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Marine litter: socio-economic study

Scoping report

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Marine litter – socio-economic study
Scoping report: ***draft for discussion***

Short Summary

Marine litter is a pressing global environmental challenge with rising economic, social and environmental costs.

Marine litter is a growing threat facing the international community. It is distributed throughout the marine environment and includes large items such as abandoned fishing nets and plastic bags that wash up on beaches and accumulate in ocean gyres, to micro- and nano-particles of plastic that are embedded in seafloors and ingested by marine species.

This litter arises from various economic sectors and activities, either directly or indirectly. Key contributing sectors include aquaculture and fisheries (accidental loss, intentional abandonment and discarding of buoys, fishing nets etc.), shipping (accidental releases of plastic pellets, 'plastic' blasting in shipyards etc.), cosmetics and personal care products (e.g. use of microbeads etc.) and retail (e.g. plastic bags, bottles, packaging etc.). The problem is exacerbated by inadequate waste management infrastructure and practices as well as by direct littering by residents and tourists.

Marine litter has economic, social and ecological impacts from the local to the international level. The presence of marine litter can affect the local and national economy (e.g. revenue losses to fisheries, tourism, shipping industry etc.), society (e.g. affecting the health and well-being of residents and visitors) and the marine environment (e.g. degrading inland, coastal and open-sea ecosystems). These impacts can be **costly** (see Table 1) and are often not borne by the polluters themselves but by other actors, including the wider public.

Table 1: Potential economic impacts and costs of marine litter - examples

Sector	Impacts of marine litter	Estimated costs
Fishing	Marine litter can lead to the loss of output or loss of value in the sales of certain types of seafood and fish.	The loss of marketable lobster due to abandoned or lost fishing gear is estimated to lead to a global loss of US$250 million per year. Microplastics are estimated to lead to a loss of up to 0.7% of annual income every year for the UK aquaculture sector.
Shipping	Plastic debris can foul ship propulsion equipment, disrupting operations, requiring clean-up, repair and rescue efforts, loss of life or injury.	In 2008, 286 rescues of vessels with fouled propellers in UK waters were carried out at a cost of between €830,000 and €2,189,000. Cost of removing litter and addressing damage in the Scottish aquaculture industry is estimated at €155,549/ year.
Tourism	Polluted beaches can discourage visitors from certain beaches, leading to lost revenues for the tourism sector.	In Goeje Island (Republic of Korea), marine debris led to lost revenue from tourists of between €29-37 million in 2011. In the Asia Pacific Economic Community (APEC) region, marine debris is estimated to cost the tourism sector approximately US$622 million/year.

Marine litter can **degrade ecosystems, their components, functions and associated services.** These environmental impacts occur via ingestion (e.g. plastic bags by turtles, plastic waste by birds or fish), entanglement (e.g. 'ghost fishing' by discarded nets), toxicity (e.g. some additives are endocrine disruptors) and the spread of invasive alien species (IAS) (e.g. affecting coral reef health). These impacts can have negative implications for local communities and certain economic sectors, through long term impacts on fisheries, tourism and through reduced coastal protection due to coral reef degradation.

Marine litter can also lead to **social costs** including reduced benefits from access to coastal environments (e.g. reduced blood pressure, tension, stress etc.), reduced opportunities for recreational activities, health risks to coastal visitors (e.g. contaminated swimming water, cuts from sharp items) and potential risks associated with the consumption of contaminated marine products. These costs can be disproportionately felt by certain groups (e.g. people living in lower income areas which may not benefit from the same level of waste management attention as other areas) and certain regions (e.g. Small Island Developing States (SIDS) are inundated with marine litter transported from other regions by ocean currents and lack the resources to deal with it).

Solutions range from upstream prevention of marine litter to downstream clean-up activities.

- **Extended producer responsibility and changes in product design** can avoid certain types of marine litter, particularly those difficult to address downstream, e.g. removing microbeads from cosmetics, installing filters in washing machines to remove microfibres from wastewater.
- **Invest in waste management infrastructure and wastewater treatment facilities** to avoid dispersion of litter in the marine environment. This can include litter netting at the perimeter of landfills, improved beach and port infrastructures, investments in wastewater treatment plant and litter traps (this does not however address items transported through storm drains).
- **Economic incentives** such as deposit refund schemes and plastic bag charges can influence consumer choice (e.g. which products to buy) and/or encourage different habits (e.g. returning bottles, multi-use bags) and can thus act as an effective upstream measure.
- **Bans** (e.g. on plastic bags, smoking on beaches, plastic blasting in shipyards etc.) can provide a cost-effective solution to avoiding marine litter, however feasibility will depend on various factors including the availability of substitutes, political considerations etc.
- **Awareness raising activities** among consumers can help to avoid the generation of marine litter, for example by informing their purchasing choices to help them reduce their consumption of plastic bags and cosmetic products containing microbeads, and reinforcing the benefits of proper waste disposal and not littering. This upstream preventative measure can be facilitated and complemented by the producer measures mentioned above.
- **Marine litter clean-ups** are costly but necessary downstream actions (at least until marine litter is tackled closer to its source). Engaging volunteers in clean-up activities can help reduce costs (although the time of volunteers also has an economic value) and improve awareness.
- **Fishing for litter** can be a useful last option in the hierarchy, but can only address certain types of marine litter. This could be combined with economic incentives to encourage action, e.g. in the Republic of Korea, fishermen are paid US$10 per 100 litre bag of litter collected.

The costs of such response measures will vary (see Table 2), however these costs can be significantly less than the costs of inaction (see Table 1).

Table 2: Potential costs of different solutions to address marine litter - examples

Response measure	Estimated cost
Participation in extended producer responsibility schemes for packaging	Cost to producers of between €1 to €20 per capita per year
Installation of a filter to capture microfibres from a washing machine	$140 per unit
Mechanical litter collection system for the Salina Landfill in Kansas (US)	US$15,000 for a custom-made unit for the landfill
Annual costs of coastal clean-up activities (excluding value of time spent by volunteers)	€10.4 million in Netherlands and Belgium €18 million in the UK US$1,500/tonne in the APEC region US$ 2.5 million in labour costs in Peru
Annual costs of removing litter from wastewater streams	US$279 million in South Africa

The evidence collated for this study so far suggests that the costs of inaction are generally higher than the costs of action, but additional research is required to verify and substantiate this.

Furthermore, there is a critical need to better understand the impacts of marine litter and what cost-effective measures are needed to address this problem.

In June 2014, the United Nations Environment Assembly (UNEA) adopted Resolution 1/6 on Marine Plastic Debris and Microplastics. The Resolution requested UNEP to undertake a study on marine plastic debris and marine microplastics and deliver a report for the second session of UNEA (UNEA-2) in 2016. One component of this report will examine the socio-economic impacts of marine litter.

Supporting Facts

1 A socio-economic study in support of the UNEP study on marine plastic debris

1.1 Marine litter, its sources and impacts

Recent research has estimated that in 2010, around 275 million metric tons (MT) of plastic waste was generated in 192 coastal countries, of which between 4.8 and 12.7 million MT entered the oceans (Jambeck et al, 2015). There are many different types of marine litter, ranging from large items such as abandoned fishing nets, to smaller but still visible items such as buoys, floats, bottles, polystyrene packaging, plastic pellets, plastic bags and cigarette stubs, and finally to micro and nano plastics, including microbeads in cosmetics and micro/nano-fibres from clothes. Over time, large items often break down to ever-smaller particles that then become widely distributed globally throughout the marine environment, and are particularly prevalent on the seabed, surface and beaches.

Sources of marine litter include a varied range of economic sectors and activities. Key sectors include aquaculture and fisheries (which can generate litter in the form of buoys, netting, ropes etc.), shipping (accidental releases of plastic pellets, use of 'plastic' blasting in shipyards etc.), transport (e.g. tyre wear), cosmetics (e.g. use of microbeads), retail (e.g. plastic bags, bottles, packaging etc.). Some marine litter originates from accidental losses (e.g. relocation of fishing gears by extreme tides, currents and waves), whilst others may be a result of deliberate action (e.g. abandonment of end-of-life fishing and aquaculture materials), or simply because actors are unaware of their obligations for the safe disposal of plastics. Product design that does not take into account the end-of-life of a product or results in single-use products, inadequate waste management practices and infrastructure, and direct littering by citizens and tourists exacerbate the problem and are other major sources of marine litter.

The route of marine litter from source to final destination is often complex, and as such, its impacts as well as potential solutions to address it can occur at different stages. In addition to direct inputs of litter to the marine environment such as those mentioned above, marine litter can be transported by rivers (e.g. buoys, floats, micro plastics and nano-fibres that pass through wastewater treatment plants) or by air (e.g. blown from unprotected landfills, insufficient urban waste infrastructure). This litter ends up on beaches and ports, gyres in the open seas, embedded in seafloors and ingested by marine species, which, through the food web, can in turn be consumed by humans.

The impacts of marine litter are as varied as its sources and can have environmental, economic and societal consequences from the local to the international level.

Ecosystem degradation can lead to impacts on the functioning of ecosystems, their resilience and the flow of ecosystem services. Environmental degradation includes both chemical impacts (e.g. chemicals leaching from plastics), physical impacts of litter items (e.g. entanglement of or ingestion by marine species), and impacts from invasive alien species that hitchhike on marine litter items. Impacts on ecosystem service provision can include reduced food provision (in terms of both quality and quantity), reduced attractiveness of coastal areas leading to a reduction in tourism and recreational activities, and in rare cases impacts on coastal protection (e.g. where coral reefs are damaged by marine plastics and invasive species).

Economic impacts of marine litter include loss of revenues from tourism in coastal areas affected by marine litter, reduced landings from certain fisheries affected by marine litter, and direct costs of clean-up (to municipalities) or repair (ship fouling and damage). Social impacts include reduced benefits from access to coastal environments and wellbeing losses from living in a polluted, degraded environment which can affect sense of identity and community, reduced opportunities for recreational activities, health risks to coastal visitors and potential risks associated with the consumption of contaminated marine products.

1.2 Aims and objectives of the socio-economic study

IEEP[1] has been commissioned by UNEP to undertake a study on the socio-economic impacts of marine litter. The study aims to identify the key socio-economic components of marine litter, highlighting its main sources, the human dimension and socio-economic conditions related to marine litter.

The study will synthesise existing information on the current costs of marine litter impacts on various sectors, actors and environments (i.e. the costs of non-action) and identify the most affected groups. It will also aim to identify the anticipated costs of addressing marine litter and therefore avoiding its impacts (i.e. costs of action). In the later stages of the study, promising solutions and approaches to addressing marine litter will be identified and a synthesis of methodologies will be provided for assessing broad socio-economic costs of marine litter. Finally, ongoing and future knowledge and data needs will be identified in order to contribute to the development of a comprehensive picture of the socio-economic implications of marine litter. The study will focus on six selected themes, namely: consumer behaviour and willingness to engage (see section 2); collection costs and infrastructure (see section 3); fishing and aquaculture (see section 4); tourism, aesthetic value and recreational opportunities (see section 5); shipping (see section 6); and invasive alien species (IAS) & pathogens transported by marine litter (see section 7).

The socio-economic study is being carried out in 2015 with a final report to be produced in November 2015. The study will feed into a broader UNEP study on marine plastic debris and marine microplastics[2] which will be presented to the second meeting of the United Nations Environment Assembly (UNEA-2) in Nairobi, Kenya in May 2016 in response to resolution UN/EA 1/6 on marine plastic debris and microplastics.

1.3 Aims and objectives of this paper

This paper provides some insights arising from the initial stage of research for the socio-economic study; as such it does not aim to provide a comprehensive summary of all elements of the full study. This paper aims to provide input to the G7 summit in Schloss Elmau by setting out some of the main socio-economic impacts of marine litter, together with initial examples of data on the costs of action to address marine litter and the costs of not taking action on marine litter. The authors would welcome receiving suggestions for studies, papers and case examples for the ongoing work[3].

[1] www.ieep.eu

[2] Plastic particles with a diameter smaller than 5mm

[3] Please contact Emma Watkins of IEEP at EWatkins@ieep.eu.

2 Producer and consumer responsibility – challenges and opportunities related to behaviour and willingness to engage

2.1 Production as a source of marine litter

The worldwide production and trading of many consumer goods is increasing. To take one example critical to marine litter, global plastics production has increased from 200 million metric tonnes in 2002 to 299 million metric tonnes in 2013, an increase of almost 50% (Statista, 2015). However, this increased level of production (and resulting consumption) has not been accompanied by a development of waste management practices that are adequate to deal with the new flood of plastic waste. In 2012, plastics made up almost 13% of the municipal solid waste stream in the US, compared with less than 1% in 1960, but only 9% of plastic waste was recovered for recycling (US EPA, 2014). Partly as a result of a lack of design guidelines or legal design requirements, products are often designed to be single-use (e.g. packaging, thin plastic bags) which drives increased consumption of new products, and/or are not designed with end of life recyclability in mind. This means that little or no value is attributed to plastic products at the end of their life, and they are often treated as disposable. In addition, most plastics can only be recycled a small number of times, so to close the loop, end uses must be found for recycled plastic (e.g. flooring, fleece clothing). The environmental damage to marine ecosystems caused by plastics has been estimated at US$13 billion per year (including financial losses to fisheries and tourism (see sections 4 and 5) and time spent on clean-up activities), whilst the total natural capital cost of plastic used in the consumer goods industry (i.e. the financial cost to companies if the impacts associated with their current practices were internalised) is estimated at over US$75 billion per year (including the cost of environmental impacts, including greenhouse gas emissions, and loss of resources when plastic waste is not recycled) (UNEP, 2014).

2.2 Consumers as a source of marine litter

Consumer behaviour and practices on land, in coastal zones or on sea contribute to a large fraction to marine litter. Land-based sources are globally the main contributor, though there are regional variations as regards importance of sources (Jang et al. 2014b, Sheavly & Register 2007, STAP 2010). Scientific monitoring and litter collected in beach clean-ups suggest that wrongfully disposed consumer goods form the largest fraction of marine litter.

Box 2.1. Analysing Marine Litter in the Baltic Sea – Findings from the MARLIN Project

The Baltic Marine Litter project has been monitoring litter at 23 beaches in Sweden, Finland, Estonia and Latvia over two years. Typical items found on urban beaches were bottle caps, plastic bags, plastic food containers, wrappers and plastic cutlery. The researchers estimate that 48% of marine litter in the Baltic Sea originates from household-related waste. Waste generated by recreational or tourism activities contributes a further 33% (MARLIN 2013).

In some cases, the actions of consumers are clearly and obviously linked to marine littering, such as uncontrolled disposal of packaging or plastic bags in the environment. In other cases, consumers contribute to marine litter through more hidden pathways such as the use of cosmetics containing microplastics or through wastewater streams which transport microfibers, for example from textiles, into the sea (Browne et al. 2011, UNEP 2014). Thus, consumers contribute to marine litter in different contexts, such as visitors to marine or coastal regions, but also in everyday life through littering on land or in everyday situations where littering is not visible as a process. To facilitate consumer response, retailers and producers need to provide clearly visible substitutes (e.g. cosmetics that do not contain microbeads, multi-use bottles) or upstream solutions (e.g. filters on washing machines). In addition, this would require adequate waste collection infrastructure (e.g. bins at beaches).

2.3 Consumer groups impacted by marine litter – cost of inaction

Consumers as final users of goods are a major contributor to marine litter. However, they are also the largest single group impacted. Marine litter can result in direct and indirect costs as a result of inaction (McIlgorm et al. 2008). Impacts on human health and well-being can occur through direct contact with debris resulting in cost of medical treatment (Hall 2000). The accumulation of harmful substances through the food chain, for example through degrading plastics, could also impact consumers (Van der Meulen et al. 2014). Many of these impacts are not fully understood yet, including their magnitude on a global, regional and local scale, and their cost dimension.

Indirect costs can occur in the form of visual impairment of littered beaches, shorelines and marine environments which lower the recreational value of sites to visitors and local residents and result in additional cost as visitors relocate to alternative sites (McIlgorm et al. 2011, Birdir et al. 2013). A degradation of marine and coastal ecosystems through litter can lead to further disutility. Clean-up costs are also significant and rising (see sections 3.4 and 5.3).

2.4 Potential means of engagement/solutions

2.4.1 Producers

Recent studies suggest that there are significant energy and emissions benefits to producers associated with the use of plastics (e.g. plastic packaging can reduce food waste and decrease transportation and fuel costs), whilst recycling and energy recovery of plastics may save consumer goods companies around $4bn per year (UNEP, 2014). There are therefore good reasons for producers to engage in actions that enable them to continue using plastic whilst ensuring that as much as possible is recycled.

Environmentally-friendly design can help to ensure more waste is captured for recycling. For example, implementation of the 2006 revision of the Packaging Recycling Act in Japan led to a significant switch by producers from green PET bottles to clear ones with green labels (helping to reduce the cost of collection by removing the need for green bottles to be collected separately) (OECD and Japanese Ministry of the Environment, 2014).

Extended producer responsibility (EPR) makes a producer financially and/or logistically responsible for the post-consumer (i.e. waste) stage of a product's life cycle. It is widely implemented in EU and OECD countries, and in recent years has been increasing in emerging Asian, African and South American economies (OECD and Japanese Ministry of the Environment, 2014). With regards to marine litter, packaging is a particularly important waste stream to be addressed by EPR: food wrappers, plastic, glass and metal beverage containers (and bottle caps) together comprised 31% of all items found during the Ocean Conservancy's 2013 International Coastal Cleanup. The fees paid by producers to EPR schemes (which may vary considerably in different countries and for different packaging materials) fund the collection and treatment of waste packaging (although in most cases this does not include the cost of dealing with packaging that is littered by consumers). EPR has contributed to a 64% recycling/composting rate, and a 77% recovery rate (including energy recovery) for waste packaging in the 27 EU Member States in 2011. In Japan, recycling of containers and packaging waste increased by 27% in the first three years after the introduction of the Packaging Recycling Act in 1997 (OECD and Japanese Ministry of the Environment, 2014).

Box 2.2 Cost to EU producers of packaging EPR schemes

One recent study found the cost to producers of participating in packaging EPR schemes in seven EU countries ranged from just over €1 per capita per year in the UK to almost €20 per capita per year in Austria. The wide variation was primarily due to the different levels of cost coverage: fees from the purchase of Packaging Recovery Notes (PRN) in the UK cover only 10% of the total cost of the system, whilst most of the other schemes reviewed cover 100% of the net costs of collection and treatment of separately collected waste. (BIO by Deloitte et al., 2014)

2.4.2 Consumers

Activities that target consumers as sources of marine litter need to address the different roles of consumers, littering contexts and littering pathways. Ideally, such activities will aim at reducing litter-prone forms of consumption such as one-way (i.e. single-use) packaging and encouraging the reuse of everyday products such as (plastic) bags.

Information and awareness raising activities are crucial to sensitise consumers about their contribution to the marine litter problem. This is especially the case for marine litter sources and pathways that are not salient to consumers. These activities need to identify littering contexts and specifically address certain consumer groups and ages, such as schoolchildren, outdoor travellers or interested citizens who want to engage actively for example as citizen scientists (Eastman et al. 2014). Promoting volunteering activities such as beach clean-ups can also help to reach the audience that is contributing to marine litter.

However, behavioural research has repeatedly shown that information itself will not automatically lead to a change of behaviour, which is often context dependant. Consumer engagement with solutions will require additional enabling instruments such as clear product labels or clear practical and step-wise guidance to behaviour change.

Box 2.3 Informing and Empowering Consumers: The "Beat the Bead" campaign

"Beat the Bead" quickly gained momentum since 2012. By specifically targeting microbeads used in cosmetics and personal care products and by providing an enabling instrument, a smartphone app that helps identify products with microbeads, the initiative led to many manufacturers and retailers rethinking their product policy. Originally an initiative of two Dutch NGOs (the North Sea Foundation and the Plastic Soup Foundation), the initiative gained wider support by environmental and consumer groups, and is now also supported by UNEP (www.beatthemicrobead.org).

Economic instruments are a further set of tools that can help curtail littering and increasing the recovery of resources. Deposit schemes can be helpful in addressing typical and relevant categories of litter such as single-use plastic bags or packaging for food and beverages.

Box 2.4 South Australia container deposit scheme

Hardesty et al. (2014) reported that South Australia's container deposit scheme, which applies a AUS$ 0.10 refundable deposit to beverage containers, resulted in a 3-fold reduction in the number of beverage containers lost to beaches.

Taxes and levies can play a similar role, with the additional option of generating revenues that can be used for addressing consumer behaviour.

Box 2.5 Irish plastic bag levy

The Irish plastic bag levy is a widely discussed and cited example of the successful application of an economic instrument. After introducing a €0.15 levy on retail plastic bags, sales in retail outlets dropped by 90%. The levy was also very cost-effective, as stores could use the existing Value Added Tax scheme for collecting and reporting the levy (Convery et al. 2007, Pape et al. 2011).

Especially for highly sensitive ecosystems or hotspots of littering activities by consumers, bans on certain products are conceivable, such as restricting smoking on beaches or banning plastic bags with certain product characteristics.

3 Collection costs and infrastructure

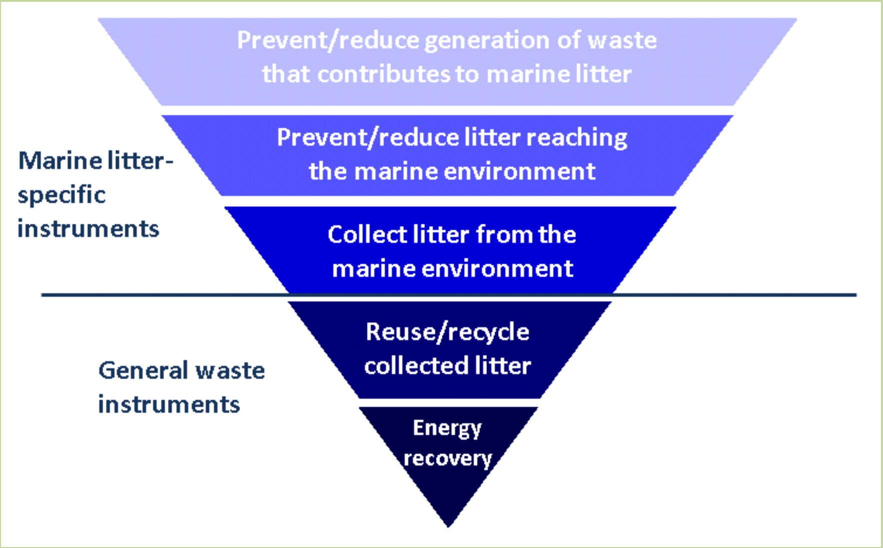
3.1 Introduction

Much marine litter originates from land-based sources; a global figure of 80% is frequently cited, although the origins of this are unclear (NOAA 2009) and there may be considerable regional variation. Land-based sources include general litter which is blown or washed into watercourses, stormwater systems, illegal dumping near watercourses, wind-blown waste from poorly managed landfills, waste items that are inappropriately flushed down toilets and other inadequately managed waste. Measures to promote improved waste management on land can ensure that waste collection infrastructures capture the maximum possible amount of waste that is prone to becoming marine litter. The global waste market sector from collection to recycling is estimated to have a value of US$410 billion a year, excluding a very large informal sector (UNEP and GRID-Arendhal, 2015).

3.2 A 'hierarchy' for marine litter

The concept of a 'hierarchy' for waste management is now commonly accepted. The typical waste hierarchy prioritises prevention as the preferred method of waste management, followed by reuse, material recycling, energy recovery and disposal. Figure 1 uses this order and applies it to marine litter to create a suggested ideal hierarchy for the management of marine litter.

Figure 1 A suggested hierarchy for marine litter management



Source: own representation.

3.3 Waste management methods to prevent marine litter

To tackle the upper elements of the marine litter waste management hierarchy, the producers of waste that ends up as marine litter should ideally be made to bear its economic costs. Marine litter is facilitated because its external cost to society is not adequately borne by the waste producer. This can be addressed for example through improved product design and extended producer responsibility (see section 2.4.1 **Fehler! Verweisquelle konnte nicht gefunden werden.**above).

With regards to waste disposal, landfill taxes/levies (typically charged per tonne of waste sent to landfill) may help to tackle marine litter by increasing the price of landfilling, in order to encourage waste diversion to closed-loop management such as recovery, recycling or reuse. Lightweight items of waste (such as many small packaging items) placed into landfills can be blown by the wind from the surface of landfills, enabling them to reach water courses and eventually enter the sea. Steps should therefore be taken at landfill sites to minimise windblown litter.

Box 3.1 Litter prevention and removal at landfills

Methods to minimise windblown litter have a cost, but are effective. Litter netting at the perimeter of landfills can be efficient in controlling litter, and is a cost-effective alternative to the labour costs of remedial litter removal. The Salina Landfill in Kansas (US) designed a mechanical litter collection system capable of collecting large pieces of litter, with a large bin for holding litter between dumping, and a device to spray litter with water prior to dumping (to minimise windblown litter). This system cost US$15,000 to construct ($12,000 of which was for the compressor) and worked for over seven years with minimal maintenance. (Martel and Helm, date unknown)

It should be noted that an increased price for landfilling can be a perverse incentive leading to illegal dumping of waste, in particular in developing countries or those with poor waste management regulation and enforcement. The Scottish Government has estimated that around 1.6% of marine litter comes from illegal waste dumping incidents (Scottish Government 2013). Tackling illegal waste dumping has a cost, but helps to prevent dumped waste from reaching rivers and seas.

Box 3.2 Cost of cleaning up illegally dumped waste

Recent estimates of the cost to English local authorities of dealing with clearance and enforcement related to illegal waste dumping range from £36m (NFTPG, 2013) to £45.2m (NFTPG, 2013) to £51.6m (Environmental Services Association Education Trust, 2014) per year. In addition, the cost to private landowners of clean-up and disposal associated with illegally dumped waste is estimated to be in the region of £50-150m per year (NFTPG, 2013).

Wastewater (i.e. used water from households, businesses, industry etc.) is emerging as an important pathway for certain types of marine litter. Two specific examples are the use of personal care and cosmetics products containing microplastics, and laundry, which is a source of synthetic fibres (from the release of plastic microfibres when synthetic clothes are washed). Some of these microplastics/fibres are not captured by wastewater treatment plants; one estimate suggests that around 20,000 fibres per litre of wastewater eventually enter rivers and seas (Life-Mermaids Project, 2015).

Box 3.3 Costs related to removal/prevention of litter from wastewater

- One estimate suggests that removing litter from South Africa's waste water streams effectively would cost about US$279 million per year (ten Brink et al. 2009).
- The Lint LUV-R washing machine filter, developed by Blair Jollimore in Canada, can be retrofitted to any washing machine and costs $140. It is fitted to the water discharge hose, and a reusable stainless steel screen removes lint and untreatable synthetic solids from the discharge water, preventing solids (including microfibres) from reaching septic tanks or mains wastewater systems. In an average household of four people, the filter should be cleaned once every 3 weeks. (Environmental Enhancements, 2015)

3.4 Marine litter collection costs

The collection of marine litter has a direct economic cost to coastal municipalities, and voluntary organisations also often play a significant role in litter removal.

Box 3.4 Cost estimates for litter removal from beaches (see also section 5.3, box 5.3)

Country / Region	Estimated cost	Source
Approximate global cost of keeping all 34 million km of global coastlines clean	€50 billion per year (theoretical cost extrapolated from estimates of cost of clean-up of UK coastline)	Wurpel et al. (2011)
Peru	US$ 200,000 per year for one municipality to deal with litter	McIlgorm et al. (2011)
US	$2.2 million per year for removal of beach litter in city of Long Beach, California	Wurpel et al. (2011)

4 Fishing and aquaculture

4.1 Impacts of the sector

The fishery sector's largest contribution to marine litter is generally due to abandoned, lost or discarded fishing gear (nets, ropes, traps), which can end up catching target and non-target fish indiscriminately for a long time after it is dumped into the sea (a phenomenon known as ghost fishing) (Macfadyen et al. 2009; Brown et al., 2006). Ghost fishing has both a direct impact in terms of reduced fish stock and an indirect impact in terms of damage to ecosystems and loss of biodiversity resulting from entanglement and subsequent mortality of endangered, threatened and protected species. In certain countries, aquaculture has the highest share/impact on marine litter, for example through the loss of buoys (Jang et al., 2014b).

4.2 Impacts on the sector

The impact of marine litter on the fishery sector is due both to the immobility and damage to fishing vessels and equipment and to the reduction of potential catches. As regards the first point, the impact is mostly due to floating objects affecting engine cooling systems and becoming entangled in propellers (McIlgorm et al., 2011). Information on the related costs is not systematically collected by marine authorities and needs to be estimated (see Box 4.1 for an example).

Box 4.1 The cost of marine litter damage to Shetland fishermen

Based on a survey with Shetland fishermen, Hall (2000) calculates that marine litter causes each boat a loss of up to £2,000 in revenue due to debris caught in the nets, contamination of fishing equipment and the need to avoid areas with a high concentration of debris.

The impact on fish is due to (a) entanglement in plastics floating at the sea surface or in derelict fishing gear (ghost fishing), (b) ingestion and (c) exposure to toxic materials (either embedded into the plastic that is directly ingested or absorbed by the plastic from surrounding polluted waters) (Thevenon et al., 2014; Rochman et al., 2013). There is an important data gap to be filled about the overall economic impact of marine litter on the fishery sector (Arthur et al., 2014; McIlgorm et al. 2009), but some anecdotal information can be found in the literature (see Box 4.2 for one example).

Box 4.2 The cost of marine litter to Scottish fishermen

Based on a questionnaire to Scottish fishermen, Mouat et al. (2010) calculate a cost of between €17,219 and €19,165 per fishing vessel due to marine litter, including lost earnings due to the time dedicated to clearing litter from nets (66% of the total), the cost of repairs to fishing gear and nets (21%), the value of dumped catch (12%) and the cost of fouling incidents (1%). Extrapolated to the entire sector, this could represent a cost of between €11.7 and €13 million per year to the Scottish fishing industry, i.e. 5% of the overall revenues. As regards aquaculture, marine litter is estimated to cost the surveyed operators about €580 per year, mostly due to the need to clean propellers (56%), repair or replace damaged propellers (35%) and remove litter from cages and mussel lines (9%). This corresponds to an estimated €155,549 per year for the entire aquaculture industry in Scotland, if the figures found through this survey were representative of the entire sector.

Ghost fishing is responsible for significant economic losses for the fishing sector, due to reduced catches (see Box 4.3 for an example).

Box 4.3 The economic loss of marketable lobster due to ghost fishing

A study by UNEP (2009) calculates a global loss of US$ 250 million per year due to the loss of marketable lobster caused by abandoned or lost fishing gear.

Microplastics also have an impact on the fish stock, as they can be ingested by small organisms at the bottom of the trophic chain, from where they can be transferred through the food web from one trophic level to the next (GESAMP, 2015; Wright et al., 2013), causing potential damage to the fishery and aquaculture sector, particularly where demand falls due to concerns of health impacts from ingestion of microplastics in food (see Box 4.4 for an example of the related costs).

Box 4.4 Economic losses potentially suffered by UK oyster & mussel aquaculture sector due to microplastics

A model developed by van der Meulen et al. (2014) calculated a yearly loss of up to 0.7% of the annual income for the aquaculture sector in the UK due to microplastics. These costs relate to the impacts of microplastics on the mussels and oysters (chemical and physical effects) and in turn on human health (through the consumption of seafood), which can lead to reduced consumer demand and hence socio-economic costs through loss of sales.

4.3 Cost of action to address the problems

The marine litter produced by the fishery sector can be reduced using a combination of preventative, mitigating and ex-post measures (MacFadyen et al., 2009). Examples of preventative measures are the requirement to mark fishing gear in order to identify the ownership, the use of on-board technology to avoid or locate gear and the provision of adequate low-cost or free and easy-to-use collection facilities in ports, incentive schemes to promote proper disposal of discarded gear (see Box 4.5 for an example) and spatial zoning to make other marine users aware of the presence of fishing gear, thereby reducing the likelihood that gear is damaged or moved.

Box 4.5 Incentives to fisher boats for marine litter collection

In the Republic of Korea, fishing boats are provided with large bags to collect litter and an economic incentive of US$10 per 100 litre bag is provided to fishermen (Cho in APEC, 2004, referenced in MacFadyen et al., 2009).

Mitigation measures include the use of biodegradable nets and pots (Kim et al., 2014), which can either be imposed by regulation or subsidised by governmental support programmes. Another interesting example can be found in the Dungeness crab fishery, where trap exits are required to be closed with rot cord that decays in approximately six months (Arthur et al., 2014).

Ex-post measures include the use of on-board technology to avoid loss of or enable location of gear (e.g. side scan sonar for sea-bed surveys) and gear retrieval programmes (MacFadyen et al., 2009). Even though it would be too expensive to remove all lost and discarded fishing gear, programmes aimed at removing it in the most sensitive areas and in areas with demonstrated high loss rates would help address the problem.

Campaigns aimed at raising awareness on the impacts of ghost fishing, such as the one carried out by the NGO World Animal Protection (see Box 4.6), will also play a key role to encourage fishermen not to discard fishing gear improperly.

Box 4.6 The Sea Change campaign

In order to contribute to reduce ghost fishing, the NGO World Animal Protection launched the Sea Change campaign, which aims at addressing the problem of ghost fishing worldwide. The project includes the involvement of different categories of stakeholders to stop gear being abandoned, to support ghost gear removal from the seas and to rescue wounded animals. The initiative includes the “Buddy Up for Sea Change” campaign, which asks people with access to beaches and dive spots to get together between 2 and 8 June 2015 and report ghost gear sightings.

The cost of all these measures can vary considerably across different geographical areas, scopes and durations (see Box 4.7 for two examples of calculations).

Box 4.7 Examples of lost or discarded fishing gear retrieval programmes

- In Sweden, US$ 70,000 is spent to retrieve lost or discarded fishing gear every year in the Baltic Sea. In Norway the annual retrieval costs are about US$ 260,000 (MacFadyen et al., 2009)
- Estimates of clean-up costs in the APEC region range from $100/tonne with volunteer labour up to $25,000/tonne for derelict fishing gear (McIlgorm et al., 2009).

5 Tourism, aesthetic value and recreational opportunities

Impacts on the tourism sector are an often cited example of the socio-economic costs of marine litter. The sector is strongly affected by the increased prevalence of marine litter and is also a major contributing source of marine litter through direct activities of tourists and other users of coastal areas.

5.1 The tourism sector as a source of marine litter

Tourists are one of the main sources of coastal and marine litter. For example a study on the generation of marine debris on Cassino beach in Brazil found that tourism was the main source of marine debris, with debris levels correlated with visitor density, annual income and literacy levels (Santos et al., 2005). Similar results were found in a survey of beach visitors in Chile where 45% of respondents admitted to littering in some way (Eastman et al., 2013).

5.2 Impacts of marine litter on the tourism sector

Impacts on the tourism sector are an often cited example of the socio-economic costs of marine litter. The visible presence of marine litter has an impact on the aesthetic value of coastal areas which can undermine some of the associated benefits such as improved physical health (e.g. reduced blood pressure) and mental conditions (e.g. tension, stress, concentration) (GESAMP, 2015). The presence of marine litter may be a reason not to visit certain marine or coastal areas (see Box 5.1).

Box 5.1 How marine litter affects beach choice – some examples

- A study of thirty-one beaches in **Orange County, California, USA** (Leggett et al. 2014) found that a 75% reduction in marine litter at six popular beaches generated over €40 million in benefits to residents over three months.
- In **Cape Town, South Africa**, 40% of foreign tourists and 60% of domestic tourists interviewed claimed that marine litter would prevent them from returning to a beach. This would lead to losses of billions of South African Rand (Balance et al. 2000, cited in National Research Council, 2009).

Marine litter can also have an impact on recreational activities, for example through damage to marine ecosystems (which reduces the attractiveness of recreational activities such as diving), fouling propellers and jet intakes of recreational boaters and affecting recreational fishers. Marine litter can also pose health and safety risks to coastal visitors for example by contaminating swimming water (e.g. discarded industrial items, medical/personal hygiene items) or cuts from sharp items (e.g. metal cans, broken glass). A survey of visitors to Cassino beach in Brazil found that at least 30% had been wounded by glass or other sharp objects on the beach (Santos et al., 2005).

The increased prevalence of marine litter thus makes certain beaches less attractive to coastal visitors and can discourage visitors to some beaches. Reduced numbers of visitors leads to lost revenues for the tourism sector which in turn can lead to a loss of jobs in the local economy - see Box 5.2.

Box 5.2 Estimated costs of marine litter to the tourism sector – some examples

- Marine debris at **Goeje Island (South Korea)** is estimated to have led to lost revenue of between €29-37 million (KRM29,217–36,984 million) as a result of over 500,000 fewer visitors (Jang et al., 2014a).
- Marine debris is estimated to cost the tourism sector in the **APEC region** US$622 million (McIlgorm, 2009).

5.3 Cost of action to address the problems

Addressing marine litter in the tourism sector requires both preventative and responsive measures. In terms of responses, costs of clean-up activities associated with littering by coastal visitors can sometimes fall on local municipalities or on private actors such as individual hotels. These costs can be quite significant – for some examples see Box 5.3. In some cases, clean-up activities can be motivated by the need to uphold certain certification standards or voluntary eco-labels such as the Blue Flag Programme[4].

Box 5.3 Estimated annual clean-up costs of marine litter – Some examples (See also section 3.4, box 3.5)

Country / Region	Estimated cost at the national and municipality level	Source
Belgium	€10.4 million (ave. €200,000/municipality/yr)	(Mouat et al, 2010)
Netherlands	€10.4 million (ave. €200,000/municipality/yr)	(Mouat et al, 2010)
Peru	US$ 2.5 million (ave. US$ 400,000/yr in municipality of Ventanillas)	(Alfaro, 2006 cited in UNEP, 2009)
UK	€18 million (ave. €146,000/municipality/yr)	(Mouat et al, 2010)
APEC region	US$1,500/tonne in 2007 terms	(McIlgorm, 2009)

There are also a number of preventative measures which can help address marine litter from the tourism sector. These include for example improvements in waste management infrastructure in tourist areas (e.g. placing suitable bins on beaches), environmental education programmes and tools targeted at tourists (e.g. awareness raising campaigns, clean-up activities), economic instruments (e.g. deposit refund schemes for bottles, fines for littering) and regulatory measures (e.g. smoking ban on beaches, restrictions on visitor numbers during certain peak periods, e.g. over the summer). A mix of different approaches is likely to be needed, and will likely attract varying degrees of public and political acceptance. For example, in a survey of beach visitors in Chile, the two most supported solutions to the problem of beach litter were community-level environmental education programmes and fines (Eastman et al., 2013). Certain regulatory measures such as bans and fines may be politically sensitive and enforcement challenging (i.e. requiring investment in capacities etc.).

[4] http://www.blueflag.org/

6 Shipping

Shipping is an important ocean-based source of marine litter, driven by inadequate infrastructure and insufficient industry understanding of the consequences of inappropriate waste disposal (UNEP, 2009; Øhlenschlæger, Newman, & Farmer, 2013). The MARPOL Convention is the most important international treaty governing the prevention of ship sourced waste (IMO, 2015). It is estimated that 12% of total sea pollution originates from marine transport (IMO, 2012). Like other sources of marine litter this has a number of socio-economic impacts (APEC, 2009; Mouat, Lozano, & Bateson, 2010).

6.1 Impacts of the sector

Waste from the shipping industry can include both deliberate and accidental discharges of items, ranging from a mix of small items of galley waste to whole cargo containers (UNEP, 2009). Common ship originated waste include operational and non-operational items (OSPAR, 2007; UNEP, 2009). The quantities of waste can be substantial and are not distributed evenly. Hot spots for ship generated waste include busy shipping routes and the major oceanic gyres, in which all types of marine waste accumulate (EPA, 2011). The problem of marine litter is likely to be particularly severe in the East Asian seas region, due to intense shipping activity and the massive industrial development which coastal zones have undergone (COBSEA, 2008). There is a relatively high level of certainty that the illegal discharge of waste by ships contributed to litter in oceans globally.

Box 6.1 Marine litter on the Belgian Coast

A Belgian study of the occurrence and distribution of microplastics showed higher concentrations in areas of shipping activity. Using marine sediments from different locations, including coastal harbours, beaches, and sublittoral areas, high concentrations of micro plastics were found in all samples. However the highest concentrations were found in harbours, with up to 390 particles per kg, which was 15-50 times higher than reported maximums in other areas.

(Claessens, Meester, Landuyt, Clerck, & Janssen, 2011)

An important point is that the shipping industry is dependent on sufficient infrastructure to manage waste appropriately including a land based exchange in managing any shipping waste. The effectiveness of this exchange is a key determinant of the impacts of the sector (Øhlenschlæger, Newman, & Farmer, 2013; COM, 2000). Shippers may be deterred from discharging their waste at ports which carry high fees and time-consuming procedures, such as bureaucracy, sanitary regulations and customs checks. On the other hand, crews which intend to manage their waste, for instance separating waste streams in accordance with international law (see below), may be limited by inadequate shore-side waste infrastructure. Hence, shipping operators may be discouraged from controlling their waste if the appropriate tools are not in place (Øhlenschlæger, Newman, & Farmer, 2013).

6.2 Impacts on the sector

The shipping sector is impacted upon by the costs of managing on-board waste streams as well as a number of risks relating to collisions with water borne waste and interference with equipment, such as propeller damage and blocked intakes.

As well as the internal costs of managing waste on-board, the shipping sector usually faces costs for port reception facilities, which are normally associated with a fee. For instance, in the Port of Rotterdam, dependent on their main engine capacity (MEC) boats pay between €225 and €315 for handling 6 m^3 of garbage (Port of Rotterdam, 2014).

Further impacts on shipping relate to the collision of litter with boats and equipment. These costs to the sector include rescue costs for aiding ships with fouled propellers or blocked outages.

Box 6.2 Costs of marine litter to shipping

- Value of debris damage to shipping was estimated at US$279 million per annum (APEC, 2009, p. 16)
- In 2008 there were 286 rescues to vessels with fouled propellers in UK waters at a cost of between €830,000 and €2,189,000 (Mouat, Lozano, & Bateson, 2010).
- Estimate of recovery and disposal of litter in ports and harbours, as well as rescue services in relation to marine litter in the UK £6 million (MaLiTT, 2002, p. 20).

As well as the impact of damage to vessels and equipment, marine litter can pose a health threat to operators of small vessels, for example putting them at risk of collision with lost containers from larger vessels. Although it is not uncommon for boats to lose containers, with an estimated 2,700 lost each year (World Shipping Council, 2014), the risks may be particularly high following single events, for instance the 2007 grounding of MSC Napoli after which 117 containers were lost (MAIB, 2007).

Box 6.3 Marine litter impacts on human health

- Korea – 1996-1998, 9% of all Korean shipping accidents involved marine litter. In one case propeller damage capsized a vessel resulting in 292 deaths (Cho, 2005).
- In 2005, the US coast guard reported that collisions with submerged objects caused 269 boating incidents, causing 15 deaths, 116 injuries and $2.9 million in property damage (US Coast Guard, 2005)

6.3 Cost of action to address the problems (port reception facilities)

Maritime law must be supported by appropriate coastal governance, infrastructure and systemic changes in approaches to waste.

Marine waste from the shipping sector is covered by a number of international, national and port based policies. The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international law covering the prevention of pollution in the marine environment from ships (IMO, 2015). In broad terms MARPOL (73/78) prohibits the disposal of waste overboard and requires signatories to ensure that there are sufficient port facilities to receive waste. At the national levels, some countries have attempted to develop their own legislation to support the implementation of international maritime law in order to reduce marine litter levels. For instance, Iran initiated its own national Integrated Coastal Zone Management (Iranian Ports & Maritime Organization, 2015). The EU has a Directive on Port facilities for ship-generated waste and cargo residues (COM, 2000). Some ocean areas, such as the Western Indian Ocean (WIO) may not have the capacities to effectively police and control litter in their Exclusive Economic Zones (EEZs) linked to shipping in the region (WIO, 2007, p. 5).

Port reception facilities are one of the most important tools for addressing waste generated at sea from all sectors, and if appropriately designed can incentivise best practices. Well-designed port reception facilities will encourage shippers to dispose of their waste correctly, relying on clear waste definitions, communication between actors, timely administration and appropriate inspections.

Box 6.4 No special fee in the HELCOM region

Following high levels of illegal waste discharges in the Baltic Sea during the 1990s, HELCOM (Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea) provided recommendations for the introduction of an indirect or "No Special Fee" approach to waste management in Baltic ports (Øhlenschlæger, Newman, & Farmer, 2013). Such a fee includes in the port fee the cost of delivering waste, irrespective of the quantities discharged. For instance in the Port of Gdansk, a fee is applied to boats depending on their type of between €0.14 – €0.64 per gross tonnage (GT) (Port of Gdansk Authority SA, 2012). The no-special-fee system effectively prevents cost from becoming a disincentive for using port reception facilities; similarly the simplicity of the system results in a reduction in administration costs for port authorities. Furthermore, whilst it can encourage inefficient waste practices on board ships it is believed this system has reduced illegal waste discharges in the Baltic (Øhlenschlæger, Newman, & Farmer, 2013; HELCOM, 2012).

Awareness-raising can also help to reduce shipping related marine litter impacts and costs. For instance, the shipping industry now has compulsory training on marine litter, following leverage from The Dutch Government and the ProSea Foundation on the IMO to amend the STWC (International Convention on Standards of Training) (ProSea, 2011). Such training, as well as the enforcement of good practices will also be associated with a number of costs, which would also need to be included in a socio-economic assessment.

7 Invasive alien species (IAS) & pathogens transported by marine litter

Invasive alien species (IAS) refers to non-native species whose introduction and/or spread outside their native range threaten biological diversity and result in negative socio-economic impacts. At the global level, IAS have been identified as a key factor in 54% of all known species extinctions documented in the IUCN Red List database and the only factor in 20% of extinctions (Clavero & Garcia-Berthou, 2005). Global trade and travel are the underlying causes for the spread of IAS and the upward trend in both sectors translates into an increased risk of IAS introductions. As more than 90% of world trade is carried by sea (IMO, 2012) this makes maritime transport (ballast water and hull fouling) one of the key pathways for IAS introductions. In addition, marine litter is increasingly being recognised as an additional vector for marine IAS.

7.1 Marine litter as a vector for IAS

Marine litter functions like natural floating debris, providing a means of travel for non-native – and potentially invasive - species (Barnes and Milner 2005, Gregory 2009, Mouat et al. 2010, CIESM 2014), and is therefore increasingly recognised as a vector for IAS. Litter can be colonised by a range of species. The most commonly identified hitchhikers include molluscs, barnacles, bryozoans, polychaete, foraminifera and hydroids (Aliani, S. and Molcard, A. 2003, Allsopp et al 2006, Gregory 2009). Recorded examples of such hitchhikers include, for example, acorn and large barnacles (*Eliminius modestus, Perforatus perforates*) and benthic foraminifer (*Rosalina (Tretomphalus) concinna*) (Barnes and Milner 2005, Rees and Southward 2008, CIESM 2014). Mobile scavengers and predators, such as peracarid crustaceans and crabs, and pathogens can also colonise plastic (CIESM 2014, Goldstein et al. 2014).

Marine litter's increasing abundance contributes to an increased risk of invasions. The number of species reported rafting on debris has increased markedly since the 1970s (CBD 2012). For example, marine litter is estimated to have doubled the opportunities for marine organisms to travel at tropical latitudes and more than tripled it at high (>50°) latitudes (Barnes 2002). Based on current information, marine litter is also considered a potential key vector for IAS in the Mediterranean, with 13 established aliens in the Mediterranean known to be able to colonise floating litter and more than 80% of known alien species in the area capable of using litter for further expanding their range (CIESM 2014). Furthermore, the slow travel rates of marine litter are considered to provide non-native species with more time to adjust to changing environmental conditions, increasing their chance of success of establishing in new areas (Moore 2008). Finally, plastic can be colonised more easily than metals, especially metals coated with anti-fouling paints (i.e. vessel hauls), thus hull-fouling non-native species are likely candidates to also colonise floating plastic (CIESM 2014).

7.2 Impacts on socio-economic wellbeing

IAS are commonly considered as one of the key causes for global biodiversity loss (CBD 2015). Furthermore, IAS have negative impacts on ecosystems and their functioning as they tend to transform the structure and composition of colonised areas, disturbing food-web structure and resource use dynamics (e.g. Derraik 2002, Donnan 2009 in Mouat et al. 2010). IAS can also be vectors for disease. IAS also have considerable socio-economic consequences linked to these ecological impacts (e.g. Lovell and Stone 2005, Kettunen et al. 2009, Vila et al. 2010).

The negative socio-economic impacts related to the spread of IAS via marine litter can include, for example, losses to fisheries and aquaculture due to an outbreak of non-native parasites or diseases, or damages to infrastructure (vessels, water pipes) due to hull-fouling barnacles or infestations of mussels and clams. Hitchhikers on marine litter can also result in the degradation of coastal ecosystems, diminishing their appeal in terms of recreation and tourism. A range of different algae have been reported as living on plastic debris, including species causing harmful algal blooms (Katsanevakis and Crocetta in CIESM 2014). Similarly, Goldstein et al. (2014) recorded the ciliate pathogen Halofolliculina (known to cause skeletal eroding band disease in corals) on floating plastic debris in the western Pacific and suggested that the spread of the disease to Hawaiian corals may be due to rafting on the enormous quantities of litter reported from the area. Increased coral mortality or the introduction of other pathogens via floating marine debris has a potential to lead to economic costs, for example through decreased revenues due to falling numbers of visiting tourists linked with possible loss of jobs to local communities.

Since marine litter as a vector for IAS remains relatively uncharted territory, examples of socio-economic consequences of invasions by non-native species facilitated by marine litter are scarce. Indirect information related to the groups of species known to hitchhike on marine litter can be used to illustrate the possible scale of the problem, both current and future (Box 7.1).

Box 7.1 Examples of socio-economic impacts of marine IAS

The examples below provide information on aquatic IAS spread by hull-fouling and ballast water. In the absence of documented examples related to the impacts of IAS hitchhiking on marine litter, these examples are helpful in illustrating the possible risks.

- The zebra mussel (Dreissena polymorpha), a fresh water species native to the Caspian, Black and Azov Seas, arrived to North America via ballast water. Several estimates exist on costs incurred, for example a U.S. Fish and Wildlife Service estimate puts the cost of damages over 10 years to intake pipes, water filtration equipment and power plants at US$ 3.1 billion (Cataldo 2001 in Lovell and Stone 2005).
- The fishhook water flea (*Cercopagis pengoi*) is native to the Caspian, Black and Azov Seas. One of the key impacts of the species is the clogging of nets and fouling of boats. In the eastern Gulf of Finland, Baltic Sea the annual losses due to fouling of fishing equipment reported by a single fish farm amounted to at least US$ 50,000. (IUCN date unknown)

7.3 Costs of inaction

Cost of inaction related to addressing marine litter as a vector for IAS are related to the costs associated by IAS invasions. In addition to economic and wellbeing impacts (Box 7.1), there are significant costs linked to the attempts to eradicate or control IAS when they are established. It is therefore generally acknowledged that prevention or early eradication of invasions is the most cost-effective means for addressing risks posed by IAS (Kettunen et al. 2012). For example, the introduction of the carpet sea squirt (*Didemnun vexillum*) in Holyhead Harbour (Wales, UK) resulted in an eradication and monitoring programme over a decade starting in 2009, which was expected to cost €670,000. This expenditure was economically justified, as allowing the species to spread and smother organisms and marine habitats would have cost the local mussel fisheries up to €8.6million alone over 10 years (Holt 2009). While no dedicated estimates on the costs of inaction addressing marine litter as a vector for IAS exist, the existing information on other IAS indicate that preventative actions could be the most cost-effective means of addressing the risks also in this case.

8 Conclusions and next steps

Marine litter is an increasing threat to the international community and there is a growing body of evidence on costs of inaction, as noted above for the areas of fisheries, shipping and tourism. **The evidence on the cost of action underlines a diversity of costs**, from the zero cost (e.g. not littering), to low cost options (such as litter traps, beach waste infrastructure; volunteer initiatives), more substantive costs (such as beach clean up by municipalities), and high costs (fishing for plastic and cleaning up water ways).

The evidence collated for this study so far suggests that the costs of inaction are generally higher than the costs of action, but further research is required to verify and substantiate this.

For example, it is better (in environmental, social and economic terms) to have a sanitary landfill than an illegal landfill and to avoid situating landfills in coastal areas. It is almost impossible to address marine litter impacts from ship blasting with plastic, clean up microfibers or micro-pellets from toothpaste and cosmetics once they reach the sea. These and other examples indicate that prevention at source is the most effective, and likely most cost-effective, way to avoid negative impacts of marine litter. See Table 8.1 for examples of measures in the marine litter hierarchy, their costs (i.e. cost of action), and examples of costs if no action is taken.

Table 8.1: Measures in the marine litter hierarchy and costs – examples

<table>
<tr><th></th><th>Measures and their costs</th><th>Cost if measure not applied</th></tr>
<tr><td rowspan="2">Prevent/reduce generation of waste that contributes to the marine litter</td><td>Participation in extended producer responsibility schemes for packaging: Cost to producers of between €1 to €20 per capita per year.</td><td rowspan="6">Fishing: The loss of marketable lobster due to abandoned or lost fishing gear is estimated to lead to a global loss of US$250 million per year.
Microplastics are estimated to lead to a loss of up to 0.7% of annual income every year for the UK aquaculture sector.

Shipping: In 2008, 286 rescues of vessels with fouled propellers in UK waters were carried out at a cost of between €830,000 and €2,189,000.
Cost of removing litter and addressing damage in the Scottish aquaculture industry is estimated at €155,549/ year.

Tourism: In Goeje Island (Republic of Korea), marine debris led to lost revenue from tourists of between €29-37 million in 2011.
In the Asia Pacific Economic Community (APEC) region, marine debris is estimated to cost the tourism sector approximately US$622 million/year.</td></tr>
<tr><td>Installation of a filter to capture microfibres from a washing machine: $140 per unit</td></tr>
<tr><td rowspan="2">Prevent/reduce litter reaching the marine environment</td><td>Mechanical litter collection system for the Salina Landfill in Kansas (US): US$15,000 for a custom-made unit for the landfill.</td></tr>
<tr><td>Annual costs of removing litter from wastewater streams: US$279 million in South Africa.</td></tr>
<tr><td>Collect litter from the marine environment</td><td>Annual costs of coastal clean-up activities (excluding value of time spent by volunteers):
• €10.4m in Netherlands & Belgium
• €18m in the UK
• US$1,500/t in the APEC region
• US$ 2.5m in labour costs in Peru</td></tr>
</table>

In some cases, **sectors can be both agents and victims of the problem**, for example the fishing, aquaculture and tourism sectors are both sources of marine litter and suffer from its impacts. In other cases, **sectors are responsible for the generation of products which can end up as marine litter without being burdened by the problem**, for example in the case of the cosmetics industry (use of microbeads in various products), retail sector (use of plastic bags, bottles, packaging) and shipping industry (use of plastic- rather than sand-blasting for cleaning). More often than not these sectors do not make an adequate contribution to addressing the marine litter they generate. There is a **need for greater producer responsibility and more widespread application of the polluter pays principle**. Finally, the costs and impacts of marine litter may **disproportionately fall on certain sectors, groups and regions even though they may not be responsible for generating the litter**. For example coastal communities and Small Island Developing States (SIDS) are often left with the responsibility of cleaning up marine litter generated by others.

There are a wide range of solutions to address marine litter, from upstream prevention to downstream clean-up.

- **Product design changes** and **extended producer responsibility** can help to avoid certain impacts which are more difficult to address downstream. Improving product design (e.g. increasing the life-span of products, avoiding single-use items, removing plastic microbeads from products), capturing more packaging waste for recycling, installing filters on washing machines to remove microfibres from wastewater can all make a valuable contribution.
- **Investing in waste management infrastructure,** such as measures to avoid waste being blown from landfills by the wind (e.g. perimeter netting), riverine, port and beach infrastructures (e.g. litter traps, booms and bins) can help to avoid the incidences of marine litter.
- **Wastewater management** can help to tackle marine litter, since wastewater treatment plants can capture larger items of (plastic) waste and avoid its dispersal into the aquatic environment.
- **Economic incentives** such as deposit refund schemes and plastic bag charges can help influence consumer choice and/or encourage different habits (e.g. return bottles; choose multi-use bags).
- **Bans** (e.g. plastic bag bans, smoking bans on beaches, bans on plastic blasting in shipyards) can provide a cost-effective solution, however feasibility will depend on various factors including the availability of viable substitutes, political considerations etc.
- **Awareness raising** activities can help to avoid the generation of marine litter through improved habits and social norms and can in turn spur changes in product design. This is an essential upstream preventative measure; however it needs to be complemented by a wider suite of measures to support behaviour change.
- **Marine litter clean-ups** are costly but necessary downstream actions (at least until marine litter is tackled closer to source). Engaging volunteers in clean-up activities can help reduce costs (although the time of volunteers also has an economic value) and improve awareness.
- **Fishing for litter** can be a useful last option in the hierarchy of means to address marine litter (although this can only address certain types of marine litter) and can be combined with economic incentives to encourage action.

A number of these measures can lead to job creation, for example in the plastic recycling sector, which is growing in many countries across the world. The development of new recycled plastic products can create additional demand and **support the development of a circular economy.**

There is a critical need to understand the impacts of marine litter across regions of the world and what cost-effective measures are needed to address this modern day problem. There remains a vast research agenda to truly understand the scale of the problem. For example, there is as yet little information on the actual health risks associated with ingestion of microplastics – both to maritime species and to human consumers. While there is a fair understanding of the effect of large-sized plastic such as fishnets (i.e. ghost fishing) and plastic items such as bags, bottles and other packaging (i.e. ingestion by and mortality of marine species), there is little understanding of the nature and extent of ecosystem impacts of smaller marine debris (e.g. nano-particles and microfibers) and leachates/uptake from all debris (e.g. chemicals that can be endocrine disruptors).

The capacity and responsibility to address marine litter is spread across a range of stakeholders and innovative collaborations are needed. Engagement by those who are responsible for, and those impacted by, marine litter is needed if the problem is to be addressed effectively:

- Marine plastic knows no geographic boundaries, so **international collaboration** can help catalyse solutions.
- **National governments** can invest in infrastructure, set incentives, support research and development (R&D), and encourage greater producer and consumer responsibility.
- **Municipalities/local governments** can invest further in waste and wastewater treatment infrastructure that can help to prevent marine litter at source.
- **The private sector** should invest in innovative product design (e.g. improved durability, recyclability and green chemistry), bring to market substitute products that do not risk contributing to marine litter, and embrace producer responsibility, each of which can reduce the incidences of marine litter.
- **NGOs and voluntary organisations** can motivate changes in consumer habits and norms and encourage producer responsibility.
- **Local communities** can engage in awareness raising and clean-up activities.
- **Consumers and individuals**, including tourists and others, need to make responsible choices regarding purchases and take responsible actions regarding waste disposal.
- **Academia** should prioritise research to improve understanding of the impacts of marine litter, the costs of action and inaction and governance solutions to marine litter.

Next Steps

- This socio-economic study will be completed and sent for peer review in November 2015, for finalisation by February 2016.
- UNEP's report on marine plastic debris and marine microplastics (that also integrated other ongoing studies) will be presented at the second meeting of UNEA (UNEA-2), to be held at UNEP headquarters in Nairobi, Kenya from **23-27 May 2016.**
- In parallel, **GESAMP** (Joint group of Experts on the Scientific Aspects of Marine Environmental Protection)[5] initiative is exploring the sources and impacts of marine micro plastics specifically.
- **These two processes will be mutually supportive, with each seeking to link to other regional initiatives around the world.**

[5] http://www.gesamp.org/

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