctic Marine Resources (CCAMLR) has initiated the Marine Debris Program in its convention area. Specific measures were employed to reduce the amount of debris entering the marine system and to mitigate its impacts. The measures include monitoring marine debris, addressing the risk associated with entanglement of marine mammals in plastic packaging bands and the injury to seabirds caused by the discharge of hooks in offal, and educating fishers and fishing vessel operators about the potential impact of marine debris on marine wildlife. Members annually submit information on marine debris beach surveys, debris associated with seabird colonies, entanglements of marine mammals, and seabirds and marine mammals soiled with oil.<sup>35</sup>

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<sup>31</sup>Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean.

<sup>32</sup>This MAP is the first UNEP RSP.

<sup>33</sup>The LBS Protocol, art. 5.1.

<sup>34</sup>The Dumping Protocol, art. 4.

<sup>35</sup>Further information on CCAMLR marine debris initiatives is available at [www.ccamlr.org](http://www.ccamlr.org).

### 15.2.2.3 National Instruments

#### US Marine Plastic Pollution Research and Control Act (MPPRCA)

The MPPRCA of 1987 is the national legislation of MARPOL Annex V (UNEP 2005). The Interagency Marine Debris Coordinating Committee (IMDCC) established by this Act engages in a holistic approach to marine litter. The committee develops and recommends comprehensive and multi-disciplinary approaches to reduce the sources and adverse impacts of marine debris on the nation's marine and coastal environment, natural resources, human health, public safety and the economy. The committee consists of several stakeholder agencies,<sup>36</sup> ensuring that these agencies increase their coordination to address marine debris (NOAA 2012).

#### US Marine Debris Program

The Marine Debris Program (MDP) is a national program to investigate and solve the problems that stem from marine debris, in order to protect and conserve the nation's marine environment, natural resources, industries, economy and people. It offers a holistic approach to marine litter and was established by the Marine Debris Research, Prevention, and Reduction Act of 2006 (MDRPRA), which was amended by the Marine Debris Act Amendments in 2012. The MDP serves as a centralized capability within NOAA, supporting national and international programs to research, prevent, and reduce the impacts of marine debris, coordinating activities within NOAA and with other federal agencies, as well as using partnerships to support projects carried out by state and local agencies, tribes, NGOs, academia and industry. The MDP has sponsored numerous programs, including Fishing for Energy, international coastal cleanups, monitoring and assessment projects, and collaboration with UNEP to provide technical assistance to countries in the wider Caribbean region. Among them, the project of Fishing for Energy was launched in 2008 and provided fishers no-cost disposal service for derelict fishing gear and recycled and converted it into renewable energy (Barry 2010).<sup>37</sup> Until May 2014, >1.1 million kg of fishing gear were collected at rubbish bins placed in 41 communities across the country. This generated enough electricity to power 183 homes for one year (NFWF 2014).

#### US National Marine Debris Monitoring Program

The National Marine Debris Monitoring Program (NMDMP) was developed to standardize marine debris data collection in the US by using a scientifically valid protocol to determine marine debris status and trends. This program was conducted

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<sup>36</sup>NOAA serves as the Chair.

<sup>37</sup>Other initiatives under the MDP are available at [www.marinedebris.noaa.gov](http://www.marinedebris.noaa.gov).

over a five-year period between 2001 and 2006. The results indicate that land-based sources of marine debris account for 49 % of the debris surveyed nationally, in comparison to 18 % from ocean-based and 33 % from general sources (Sheavly 2010).

### US Legislations Relevant to Marine Litter

Other legislations of relevance to marine litter could have a significant impact on the amount of waste in the ocean. For example, the Shore Protection Act aims to minimize trash, medical debris, and other harmful material from being deposited into coastal waters as a result of inadequate waste handling procedures by vessels transporting waste. The Beaches Environmental Assessment and Coastal Health Act aims to reduce the risk of diseases to users of the coastal recreation waters.<sup>38</sup>

### UK Legislations on Garbage from Ships and PRFs

In the UK, the national legislation of Annex V is the Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulation 2008 and the Merchant Shipping and Fishing Vessels (Port Waste Reception Facilities) Regulations 2003 and amendments. The former contains provisions on garbage disposal restriction, garbage management plans and record books, inspection, detention and offences. The latter requires all ports, terminals, harbors and marinas to provide adequate reception facilities for waste and prepare a waste management plan.<sup>39</sup>

### UK Beach Cleanup and Awareness Campaigns

Numerous cleanup and awareness campaigns have been carried out in the UK, including the Marine Conservation Society's 'Beachwatch' and 'Adopt a Beach' campaigns (MCS 2013; UNEP 2005), and the Forth Estuary Forum's Coastal Litter campaign (Storrier and McGlashan 2006).

### Scotland Marine Litter Strategy and National Litter Strategy

The Scottish Government and Marine Scotland recently initiated a process to advance the Marine Litter Strategy and the National Litter Strategy to jointly manage litter in Scotland's terrestrial (including inland waters), coastal and marine environments. Both strategies were initiated in response to the MSFD, cover the

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<sup>38</sup>Further information on US legislations relevant to marine litter is available at [www.water.epa.gov/type/oceb/marinedebris/lawsregs.cfm](http://www.water.epa.gov/type/oceb/marinedebris/lawsregs.cfm).

<sup>39</sup>Full text of regulations is at [www.legislation.gov.uk](http://www.legislation.gov.uk).

period 2012–2020 and seek to prevent and/or reduce the incidence of litter through a combination of approaches: education and awareness, infrastructure and tools, and enforcement and deterrence (The Scottish Government 2013).

### South Korea Initiatives on Marine Litter

Since 1999, South Korea has begun to develop comprehensive and field-oriented strategies to address marine litter at the national level. Diverse initiatives were put forward, including: cleanup operations, recycling or environmentally friendly disposal of material collected, underwater marine debris removal programs, development of a practical integrated system of marine debris, river basin marine debris management systems, a fishing gear buyback program, a national coastal monitoring and education system on marine debris, and relevant legal and institutional restructuring (Jung et al. 2010). In addition, South Korea introduced a gear-marking initiative in 2006, which helps to identify owners or users of the marked fishing gear and thus contributes to preventing fisheries-related marine litter being abandoned (Macfadyen et al. 2009).

The practical integrated system started in 1999 and aimed to reduce marine litter through technological innovations in prevention, deep-water survey, removal, treatment and recycling. For example, a floating debris containment boom was developed to prevent floating debris from entering the coastal waters through rivers or channels. Deep-water survey equipment (termed “Tow-Sled”) was designed to examine benthic deep-sea derelict fishing gear at depths of 500–1000 m, which was adequate for the East Sea of Korea where the steep slope of theseabed provides a suitable habitat for snow crabs (Jung et al. 2010).

The fishing gear buyback program encouraged fishers to collect fishing gear or other marine debris (excluding that generated by the fishers’ own ships) during fishing by offering monetary rewards based on the amount of debris collected (Cho 2009). The program has generated desirable results: between 2004 and 2008 almost 30,000 t of litter were collected and there was an annual increase in the amount of litter collected from 2,819 t in 2004 to 8,797 t in 2008 (Noh et al. 2010). In addition, the cost of this program (€1.5 million) was less than half of the cost incurred if the same volume of litter had been collected directly by the government (€3.1 million). The coastal cleanup program was carried out at ports and harbors, seabed areas and coastline. It has provided supplementary job opportunities for local residents (mainly senior citizens): >46,000 residents were hired as workers (Han et al. 2010).

As for legal and institutional restructuring, the “National Basic Plan for the Marine Debris Management” was institutionalized in 2008 by most of the concerned central government agencies (Jung et al. 2010). The First Basic Plan to Manage Marine Debris was established for the period from 2009 to 2013 with a budget of ca €45 billion (Jang and Song 2013). This plan is referring the Marine Environment Management Law as its legal base<sup>40</sup> and sets two quantitative goals: reduce the amount of marine debris annu-

<sup>40</sup>Sentence 1, Article 24 of the Law states that Minister of Maritime Affairs and Fisheries should establish and implement the plan to treat the garbage at sea, which was flown to or generated at sea.

ally entering the ocean from 159,800 t (2007) to 127,840 t (2013) and increase the collection rate from 34 % (2007) to 45 % (2013). However, a study showed that this marine debris policy is not successful in dealing with the marine debris issue since the policy focuses on collecting debris already at sea rather than preventing it from entering the ocean initially and it is almost impossible to measure the debris flow, given countless non-point sources (Jang and Song 2013).

### Taiwan Legislations Relevant to Marine Litter

A comprehensive national program to assess or remediate marine litter is currently not available in Taiwan, although marine litter is pervasive along its coastline. No clear integral mechanism exists for solving marine litter problems. Regulations governing the marine litter disposal fall under the management bodies. Specifically, the Fishing Harbor Act prohibits the discharge of litter to harbor areas. The Commercial Port Act regulates waste discharges at PRFs. The Marine Pollution Control Act is the national legislation of MARPOL 73/78 and London Protocol. The act regulates that waste shall remain on board or be discharged into reception facilities, unless specific conditions apply for legal discharge. However, thus far, specific conditions have yet to be promulgated. In addition, while the authority has already transposed the revised MARPOL Annex V into national law in 15 April 2013, no penalties in breach of this rule exist. Therefore, the relevant regulations have no deterrent effects and are difficult to enforce.

### Taiwan Initiatives on Land-Based Waste Management

The plastic restriction policy and the compulsory garbage sorting policy are two major initiatives on land-based waste management. These two initiatives were intended to reduce the amount of waste and have a significant impact on the reduction of the volume of plastic waste. Since 1997, Taiwan has engaged in a waste-recycling campaign by collaborating with communities, recycling enterprises, municipal trash collection teams and the recycling fund. In 2006, a compulsory nation-wide garbage sorting program was initiated to further enhance the household recycling rate.<sup>41</sup> The recycling rate of 38 % in 2010 was high, a 100 % increase compared to 2002 (TEPA 2010). In 2002, the government started to implement the plastic restriction policy. Measures include restrictions of the use of plastic shopping bags and disposable plastic tableware in all government agencies and public facilities (e.g. department stores, shopping centers, supermarkets, convenience stores). Within three years of this policy's implementation, the number

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<sup>41</sup>The recyclable materials include iron/ aluminum/plastic containers, paper tableware, batteries, tires, lubricants, IT objects, house appliances (televisions, washing machines etc.) and light bulbs.

and the weight of plastic carrier bags were reduced by 58 and 68 %, respectively. In addition, >80 % of shoppers carried shopping bags compared to <20 % prior to the policy, indicating that this policy has initiated a behavioral change toward the use of fewer plastic bags (TEPA 2011).

### Taiwan Coastal Cleanup Activities

The project of cleaning the coastal environment has been in place since 1997 with an aim to keep the coastal environment tidy, particularly the relatively populated areas, by conducting regular cleanup activities and setting up adequate reception facilities. However, this project did not involve monitoring marine debris. In general, beach litter surveys around Taiwan have been conducted by civil groups (e.g. Taiwan Ocean Cleanup Alliance) without formal long-term commitments by the government. However, the surveyed areas were limited to a few coastal locations and the survey results were not considered by relevant authorities.

## 15.3 Types of Management Measures to Combat Marine Litter

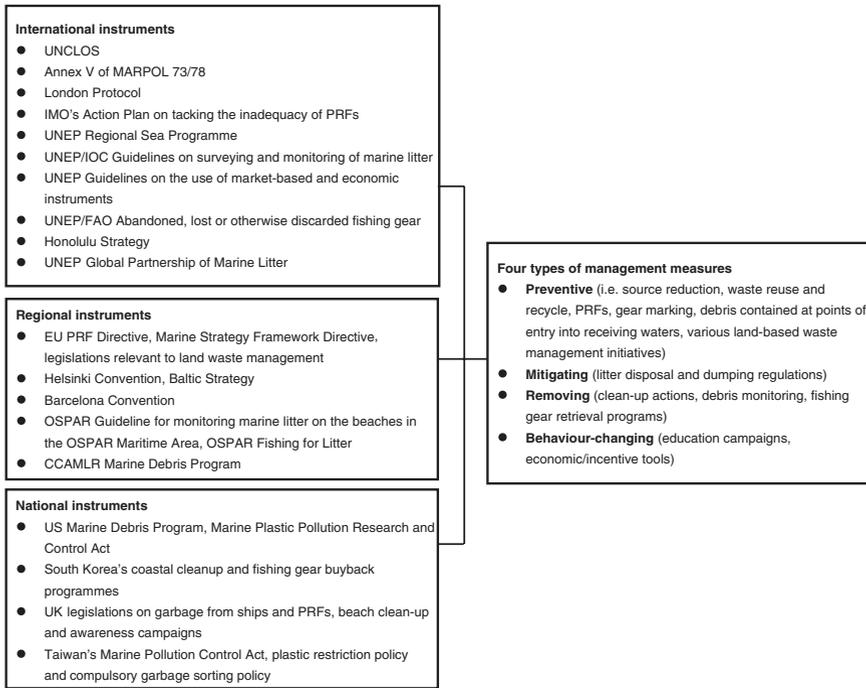
It should be noted that the preceding description of international, regional and national instruments tackling marine litter presents a representative snapshot of a wide range of relevant instruments, rather than an exhaustive list. While such representative information is not complete, it shows that a basic framework for addressing marine litter is in place (Fig. 15.2) and provides an overall picture of the current management measures. Based on their principle purposes, the measures can be divided into four categories: preventive, mitigating, removing and behavior-changing (Table 15.2).

### 15.3.1 Preventive Measures

Preventive measures focus on avoiding the generation of debris, or preventing debris from entering the sea. Measures of this type include source reduction, waste reuse and recycling, waste conversion to energy,<sup>42</sup> portreception facilities, gear marking, debris contained at points of entry into receiving waters and various waste management initiatives on land. Product modification and improvement (e.g. through eco design) is an important method for source reduction. A variety of

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<sup>42</sup>But during this process toxins are produced and even if they are filtered the toxic filters have to be disposed of.



**Fig. 15.2** The regulatory and management framework of marine litter

**Table 15.2** Management schemes addressing marine litter

Types	Examples of measures
Preventive	Source reduction (e.g. eco design), waste reuse and recycling, waste converted to energy, port reception facilities, gear marking, debris contained at points of entry into receiving waters, various land-based waste management initiatives
Mitigating	Various debris disposal and dumping regulations, i.e. waste discharged outside certain distances from land, wastes not containing harmful substances to the marine environment allowed for discharge, prohibition of waste discharge into ecologically sensitive areas, prohibition of the disposal of certain types of garbage into seas
Removing	Beach and seafloor cleanup activities, derelict fishing gear retrieval programs, marine debris monitoring
Behavior-changing	Educational campaigns, economic/incentive tools

source reduction schemes are available, such as designing packaging such that the product can be refilled (e.g. shampoo bottles), maintaining and repairing durable products (e.g. bicycles), developing more concentrated products (e.g. laundry detergent) and electric messaging (Vaughn 2009). Other methods include the development of packaging material that is made from sustainable resources, the

design of push-tap opening of metal beverage cans<sup>43</sup> and the design of lids of beverage bottles or containers attached to bottles with a leash (Gold et al. 2013). Restriction of the use of plastic bags is one of such measures, which is significant in the reduction of plastic waste. Bangladesh was the first nation to outlaw polythene bags in 2002 followed by Myanmar, China and a number of African countries including Eritrea, Mali, Mauritania, South Africa, Tanzania, Uganda and Kenya. What is more, the production of plastic bags has become a criminal offence in Mauritania, Mali, Somalia and Rwanda, which even searches the luggage of visitors upon arrival at its airports.

Based on the hierarchy of waste management, the strategies of preventing wastes from being formed in the first place is of paramount importance as are recycling, resource recovery and waste-to-energy approaches as less waste is generated and relatively low risks and costs are associated with waste management, compared to other strategies such as treatment and disposal (Cheremisinoff 2003). In this regard, extended producer responsibility (EPR) should be well established since it is a strategy to prevent wastes at source, promote product design for the environment and support the achievement of public recycling and materials management goals (OECD 2001) (see also Newman et al. 2015). Currently, consumers often do not have a chance to select a more environmentally friendly packaged/produced good as they are all packaged/manufactured with plastics. With EPR established, producers accept significant responsibility for the treatment or disposal of post-consumer products. It may take the form of a reuse, buy-back, or recycling program. The EU Waste Framework Directive establishes EPR and describes drivers for sustainable production taking into account the full life cycle of products (EU 2013). This directive encourages member states to take legislative or non-legislative measures in order to strengthen re-use and the prevention, recycling and other recovery operations of waste.

### ***15.3.2 Mitigating Measures***

Mitigating measures concern the ways that litter is disposed of. Methods of debris disposal are employed to minimize its adverse impact on the marine environment. These measures are largely command and control regulations, and overlap with preventive ones if they also involve preventing certain types of debris from entering the sea. Examples of such measures include prohibition of certain types of litter (e.g. plastics) discharged into seas or to coastal landfills, dumping regulations if dumping is allowed, prohibition of certain types of wastes discharged into ecologically sensitive areas, specifications of the distances from the land and of waste

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<sup>43</sup>As opposed to the design of pull-tap opening, this design prevents taps from separating from beverage containers and thus the two could be retrieved together for recycling. It is noted that taps separating from cans could conveniently be thrown away and easily become marine litter items.

status for disposal (e.g. waste discharged  $\geq 12$  miles from the land and wastes not containing substances harmful to the marine environment), and prohibition of certain activities at sea (e.g. incineration of wastes at sea).

### ***15.3.3 Removing Measures***

Removing measures aim to remove debris already present in the marine environment. Beach cleanups are commonly employed for this but are time-consuming, costly (see Newman et al. 2015) and only capture a fraction of the overall debris. UK municipalities, for example, spend approximately €18 million each year removing beach litter, representing a 37 % increase in cost over the past decade (Mouat et al. 2010). In addition to beach cleanups, a few initiatives have employed divers to collect and monitor benthic marine debris, for example, in Hawaii (Donohue et al. 2001) and the Florida Keys (Watson 2012). In Fishing for Litter initiatives fishers remove all litter items collected during normal fishing operations and deposit them safely on the quayside to then be collected for disposal. Gear retrieval programs encourage fishers to retrieve derelict fishing gear at sea during fishing operations (e.g. Noh et al. 2010; Watson 2012). While monitoring marine debris is concerned with recording information on debris types, amounts and sources, it can be classified as removing measure since it often concomitantly involves the removal of debris. Monitoring is instrumental in devising effective management strategies to prevent specific types of litter from entering the sea. Importantly, long-term monitoring programmes enable us to assess the effectiveness of legislation and coastal management policies (Rees and Pond 1995) and have the potential to help management at individual sites and to generate large-scale pollution maps (from regional to global) to inform decision makers (Ribic et al. 2010).

### ***15.3.4 Behavior-Changing Measures***

Behavior-changing measures seek to influence behavior such that people engage in activities that help to reduce marine debris. Behavior-changing schemes are cross-cutting and aid the development and implementation of the above-mentioned three types of measures. Such schemes aim to encourage people to embrace the notion of waste as a resource and choose the products that generate lower quantities of litter (preventive), dispose of waste in a more environmentally sound way (mitigating) and participate in beach cleanups (removal). Education campaigns (Hartley et al. 2015), activities raising awareness such as Fishing for Litter initiatives and provision of incentives are examples of such measures. Behavior-changing schemes are fundamental in addressing marine debris at its root.

## 15.4 Potential Gaps in Marine Litter Management

As previously described, a basic regulatory and management framework addressing marine litter is in place and a number of regions and countries have taken management measures to tackle the issues. A few cases indicate that some of the management measures have generated desirable results, such as South Korea's fishing gear buyback programme, Taiwan's plastic restriction policy and compulsory garbage sorting policy, US Fish for Energy, OSPAR Fishing for Litter, EU PRF Directive, HELCOM Baltic Strategy (see previous sections). Despite this, marine litter continues to increase worldwide: on shorelines, in estuaries and mangroves, in oceanic gyres, and on seafloors, signalling that marine litter remains an abiding problem, particularly with respect to microplastics (Barnes et al. 2009; UNEP 2011; Lima et al. 2014; Mohamed Nor and Obbard 2014; Pham et al. 2014; Lusher 2015). There are complex reasons for this and, it is possible to identify a number of gaps in the current framework that prevent the effective control of marine litter.

- Limits of existing instruments in addressing plastic marine litter  
Gold et al. (2013) identified a number of limitations in existing international instruments in addressing marine litter, including their insufficient scope with respect to the main sources of plastic pollution, exemptions and lack of enforcement standards. For instance, UNCLOS acknowledges the existence of land-based sources but simply requests that countries address the problem through domestic means.<sup>44</sup> MARPOL Annex V exempts accidental loss of disposal of plastic resulting from damage to the ship or its equipment,<sup>45</sup> as well as ships <400 GT, a category to which most of the fishing vessels belong, from recording garbage discharge operations in Garbage Record Books (GRBs).<sup>46</sup> However, GRBs are of utmost importance to ensure compliance with discharge regulations (HELCOM 2012).  
The lack of enforcement standards can be found in the terms used in the legal instruments. UNCLOS, for instance, requires only that nations “shall endeavor” to use the “best practical means” to reduce marine pollution “in accordance” with their capabilities. Similarly, the Helsinki Convention requires contracting parties to take “all appropriate” measures to prevent and eliminate pollution. This leaves room for interpretation for countries with differing legal systems, environmental circumstances and capacities (Gold et al. 2013).
- Deficiencies in the legislation and a lack of implementation and enforcement of regulations and management measures  
The implementation and enforcement of regulations and management measures at national levels is a key component to combat marine litter. However, a number

<sup>44</sup>UNCLOS, art. 207 (concerning pollution from land-based sources).

<sup>45</sup>Revised Annex V, reg. 7.

<sup>46</sup>Revised Annex V, reg. 10.

of cases below show that international initiatives have not yet been transposed into national management schemes; or where they have there is a lack of enforcement, insufficient implementation, insufficient penalties to deter violators, or a lack of clarity in legislation leaving room for interpretation. These all represent major obstacles to the effective control of marine litter. For instance, the UNEP (2009) pointed out that at the national level, only the Wider Caribbean and Northwest Pacific regions have countries with specific national legislation addressing marine litter. The revised MARPOL Annex V has not yet been transposed into national law in countries such as Germany (UBA 2013) and thus there is no legal footing to implement this revised Annex V at the national level. The IMO Global Integrated Shipping Information System (GISIS) shows that there are numerous reported cases of alleged inadequacy of reception facilities.<sup>47</sup> In the US, as of 1995, <10 % of cases put to trial under MARPOL Annex V have resulted in penalties<sup>48</sup> and each of the penalized cases was fined an average of €4,560, an amount far too low to serve as a deterrent (Gold et al. 2013). In Taiwan, no penalties exist for the violation of the Annex V. The EU PRF Directive is vague at defining the fee/cost recovery system. The transposition of the directive into national legislation leaves room for different solutions on how to introduce incentives for waste delivery at ports. The use of different waste-fee systems by EU ports creates confusion among ship owners and operators (EMSA 2012; Øhlenschläger et al. 2013).

- Poor cooperation and insufficient participation of states in international/regional initiatives

Despite the fact that numerous international and regional initiatives already exist and provide a platform for cooperation and coordination of marine debris issues, a few cases indicate that cooperative action on marine litter has lagged behind, or the participation of states in these initiatives was insufficient. This would leave a loophole in the global/regional efforts, given the fact that marine debris is a transboundary issue. For example, there are no legal instruments in place dedicated to the management of marine litter as yet in the Black Sea, even though the *Bucharest Convention*<sup>49</sup> contains several articles pertaining to marine debris (Interwies et al. 2013). Some regional seas do not even participate in the UNEP Global Initiative, such as west central and southern Africa, north-east Pacific, Pacific and the ROPME<sup>50</sup> sea area (UNEP 2009). Countries bordering these regional seas might lack appropriate waste-management schemes because of economic constraints, although a number of African countries have recently banned the use of plastic bags.

<sup>47</sup>Detailed information is available at [www.gisis.imo.org](http://www.gisis.imo.org).

<sup>48</sup>Most often, the US Coast Guard chose to settle violations with a warning, dismissal, or referral of the case to the ship's flag state (Gold et al. 2013).

<sup>49</sup>Convention for the Protection of the Black Sea Against Pollution.

<sup>50</sup>Regional Organization for the Protection of the Marine Environment. The ROPME sea area is surrounded by Bahrain, I.R. Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the UAE.

- Insufficient data on marine litter

Despite the existing schemes against marine litter, our current knowledge of the quantities and the degradation of litter in the marine environment and its potential physical and chemical impacts on marine life are scarce (Galvani et al. 2013). Our knowledge gaps in terms of the biological consequences of micro-plastics exposure, economic and social impacts of marine debris have been mentioned (see other chapters). These gaps hinder the ability to prioritize mitigation efforts and to assess the effectiveness of implementation measures (The Scottish Government 2012). Specific data gaps were identified in a number of studies. For instance, very little data exist on quantities, trends, sources and sinks of marine litter in the west Indian Ocean region and very little is known about the extent and nature of the problem in the east Asian Seas region (GESAMP 2010). In European seas, data gaps were identified, including amounts and composition, transport, origin and impacts of marine litter on the seafloor, in the water column and rivers (Interwies et al. 2013). In addition, illegal, unreported and unregulated fishing activities and their contribution to litter generation, quantities and impacts of derelict fishing gear and micro-particles were referred to. Further data are needed in relation to large-scale and long-term monitoring across countries and environments, smaller-scale dynamics that affect plastic movement and accumulation, and trophic transfer dynamics of persistent organic pollutants via plastics through the marine food web (USEPA 2011).

## 15.5 Recommendations

In view of the above and taking into account the relevant information that has been put forth in the literature, recommendations for improvement are made as follows:

- Development of a new international instrument to tackle the marine litter problem

Given that the scope of existing international law fails to match the scale and severity of the marine litter problem, Gold et al. (2013) urged the global community to develop a new multilateral agreement similar to the Montreal Protocol on Substances that Deplete the Ozone Layer. A set of elements were proposed to be included in such an agreement, including regulation of disposal of plastic litter from both ocean- and land-based sources, incorporating tracking, monitoring, reporting and enforcement standards and mechanisms, banning the most common or deleterious types of plastic litter, calling for a phase-out of all plastics that are not recycled at a rate of 75 % or higher by a certain date.

- Amending existing instruments to narrow exceptions and clarify enforcement standards

Given the long time required to reach and implement a new agreement, Gold et al. (2013) recommended modifications to existing policy to eliminate some of the gaps. For example, amendment of the current vessel size and tonnage

limitations in Annex V for requirements respecting placards, garbage management plans, and garbage record books is recommended so that fewer vessels are exempted.<sup>51</sup> Macfadyen et al. (2009) suggested amending Annex V so as to provide specific guidance on reasonable accidental losses of fishing gear. Regarding the vague definition of the fee systems in the EU PRF Directive, Øhlenschläger et al. (2013) recommended implementation of a 100 % indirect fee system<sup>52</sup> for all European ports.

- Establishment of comprehensive national marine litter programmes  
Marine litter is a transboundary governance problem as it crosses scale, sectors and social divisions (Hastings and Potts 2013). To solve this problem, each state should develop a national marine litter programme (or a similar management scheme). This would constitute a high-level political commitment that could be a driver for relevant actions to be undertaken and ensure that marine litter issues are reflected in all policymaking. Such programmes have the potential to tackle the previously mentioned deficiencies. They should not only aim to reduce litter, but also quantify the sources of litter from land and ocean and promote a culture change with a view to consider “waste as a resource”. To ensure its effective implementation, such programmes should have clear objectives, develop an efficient and integrated regulatory and management system, implement a suit of actions related to monitoring and research, infrastructure, education, incentive schemes, and enforcement and compliance, and establish public-private partnership/community involvement. In particular, such programmes should focus on long-range land-based waste management plans that lead to full collection and disposal services since the management of solid wastes on land directly affects quantities of marine litter (Liffmann et al. 1997).
- Enhancing participation and cooperation of states in international/regional initiatives

The transboundary nature of marine litter underlines that the problem is global in scale and international in impact. In this regard, national measures alone are insufficient to control marine debris, and international/regional cooperation is required. An empirical long-term litter monitoring study in the Southern Ocean showed that ocean-based litter monitoring needs to be integrated at an international or regional level (Edyvane et al. 2004). A wide range of international/regional initiatives on marine litter (such as UNEP RSP, GPA and GPML and various regional sea instruments) have established a platform for concerned states to engage in cooperation; participation and cooperation should be enhanced and strengthened both in terms of the number of participating states and the substantiality of cooperation.

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<sup>51</sup>According to Revised Annex V, reg. 10, ships  $\geq 12$  m length are required to display placards, ships  $\geq 100$  GT to follow garbage management plans, and ships  $\geq 400$  GT to use garbage record books.

<sup>52</sup>This fee is paid by all ships calling at a port irrespective of the amount of waste disposed of at PRFs. It can effectively prevent cost from becoming a disincentive for using PRFs and has been implemented in ports such as Copenhagen (Denmark) and Stockholm (Sweden) (see Newman et al. 2015).

This would promote a dialogue among states on good practices in marine litter management and allow for substantial coordination and cooperation in research and developing and implementing more effective and practical management measures, such as the standardization of litter monitoring methods, the technologies for solid waste management, the waste notification system and the fee system for ship-generated waste. Moreover, this would help less wealthy countries to advance solid waste and sewage management through technical and financial assistance and training provided by more experienced countries and international organizations (Liffmann et al. 1997).

- Strengthening management measures on fishing vessels

Although many studies suggest that fisheries are an important source of marine litter, most fishing vessels are exempt from the discharge regulations of Annex V of MARPOL 73/78 because of their low tonnage. In addition to the previous recommendations to amend Annex V to narrow exceptions, I propose two approaches based on the area where fishing vessels operate. For vessels, which work solely in national waters, management measures at national levels should be specifically devised and strengthened. For example, Murray and Cowie (2011) demonstrated the presence of plastic microfibrils shed from fishing net protectors in the intestines of >80 % of the commercially harvested prawns, an issue that could be well addressed by gear regulations. Arthur et al. (2014) found that the number of crabs caught per derelict fishing trap per year ranged from 4 to 76 in selected US coastal waters. This issue could be addressed by designing traps (e.g. escape panels) that allow species to escape when traps become derelict, thus rendering derelict traps “non-fishing”. Kim et al. (2014) estimated that 11,500 t of traps and 38,500 t of gill-nets are abandoned annually in Korean waters and suggested incentive programmes for fishermen to use eco-friendly gear designs.

In addition, several measures could be adopted, including developing waste recycling practice among fishers, installing adequate PRFs, encouraging environmental education, promoting lost gear recovery, encouraging the use of environmentally friendly gear, promoting spatial management to reduce gear conflict and improving gear marking (Cho 2009; Macfadyen et al. 2009; Chen and Liu 2013; Gold et al. 2013; Arthur et al. 2014). Some of these measures may also apply to other types of small vessels (e.g. pleasure crafts), which are also exempt from Annex V.

For vessels operating on the high seas, numerous regional fishery bodies (RFBs)<sup>53</sup> have been established to manage and conserve fisheries resources based on geographical areas or fish species. They are generally established by coastal states and fishing nations with a common interest in overcoming collective-action problems related to the management of transboundary stocks (Sydnes 2001). Many have management mechanisms in place to regulate fishing activities, such as CCLAMR, International Commission for the Conservation of Atlantic Tunas,

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<sup>53</sup>A full list of RFBs is available at [www.fao.org/fishery/rfb/search/en](http://www.fao.org/fishery/rfb/search/en).

Indian Ocean Tuna Commission, Western and Central Pacific Fisheries Commission, Northwest Atlantic Fisheries Organization, to name but a few. Taking advantage of the fully fledged management mechanisms, RFBs could take further actions to integrate fishery-related debris reduction into their wider management regime. To enable RFBs to adopt appropriate actions, it is advisable that the FAO, the lead organization of fisheries management and conservation, takes a lead in this initiative by providing guidance on effective and practical measures. In relation to this, some progress is being made to deal with derelict fishing gear by proposing a list of recommendations in a UNEP/FAO Technical Paper. The recommendations include both international and national actions, including developing an action plan on adequacy of PRFs for fisheries waste, amending Annex V, and formulating a global action plan to address the waste of fishing gear (Macfadyen et al. 2009). In addition, Gold et al. (2013) suggested that RFBs should adopt management standards to minimize the impacts of gear loss and move toward the replacement of plastic and synthetic gear with biodegradable nets and traps to minimize ghost fishing and entanglement.

## 15.6 Conclusion

The problem of marine litter is complex, as it is rooted in our prevailing production and consumption patterns and the way we dispose of and manage waste. Tackling this problem necessitates the inclusion of a vast amount of activities, sectors and sources that cannot be addressed by a single measure. A global reduction of the production of plastic waste/products through extended producer responsibility should be at the heart of all management solutions as this would ultimately be reflected in decreased inputs into our oceans. A variety of instruments at international, regional and national levels has been developed. In this chapter, the general mechanisms of instruments were analyzed and a number of them, including specific management measures contained therein, were profiled as illustration. The measures on marine litter are either on a mandatory or voluntary basis. In addition, based on the principle purposes, management measures were broadly divided into four categories: preventive, mitigating, removing and behavior-changing. This chapter further identified the potential gaps in existing frameworks and offered recommendations for improvement. The recommendations include establishment of a new international instrument targeted to the plastic marine litter problem, amending existing instruments to narrow exceptions and clarify enforcement standards, establishing comprehensive national marine litter programmes, enhancing participation and cooperation of states with regard to international/regional initiatives, and devising measures to prevent marine litter from fishing vessels.

As with other environmental problems, marine litter could be prevented and controlled through an effective collaboration of education and outreach programmes, strong regulations and policies, effective enforcement, and adequate

support infrastructure. Based on this perspective, I hope that the current regulatory and management framework, potential gaps identified and recommendations made, will contribute to better management of marine debris. Last but not least, it is envisaged that through the ongoing efforts to combat marine litter, a shared vision for “litter-free marine environments” would be realized among all of the various actors and stakeholders concerned.

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