MARINE LITTER SOCIO-ECONOMIC STUDY

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MARINE LITTER:
SOCIO-ECONOMIC STUDY

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EXECUTIVE SUMMARY

Marine litter is a pressing and growing global environmental challenge, but also an economic opportunity; preventing marine litter can enable materials and their value to remain in a circular economy.

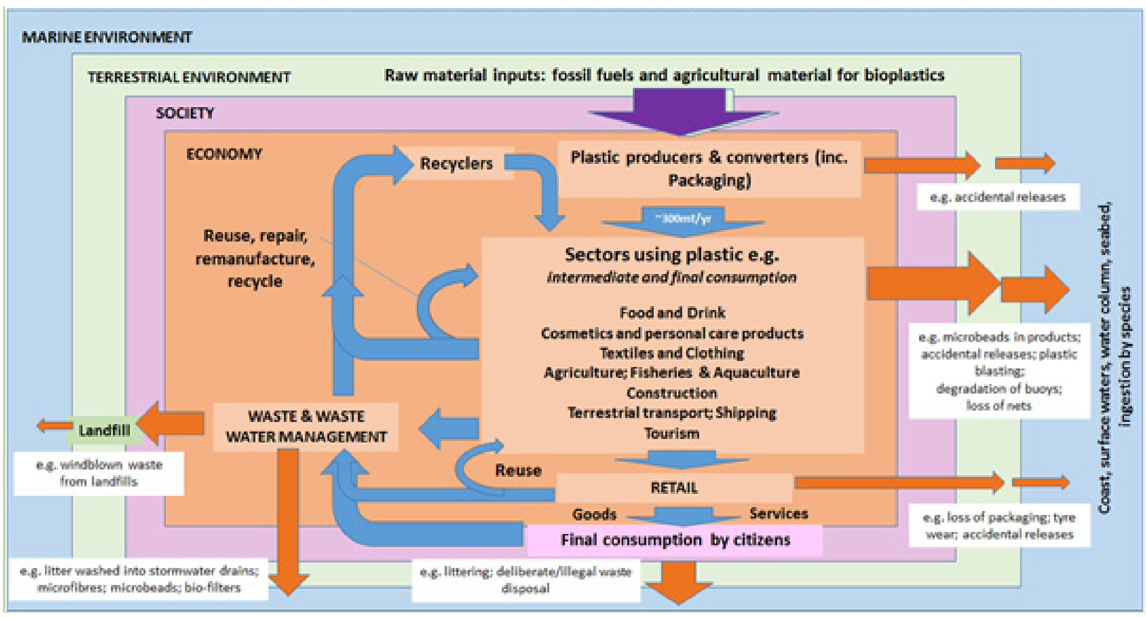
Marine litter – any persistent, manufactured or processed solid material that has been discarded, disposed of, abandoned in, or eventually reaches the marine or coastal environment – **has become a major global environmental challenge in recent decades.** It is now widely recognised that the amount of such litter is both significant and growing. For this reason, marine litter is the focus of growing political attention around the world, from the global level (e.g. G7 and United Nations Environment Assembly commitments), to regional and national actions and a proliferation of local level initiatives.

Marine litter is distributed throughout the marine environment – **on coasts, in ports, on the surface of the seas, in the water column, on the seabed and in the bodies of marine species.** It includes **large items** such as abandoned fishing nets, traps, rope and plastic bags that wash up on beaches and accumulate in ocean gyres, to small, micro- and nano-particles of plastic that are embedded in seafloors and ingested by marine species (see Table E3).

This litter arises from various economic sectors and activities, either directly or indirectly (see Figure E1). Key contributing sectors include aquaculture and fisheries (e.g. accidental loss, intentional abandonment and discarding of fishing gear), shipping (e.g. ship-generated waste, accidental releases of plastic pellets, plastic blasting in shipyards etc.), cosmetics and personal care products (e.g. use of microbeads), textiles and clothing (e.g. synthetic fibres released during washing), retail and tourism (e.g. plastic bags, bottles, packaging, disposable tableware and cutlery). The problem is exacerbated by inadequate waste management infrastructures and practices as well as by direct littering by residents and tourists.

Citizens' consumption of goods and services, personal habits (e.g. use of plastic bags and packaging) **and waste practices** (e.g. littering, poor household waste separation) **are a related and further driver of marine litter.**

Plastics: production, use by sectors, end use by citizens, and flows back into economy or into the environment Figure E1



Source: Own representation, Patrick ten Brink

The waste management sector, waste water infrastructure, and recycling activities can play a pivotal role contribution to keeping plastic and other materials out of the waste stream. Ineffective activities in these areas can also lead to major points of release of plastic and other items that become marine litter.

Plastic is a valuable material that is used throughout the economy and by consumers through their use of goods and services (see Figure E1). Some plastic is reused or recycled and therefore remains part of a circular economy, some goes to controlled waste disposal, but a significant proportion becomes waste that directly or indirectly reaches the sea. **The significant value inherent in plastic is lost when plastic becomes marine litter or is landfilled.** There is considerable potential for more of this value to stay within the economy. Of the more than 300 million tonnes of plastic produced every year, it has been estimated that 9 million tonnes end up as waste in the oceans and beaches. This represents an important opportunity cost to economies.

Inaction leads to rising economic, social and environmental costs.

Marine litter has economic and social impacts from the local to the international level. The presence

Table E.1 **Economic impacts and costs of marine litter – examples of costs of inaction**

Sector	Impacts of marine litter	Estimated costs - examples
Fishing	Marine litter can lead to a reduction in catch due to entanglement, ingestion and exposure to toxic materials (either embedded in plastic that is ingested or absorbed by the plastic from surrounding polluted waters), as well as a range of costs related to damage to vessels.	Total cost of marine litter for the EU fishing fleet: **USD 81.7** (EUR 61.7 million) **per year**. (Arcadis 2014) Costs to fishing sector related to marine litter in the UK: USD 35 million (GBP 23.4 million) per year ; cost to aquaculture sector: **USD 475,000** (GBP 316,800) for cage clearance and **USD 890,000** (GBP 594,000) for fouled propellers and intakes per year (Fanshawe and Everard 2002) Examples of losses of marketable catch from ghost fishing: ▪ Lobster in US: USD 250 million per year (JNCC, 2005); ▪ Dungeness crabs in Puget Sound (USA): USD 744,000 per year (Antonelis et al. 2011); ▪ Blue crab in Chesapeake Bay, Virginia (USA): USD 300,000 per year (Havens et al. 2011).
Shipping	Marine litter can damage vessels, fouling ship propulsion equipment or cooling systems. Loss of productivity and revenues and disrupted supply chains can result from delays and accidents. Further impacts relate to repair costs, rescue efforts and loss of life or injury.	Total value of litter damage to shipping: **USD 279 million** per year in APEC region (APEC 2009). In 2008, 286 rescues of vessels with fouled propellers in UK waters were carried out at a cost of **between USD 1.1 million and USD 2.9 million** (EUR 830,000 and EUR 2,189,000) (Mouat et al. 2010). **USD 2.9 million** in property (vessel) damage in USA in 2005 (USCG 2005).
Tourism	Polluted beaches can discourage visitors, reducing visitor numbers and leading to lost revenues and jobs for the tourism sector.	In Goeje Island (Republic of Korea), marine litter led to lost revenue from tourists of **between USD 27.7 and 35.1 million** (KRW 29,217–36,984 million) (Jang et al. 2014). In the Asia Pacific Economic Community (APEC) region, marine litter is estimated to cost the tourism sector approximately **USD 622 million per year** (McIlgorm 2009). Annual loss of approx. USD 22.5 million (GBP 15 million) and 150 person-years of work to local community on the Skagerrak coast of Bohuslan (Sweden) (due to 1-5% reduction in tourism) (Fanshawe and Everard 2002). Annual costs to tourism sector in certain regions of the UK: **USD 2.27-823 million** (GBP 1.38-500 million) in the 2010-2100 period (Van der Meulen et al. 2014).

Source: Own representation, Patrick ten Brink

of marine litter has significant documented impacts on the marine environment (e.g. degrading inland, coastal and open-sea ecosystems). Degradation of ecosystems can have a negative effect on the economy (e.g. revenue losses in the fisheries, tourism and shipping sectors) and on society (e.g. affecting the health and well-being of residents and visitors) (see Table E.1). These impacts can be **costly** and are often not borne by the polluters themselves but by other actors, including the wider public or communities that are remote from the polluters.

The cost of inaction – of not acting to avoid marine litter – is already unacceptably high and increasing, with burdens on ecosystems, their functions and related ecosystem services, on citizens and communities' well-being, on the public sector (i.e. municipal budgets) and on economic activities, notably fisheries and aquaculture, and tourism and recreation. In both sectors, the quantity and quality of the product – fish/shellfish and recreational activities on clean beaches and in the sea respectively – can be compromised by macro and micro marine litter. This creates a risk of reduced value of the product (i.e. sale price) and reduced volumes (i.e. amount caught and landed), and hence reduced income and compromised livelihoods.

Marine litter **can degrade ecosystems, their components, functions and associated ecosystem services.** For example, ingestion by and entanglement of species (e.g. 'ghost fishing' by discarded nets) are increasingly documented problems in marine and coastal ecosystems. Furthermore, litter items can be toxic to species (e.g. some plastic additives are endocrine disruptors), or they can facilitate the spread of invasive alien species (IAS), with negative impacts on the receiving ecosystems.

Negative impacts on the marine environment and ecosystems can have further negative implications for **local communities and certain economic sectors**, such as long term impacts on fisheries and tourism (e.g. through reduced coastal protection due to degradation of coral reefs affected by IAS). They can also lead to **social costs** including reduced opportunities for recreational activities, health risks to coastal visitors (e.g. contaminated swimming water, cuts from sharp items) foregone benefits from access to coastal environments (e.g. reduced tension and stress) 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 areas which do not have well-developed waste management infrastructures) and certain regions (e.g. Small Island Developing States (SIDS) which 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.

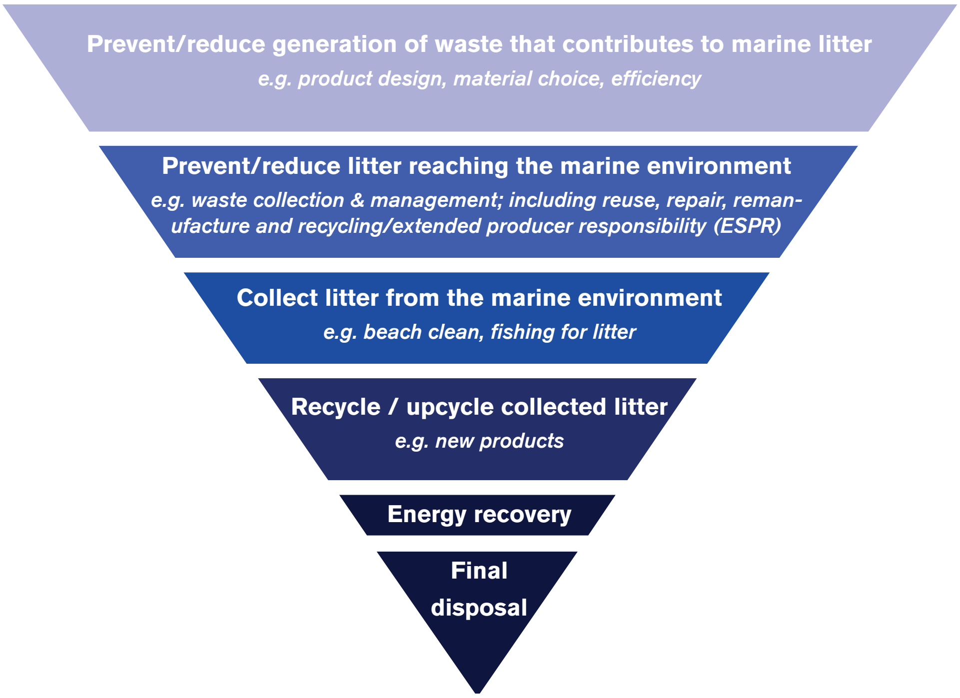
A wide toolkit of options exists to avoid marine litter, following a hierarchy from preventative upstream measures to down-stream clean up measures. Generally, upstream measures are preferable to downstream measures, but all are needed (at least in the short and medium term) to address marine litter (see Figure E2).

Upstream measures include instruments to prevent the generation of waste that could in turn become marine litter – e.g. product design, substitution or reuse of materials, and efficiency measures. Other tools can help prevent waste from reaching the marine environment – e.g. waste collection and management, including recycling. Others focus on collecting marine litter from the marine environment – e.g. beach cleaning or fishing for litter. Once such waste is collected, options include recycling (which recoups some of the value of plastics that are not too contaminated or degraded), energy recovery and finally disposal – e.g. in sanitary landfills – at which point all the value is lost to the economy.

The toolkit of measures includes research and development (e.g. for product innovation), **regulation** (e.g. bans, application of extended producer responsibility), **direct investments** (e.g. government spending on waste management infrastructures), **market-based instruments** (e.g. deposit-refund schemes or product charges), **awareness-raising tools** (e.g. campaigns promoting smartphone apps), and **clean up measures. Instruments include**:

- **Research to improve product design and efficiency of processes can prevent waste, and improve recycling and resource efficiency.** ***Potential priority actions:*** Research into design options, in particular for plastic and plastic products, to facilitate reuse, repair, remanufacture and recycling, and support a transition to a circular economy where more of a product's value is kept within the economy. Furthermore, research into the costs of inaction, the costs of action and the benefits of action is needed to inform decision making, to highlight the importance of actions and which instruments are likely to be effective and efficient, coherent with other policies, and to offer added value.

Figure E2 **A hierarchy for marine litter management**



Source: Own Representation, Emma Watkins

- **The application of extended producer responsibility (EPR) can help to avoid certain types of marine litter** including some that are particularly prevalent such as single-use packaging items. Making producers financially and/or logistically responsible for their products at the end-of-life stage encourages the development of take-back and collection schemes, which help to capture more of the waste streams concerned.

- **Investment in waste management infrastructure and wastewater treatment facilities can avoid dispersion of litter in the marine environment.** This can include perimeter netting at landfills to catch windblown waste, improved beach and port waste infrastructures, investment in wastewater treatment plants to capture microfibers, and litter traps for wastewater treatment plants (although this does not address items transported through storm drains). ***Potential priority action:*** Investment in waste collection and management infrastructures, particularly in coastal areas or near rivers, and particularly in areas where such infrastructures are inadequate or totally absent.

- **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. ***Potential priority action:*** Ensure that plastic has a price and is therefore more widely recognised as a valuable resource – e.g. apply deposit refunds to bottles, and charges/taxes to plastic bags. This will reduce consumption and waste and increase recycling, as well as supporting the transition to a circular economy.

- **Bans** (e.g. on plastic bags, smoking on beaches, plastic blasting in shipyards or plastic microbeads in cosmetics) **can provide a cost-effective solution to avoiding marine litter**, although feasibility will depend on various factors including the availability of substitutes, competitiveness concerns and political will.

- **Awareness-raising activities among consumers can help avoid the generation of marine litter**, for example by informing purchasing choices to reduce 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. ***Potential priority action:*** Communicate the costs of inaction, the costs of action and the benefits of action to key policy makers, businesses and citizens; increase the number of awareness campaigns and tools (e.g. smartphone apps for community science) and engage with more stakeholders; use beach clean-ups as educational campaigns; and invest in education, with a particular emphasis on children.

- **Better implementation of existing legislation on the release of litter, on land and at sea,** can help to reduce marine litter at source. The MARPOL Convention for vessels, and national and local laws on littering on land, already provide a good basis to prevent the illegal release of waste into the oceans.

- **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 final option, but can only address certain types of marine litter. This could be combined with economic incentives to encourage action, e.g. payments to fisherman for the litter they collect.

In choosing an instrument it is important to assess how it is likely to be implemented, who will be involved, what the costs will be and whom they will fall on, the expected effectiveness and impacts over what timescale, the possible perverse incentives that may undermine effectiveness or efficiency, and the environmental, social and economic benefits and costs of action. Furthermore, it is important to assess whether the instrument, or a package of instruments, will work within a country's legislative, institutional, and cultural context.

The costs of action range widely.

The costs of action will vary depending on where the measures are focused in the value chain and waste hierarchy, which sectors and products they target, and the location and scale of the marine litter being addressed. **While there are still data gaps, it is expected that the costs of action** (see Table E2) **are generally significantly less than the costs of inaction** (see Table E1).

Potential costs of different solutions to address marine litter – examples Table E2

Response measure	Estimated cost - examples
Participation in **extended producer responsibility** schemes for packaging	Cost to producers of between **USD 1.3 to USD 26.5** (EUR 1 to EUR 20) per capita per year (Deloitte et al. 2014).
Measures to encourage **product substitution**	Charge of **USD 0.25** (EUR 0.22) **per single-use plastic bag** in Ireland (DECLG 2016). Refundable deposit of **USD 0.09** (AUD 0.10) **paid per beverage container** (carbonated soft drinks, beer, fruit-based alcohol (except wine) water, flavoured milk, juice) in South Australia, refunded when container returned to collection depot or point of sale (EPA South Australia 2015). Tax of **USD 4.08/kg** (EUR 3.6/kg) applied to disposable plastic tableware in Belgium (IBGE 2011).
Installation of **a filter to capture microfibers** from a **washing machine**	Cost of **USD 140** to retrofit a Lint LUV-R filter to a washing machine (Environmental Enhancements 2015).
Collection of municipal waste	Collection of municipal waste: **USD 28-119** (EUR 30-126) **per tonne** (**USD 17-71** (EUR 18-75) **per household per year** for non-recyclable waste) and **USD 188-282** (EUR 200-300) **per tonne** for light packaging materials (e.g. plastics, cans) in EU countries (Eunomia 2002). Collection of trash that might otherwise become marine litter: around **USD 13-14 per resident per year (a total of USD 520 million)** in communities in three USA West Coast states (Stickel et al. 2012).
	Mechanical litter collection system for the Salina Landfill in Kansas (US): **USD 15,000** for a custom-made unit for the landfill (Martel and Helm 2004).

Table E2 *(cont.)* **Potential costs of different solutions to address marine litter – examples**

Response measure	Estimated cost - examples
Clean-up/enforcement relating to illegally dumped waste	Cost to English local authorities of **USD 56-80.7 million** (GBP 36-51.6 million) **per year**; cost to private landowners of **USD 78 to 234 million** (GBP 50 to 150 million) **per year** (NFTPG, 2013).
Removing litter from wastewater streams	Annual costs of removing litter from wastewater streams: **USD 279 million** in South Africa (ten Brink et al. 2009).
Recycling activities	Cost to set up a Recycle Swop Shop (RSS) in South Africa: **less than USD 10,000** (RSS, http://www.recycle-swop-shop.co.za/index.htm).
Activities in harbours and ports	Recovery and disposal of litter in ports & harbours and rescue services related to marine litter: **USD 9 million** (GBP 6 million) in UK (MaLiTT, 2002); Removal of litter from Esbjerg Harbour, Denmark: **USD 86,695** (GBP 57,300) for one year (Hall 2000); Investment in shipping waste management infrastructure by African Circle Pollution Management Ltd **USD 70 million** by 2012 (Obi 2009). ***Port reception fees to ships:*** Environmental levy of **USD 0.12 per tonne** of cargo/**USD 4.45 per TEU**, and **USD 2.76 per vehicle** used to transport waste at Nigerian ports (NIMASA 2015; NPA 2015). Waste handling charge of **USD 299-418** (EUR 225-315) **for 6 m³** at Port of Rotterdam (Port of Rotterdam 2014); No Special Fee at Port of Gdansk: **USD 0.18-0.82** (EUR 0.14-0.64) **per gross tonnage** (GT) (Port of Gdansk Authority SA 2012).
Coastal clean-up activities	Theoretical estimated cost of keeping all 34 million km of global coastlines clean: **USD 69 billion** (EUR 50 billion) per year Annual costs of coastal clean-up activities (excluding value of volunteers' time) (Wurpel et al. 2011): ▪ **USD 13.8m** (EUR 10.4m) in Netherlands and Belgium (Mouat et al. 2010; OSPAR 2009) ▪ Up to **USD 25m** (EUR 19m) in the UK (Mouat et al. 2010) ▪ **USD 2.2m** for removal of beach litter in Long Beach, California (US) (Wurpel et al.2011) ▪ **USD 1,500** per tonne in the APEC region (McIlgorm 2009) ▪ **USD 2.5m in labour costs** in Peru (McIlgorm et al. 2011) ▪ **USD 1.4m** (GBP 937,000) per annum on Skagerrak coast of Bohuslan (Sweden) (Fanshawe and Everard 2002). ▪ **USD 589 per tonne** to clean up marine litter from Hawaii coastline (Lamson et al. 2011). Participation of volunteers in two large clean-up schemes in the UK: estimated value of **USD 173,500** (EUR 131,000) (Mouat et al. 2010).
Fishing for litter	Fishing for litter in Korea: payment of **USD 5 per 40 litre bag** (compared with USD 48 cost of direct collection/removal of abandoned and lost fishing gear); total budget of national fishing for litter incentive programme **USD 5.2 million per year** from 2009-2013 (Cho 2005). Costs related to abandoned and lost fishing gear retrieval programmes: USD 70,000 for Baltic Sea, Sweden; **USD 260,000** for Norway; **USD 185,000** for the Northeast Atlantic (Brown et al. (2005), as reported by Macfadyen et al. 2009).

It is in the interests of many economic sectors to find strategies to reduce marine litter, as this can help reduce the burdens on them.

The benefits of action are not just about avoiding the burdens arising from inaction, but also about new opportunities – for economic activities and for society.

In some cases, significant value can be generated from recycling or upcycling[1] marine litter. The Kenyan-based Ocean Sole creates 220 different products from recovered flip-flops, and sells up to USD 500,000 worth of products each year. Through the Net-Works programme, the world's largest carpet tile producer, Interface and material partner, Aquafil, reprocess discarded and abandoned fishing nets in the Philippines into carpet products which are used in buildings around the world. Through its Net+Positiva programme, Bureo manufactures collected fishing nets into skateboards that retail at USD 149 and sunglasses that retail at USD 129; over 3,000 skateboards have been sold to date. Items in the RAW for the Oceans fashion range by G-Star Raw and Bionic Yarn, which contain yarn made from PET bottles recovered from the oceans, retail for prices between USD 68 (GBP 45) and USD 304 (GBP 200).

Generally, however, **the value of marine plastic for recycling is less than plastic before it becomes contaminated or partly degraded in the marine environment.** This is because plastic that has spent time in the oceans may become contaminated with chemical or biological materials, or may partially degrade to the point that it can no longer be used in standard recycling processes, since it would reduce the quality of the recycled material.

Dealing with marine litter can benefit communities, e.g. through awareness-raising, education, and paid employment in projects (litter picking, upcycling), which can also help to develop marketable skills. It can also support long term livelihoods (e.g. links to fisheries or tourism), well-being (e.g. linked to recreation) and social cohesion (e.g. development of community banks through revenue-raising litter projects, or a wider sense of ownership of, and responsibility for, a clean environment).

1 'Upcycling', or creative reuse, is the process of transforming by-products, waste materials or unwanted products into new materials or products of better quality or with increased environmental value.

There is a critical need for research to better understand the impacts of marine litter and what cost-effective measures can address the problem.

Whilst the work under this study and other parallel studies provided valuable knowledge for the second session of the United Nations Environment Assembly in May 2016, **a long term research agenda is needed.** Examples of priority needs include:

- **Measuring a plastic footprint – of a person, a company, sector or a nation –** then communicating it, and where possible attaching reduction objectives to it.
- **Understanding the impacts of microplastics on human health via fish/shellfish ingestion, how social perceptions respond to uncertainty/knowledge,** and how these risks translate into economic impacts.
- **Improving understanding of the costs of inaction and how they relate to the costs and benefits of action,** to underline where early action is particularly important, beneficial or effective. This could be done at the macro, sector, product or marine litter material levels to give different evidence bases for various decision-making frameworks and governance processes.
- **Determining why some people do not take responsibility for their waste and what motivates others that do take responsibility,** and assessing the implications for measures to bring about change in social norms, habits and practice to create responsible behaviour in the longer term.
- **Exploring the effectiveness of market-based instruments and behaviour change initiatives to reduce marine litter,** including how these approaches can work in combination.

There is a need for high level commitment to action and multi-level governance to address the marine litter challenge, reduce the pressures it exerts on the environment, society and the economy, and keep the value of materials, in particular plastics, within the economy.

The way forward requires a mixture of high-level commitments, regional cooperation, national champions, vanguard company research, entrepreneurship and investment, research and education, community engagement, and producer, sector and citizen responsibility. There is plenty of momentum on which to build, including: Resolution 2/11 on Marine plastic litter and micro-plastics adopted at UNEA-2 in May 2016; the G7 Leaders' commitment from June 2015; scientific and policy research including the major report by the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP 2016); the regional action plans on marine litter from around the world, national legislative action (e.g. the forthcoming US ban on plastic microbeads in personal care products and cosmetics), voluntary actions such as Beat the Microbead and the Good Scrub Guide, and actions by individual consumers to change their behaviour.

In addition, a step change is required in understanding the nature of the problem, awareness of its existence and impacts, and an evidence base to support future action. Cooperation across stakeholders will be needed to enable sufficient progress to address the challenge and keep materials, and in particular plastics, as a valuable element of the global economy and out of the world's oceans.

Table E3 **Marine litter items, examples of their Impacts and status**

Key: (weight of scientific evidence)	Major knowledge/ evidence gaps	Weak knowledge and evidence	Understanding of causal factors/ relationships but very little evidence	Fair knowledge and evidence	Good knowledge and evidence

MARINE LITTER: SIZE, DETECTABILITY AND EXAMPLES

Marine litter sizes, types and impacts*					
Marine litter size:	**Nano <1um**	**Micro <5mm**	**Meso <2.5cm**	**Macro <1 m**	**Mega >1m**
Detection/ identification method:	Needs special detection methods as smaller particles undetected by microscopes – to date have not been detected in environmental samples	Often needs microscopes and instrumentation to confirm it is plastic; *Larger:* visible/ identifiable to naked eye	Visible/identifiable to the naked eye	Visible/identifiable to the naked eye	Visible/identifiable to the naked eye
Examples of marine litter:	e.g. nanofibres from clothing; rubber dust from tyre wear; nanoparticles in products and pharmaceuticals. Have not yet been detected as litter due to technical limitations, but undoubtedly present in environment	e.g. microbeads from personal care products; fragmentation of existing (plastic) products; polystyrene; plastic from blasting in shipyards; particulates from waste incineration	e.g. bottle caps; cigarette filters and butts; plastic pellets; wind-blown/ storm-washed waste	e.g. beverage bottles and cans; plastic bags; food packaging; other packaging; disposable tableware/cutlery; beer-ties; fishing lines and floats, buoys; tyres; pipes; balloons; toys; whole textiles	e.g. abandoned fishing nets and traps; rope; boats; plastic films from agriculture; construction PVC (Polyvinyl chloride)

Marine litter items, examples of their Impacts and status of knowledge/uncertainty Table E3 *(cont.)*

	Marine litter sizes, types and impacts*					
	Marine litter size:	**Nano <1um**	**Micro <5mm**	**Meso <2.5cm**	**Macro <1 m**	**Mega >1m**
SOCIAL IMPACTS	**Human health**	Risk from nano particles passing cell walls. Potential perceived (subjective) risk from chemical contamination in fish and shellfish eaten in the future, and possible transfer of pathogens.	Perceived (subjective) risk from chemical contamination in fish and shellfish eaten, and possible transfer of pathogens.		Injury on beaches, danger to fishermen, well-being loss / mental health impacts from degraded environment.	Loss of protein (where fish availability is reduced). Physical health risks of boats / individuals becoming entangled, and mental health risks from degraded environment. More indirect: loss of health benefits by avoiding littered coastlines.
	Communities (e.g. coastal fishing communities)	Concern regarding health of the community's environment. Actual impacts unclear.		Cost of clean-up, well-being loss from degraded environment.	Cost of clean-up, well-being loss from degraded environment; risk to community cohesion / local identity / cultural values.	Loss of livelihoods, well-being loss from degraded environment; risk to community cohesion / local identity / cultural values
	Poor / poverty (e.g. lowest income groups)	Loss of well-being in polluted living environments – but given "invisibility" of nano and microplastics – actual perception of well-being loss depends on awareness levels.		Loss of well-being in polluted living environments	Loss of well-being in polluted living environments.	Loss of well-being, fish stocks, tourist revenue in polluted living environments
ENVIRONMENTAL IMPACTS	**Pressure:**	Uptake via absorption, ventilation, and/or ingestion; transfer of chemicals: e.g. mussels, oysters, sponges, fish, corals, phytoplankton	Uptake via absorption, ventilation and/or ingestion; transfer of chemicals: e.g. fish, birds, oysters, corals	Ingestion, transfer of chemicals: e.g. birds, fish and marine mammals	Ingestion, transfer of chemicals; entanglement: e.g. birds, crustaceans, turtles, whales, dolphins, sea lions	Entanglement: whales, dolphins, sea lions, turtles, birds, fish
		Rafting: movement of animals using plastic as a raft e.g. microbes, larvae, jellyfish.				Rafting, movement of animals.
	Impacts: Individual organism	Sub-lethal impacts at lower levels of organization e.g. cellular intrusion, changes in gene expression. Health impacts unclear.	Potential effects from physical presence of ingested plastic, concerns about possible effects from transfer of chemicals: reduced feeding, sub-lethal impacts at lower levels of organization e.g. cellular intrusion, changes in gene expression.	Sub-organismal impacts: e.g. organ damage. Organismal impacts: death, reduced feeding & impairment of digestive process: impacts on fitness & reproduction.	Sub-organismal impacts: e.g. organ damage. Organismal impacts: death, reduced feeding & impairment of digestive process: impacts on fitness & reproduction	

Table E3 *(cont.)* **Marine litter items, examples of their Impacts and status of knowledge/uncertainty**

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Marine litter sizes, types and impacts*

	Marine litter size:	**Nano <1um**	**Micro <5mm**	**Meso <2.5cm**	**Macro <1 m**	**Mega >1m**
ENVIRONMENTAL IMPACTS	**Impacts: Ecological impacts** **(e.g. population, assemblages, ecosystems)**	Potential for population decline, changes in assemblages and ecosystem functioning e.g. shift in microbial community.	Potential for population decline, changes in assemblages and ecosystem functioning, e.g. endocrine disruption in fish.	Potential for population decline, changes in assemblages and ecosystem functioning, e.g. mass decline in population due to ingestion causing mortality in sea turtles and sea birds.	Evidence of effects on assemblages and ecosystem functioning e.g. plastic bags. Population decline, changes in assemblages and ecosystem functioning e.g. from mass strandings of sea turtles from entanglement; changes in assemblages due to changes in habitat structure.	Population decline, changes in assemblages and ecosystem functioning e.g. changes in populations and assemblages due to ghost fishing. Invasive alien species (IAS) predation / displacement of indigenous species.
ECONOMIC IMPACTS	**Fisheries and aquaculture**	Potential perceived (subjective) risk from chemical contamination in fish, shellfish and aquatic plants that are eaten. Pending perception issues this can lead to lower demand for and/or value of fish/seafood.		Ingestion could lead to lower quality fish and hence lesser market value.	Entanglement in: propellers and damage to fishing vessel; related loss of fishing time, loss of fish and associated revenues. Potential risks to fisheries community cohesion / local identity / cultural values.	Ghost fishing: loss of output and hence livelihoods; damage to boats and equipment.
	Tourism and Recreation	Unlikely to have any discernible impact unless new information comes forward on health impacts.	Only if integrated into beach labelling.	Evidence of marine litter can discourage tourism and recreation on beaches, reducing income and/or well-being.	Reduction in tourist and recreation numbers and hence income / well-being. Increased costs of clean up to maintain activities. Damage to vessels (propellers, cooling systems).	Reduced income from polluted beaches. Increased costs of clean up to maintain activities. Damage to vessels (propellers, cooling systems).
	Shipping	No	No/unlikely	Damage to vessels (cooling systems)	Damage to vessels (propellers, cooling systems); potential loss of productivity and revenues from delays or accidents affecting supply chains.	Damage to vessels (propellers, cooling systems); potential loss of productivity and revenues from delays or accidents affecting supply chains.
	Local authorities and municipalities	Degradation of the natural environment within their jurisdiction. Potential increased cost of waste water treatment.		Degradation of the natural environment/heritage; Cost of clean-up and infrastructures. Loss of income and livelihoods.	Degradation of the natural environment/heritage; Cost of clean-up and infrastructures. Loss of income and livelihoods.	Degradation of the natural environment/heritage; Cost of clean-up and infrastructures. Loss of income and livelihoods.

** note that over time mega/macro marine litter can become microparticles or even nanoparticles as it breaks down – so may have impacts across ranges.*

Risk assessment is a key element in identifying appropriate intervention points and establishing which stakeholder groups need to be involved in helping to define the problem and potential solutions to 'close the loop' and prevent plastics escaping to the ocean. Criteria are presented to help select the most appropriate measures. Indicators of the state of the environment are needed to establish trends, set reduction targets and evaluate the effectiveness of any measures that are introduced. Harmonisation of monitoring and assessment approaches will help to select, implement and oversee measures for marine plastics reduction on regional scales.

There is a great need to improve the sharing of knowledge and expertise, to encourage a more multi-disciplined approach, to develop public-private partnerships and empower citizen-led movements. The Global Partnerships on Marine Litter (GPML) and Waste Management (GPWM) should be utilised to this end, together with other local-, national- and regional-scale arrangements.

There are several areas of research that should be pursued to gain a better understanding of the relative importance of different sources, and the fate and effects of marine macro and microplastics. Filling these knowledge gaps will help direct most cost-effectively the efforts taken to reducing further inputs of plastic to the ocean and mitigate the impacts of plastic debris that is already there.

1

1. ENVIRONMENTAL/ ECOSYSTEM IMPACTS OF MARINE LITTER

1.1

ENVIRONMENTAL AND ECOSYSTEM IMPACTS OF MARINE LITTER

Marine litter washes up on beaches, accumulates in mid-ocean gyres, becomes embedded in seafloors and can be ingested by marine biota. This generates direct and indirect negative impacts on marine ecosystems, which provide a key motivation for action to be taken to address marine litter.

The accumulation of marine litter causes significant harm to species (from plankton to whales) and has negative impacts on the functioning of ecosystems (UNEP 2005; UNEP 2009; European Commission 2013; CIESM 2014; Syberg et al. 2015). The negative impacts of litter include both chemical impacts (e.g. chemicals leaching from plastics) and physical impacts of litter items (e.g. damage to ecosystems and species), as well as impacts from invasive alien species that 'hitchhike' or 'surf' on marine litter items. Furthermore, efforts to remove marine litter can also cause harm to ecosystems; for example mechanical raking of marine litter can have an adverse impact on shoreline habitats.

The negative impacts outlined above result in overall degradation of marine and coastal ecosystems, including negative effects on biodiversity and functioning of these ecosystems, their resilience and their contribution to socio-economic well-being (i.e. ecosystem services) (see Table 1.1). Impacts on biodiversity include injuries and/or mortality caused by ingestion and entanglement, often threatening already vulnerable and/or endangered species such as marine mammals (e.g. Wright et al. 2013; Baulch & Perry 2014; English et al. 2015; Lawson et al. 2015). A recent study has estimated that by 2050, 99% of seabirds are likely to have ingested plastic (Wilcox et al. 2015; Gall et al. 2015). Possible negative consequences on the functioning of ecosystems, with knock-on impacts on ecosystem services, include reduced provision of marine resources (in terms of both quality and quantity), reduced attractiveness of coastal areas leading to a reduction in tourism and recreational activities, and in some cases decreased ability of ecosystems to provide coastal protection (e.g. where coral reefs or mangroves are damaged by marine litter such as discarded fishing line, or by invasive species).

1.2

FROM ECOSYSTEM IMPACTS TO SOCIO-ECONOMIC CONSEQUENCES

The degradation of ecosystems due to marine litter can have both direct and indirect socio-economic impacts.

Marine litter can lead to loss of output in the **fishery** sector due to the loss of potential fish catch caused by lost or discarded fishing gear, and due to damage to fishing nets and vessels caused by entanglement or collision with marine litter in general. Furthermore, ingestion of litter items or chemical contamination caused by marine litter can affect the quality of catch. In some cases, ingestion may also lead to impacts on reproduction, which could over time reduce the quantity of catch. For example, recent research has indicated that polystyrene microspheres (2-6 µm in diameter) fed to Pacific oysters compromised the reproductive health of both female and male oysters (Sussarellu et al. 2016).

Marine litter can also negatively impact **tourism and recreation**, with knock-on impacts on commercial actors benefiting from these activities. Contamination of coastal areas (e.g. beaches and coral reefs) by marine litter reduces the aesthetic value and appeal of areas for recreational use and can discourage visitors from certain beaches, leading to a loss of revenues for the tourism sector. Recreational use of coastal and marine areas can also diminish due to risk of injury or pathogens and/or due to the loss of charismatic or flagship species and ecosystems (e.g. damage to coral reefs) by marine litter. Similarly, negative impacts of marine litter on certain fish species can reduce revenues from recreational fishing.

There are also **broader social impacts** liked to marine litter (e.g. Wyles et al., 2015). These include, for example, reduced benefits from the use of or access to coastal environments and related recreational activities (e.g. improved physical health and well-being linked to regular access to nature) as well as well-being losses from living in a polluted or degraded environment (e.g. health and safety risks to

Summary of key negative impacts of marine litter on species and ecosystems, varying between different types of marine litter

Table 1.1

Marine litter size	**Nano** **<1um** **nanofibers from clothing, rubber dust from tyre wear etc.**	**Micro** **<5mm** **Microbeads, fragmented plastic, polystyrene etc.**	**Meso** **<2.5cm** **bottle caps, plastic pellets, cigarette filters, toys etc.**	**Macro*** **<1 m** **bottles, plastic bags, beer-ties, packaging etc.**	**Mega*** **>1m** **abandoned fishing nets, rope, boats, plastic films from agriculture, construction PVC etc.**
Pressure	Uptake via absorption, ventilation, and/or ingestion; transfer of chemicals: e.g. mussels, oysters, sponges, fish, corals, phytoplankton	Uptake via absorption, ventilation and/or ingestion; transfer of chemicals: e.g. fish, birds, oysters, corals	Ingestion, transfer of chemicals: e.g. birds, fish and marine mammals	Ingestion, transfer of chemicals; entanglement: e.g. birds, crustaceans, turtles, whales, dolphins, sea lions	Entanglement: whales, dolphins, sea lions, turtles, birds, fish
	Rafting: movement of animals using plastic as a raft e.g. microbes, larvae, jellyfish.				Rafting, movement of animals.
Impacts: Individual organism	Sub-lethal impacts at lower levels of organization e.g. cellular intrusion, changes in gene expression. Health impacts unclear.	Potential effects from physical presence of ingested plastic, concerns about possible effects from transfer of chemicals: reduced feeding, sub-lethal impacts at lower levels of organization e.g. cellular intrusion, changes in gene expression.	Sub-organismal impacts: e.g. organ damage. Organismal impacts: death, reduced feeding & impairment of digestive process: impacts on fitness & reproduction.	Sub-organismal impacts: e.g. organ damage. Organismal impacts: death, reduced feeding & impairment of digestive process: impacts on fitness & reproduction	
Impacts: Ecological impacts (e.g. population, assemblages, ecosystems)	Potential for population decline, changes in assemblages and ecosystem functioning e.g. shift in microbial community.	Potential for population decline, changes in assemblages and ecosystem functioning, e.g. endocrine disruption in fish.	Potential for population decline, changes in assemblages and ecosystem functioning, e.g. mass decline in population due to ingestion causing mortality in sea turtles and sea birds.	Evidence of effects on assemblages and ecosystem functioning e.g. plastic bags. Population decline, changes in assemblages and ecosystem functioning e.g. from mass strandings of sea turtles from entanglement; changes in assemblages due to changes in habitat structure.	Population decline, changes in assemblages and ecosystem functioning e.g. changes in populations and assemblages due to ghost fishing. Invasive alien species (IAS) predation / displacement of indigenous species.

**Note that over time mega/macro marine litter can become microparticles or even nanoparticles as it breaks down.*

the users of coastal areas such as fishers and sailors). Wider **health risks** might also be caused by the consumption of contaminated marine products such as fish and shellfish. In addition to the above, there can be direct costs of clean-up (to municipalities and private actors such as hotels) or repair (ship fouling and damage). Subsequent chapters of this report provide further insight into the scale of such impacts.

Finally, as highlighted above, marine litter is also known to facilitate the **spread of invasive (alien) species**, with possible severe impacts on species and ecosystems and knock-on impacts on economic sectors and human well-being (see Box 1.1). Linked to the above, the negative socio-economic impacts related to the spread of such species via marine litter can include, for example, losses to fisheries and aquaculture due to an outbreak of non-native parasites or diseases, or damage to infrastructure (e.g. vessels and water pipes) due to hull-fouling barnacles or infestations of mussels and clams. Organisms that hitchhike on marine litter can also result in the degradation of coastal ecosystems in their new areas, diminishing their appeal in terms of recreation and tourism.

Box 1.1

ECOSYSTEM IMPACTS LEADING TO SOCIO-ECONOMIC CONSEQUENCES: THE EXAMPLE OF INVASIVE ALIEN SPECIES (IAS) & PATHOGENS TRANSPORTED BY MARINE LITTER

Invasive alien species (IAS) are 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, maritime transport is becoming one of the key pathways for IAS introductions (e.g. through ballast water and hull fouling by organisms).

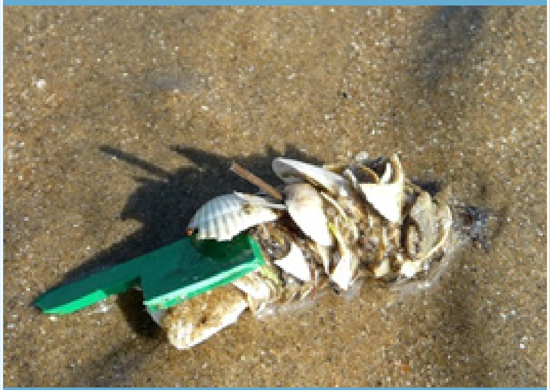
IAS and marine litter

Marine litter functions like natural floating debris, providing a means of travel for both native and non-native – and potentially invasive – species (Barnes and Milner 2005, Gregory 2009, Mouat et al. 2010, CIESM 2014, de Tender et al. 2015), and is therefore increasingly recognised as a vector for marine IAS. Litter can be colonised by a range of species. The most commonly identified hitchhikers include molluscs, barnacles, bryozoans, polychaete, foraminifera and hydroids (Aliani and Molcard 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 (R osalina (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).

It is hard to estimate the relative importance of marine litter as a vector of IAS in comparison to other well-known – and highly significant vectors – such as ballast water and hull fouling. However, it can logically be assumed that marine litter's increasing abundance contributes to an increased risk of invasions. The number of species reported rafting on litter has increased markedly since the 1970s (CBD 2012). For example, marine litter is estimated to have doubled the opportunities for marine organ-

Box 1.1 *(cont.)*

Figure E2 **Marine organisms hitchhiking on plastic litter, Ile d'Oléron (France), October 2015**



Source: Emma Watkins

isms 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 alien species 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 (e.g. vessel hulls), thus hull fouling non-native species are also likely candidates to colonise floating plastic (CIESM 2014).

IAS are commonly considered as a key cause 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 foodweb 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).

Socio-economic impacts and costs of inaction

The negative socio-economic impacts related to the spread of IAS via marine litter include, for example, losses to fisheries and aquaculture due to an outbreak of non-native parasites or diseases, or damage to infrastructure (e.g. 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 litter, 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 litter 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 in the area. Increased coral mortality, or the introduction of other pathogens via floating marine litter, has a potential to lead to economic costs, for example through decreased revenues due to falling numbers of tourists linked with possible loss of jobs to local communities.

Since marine litter as a vector for IAS has not yet been subject to extensive research, examples of socio-economic consequences of invasions by non-native species facilitated by marine litter are currently 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. The zebra mussel (Dreissena polymorpha), a freshwater species native to the Caspian and Black Sea and the Sea of Azov, arrived in North America via ballast water. Several estimates exist on costs incurred, for

Box 1.1 *(cont.)*

example, the US Fish and Wildlife Service estimate the cost of damage over 10 years to intake pipes, water filtration equipment and power plants, at USD 3.1 billion (Cataldo 2001 in Lovell and Stone 2005). The fishhook water flea (Cercopagis pengoi) is also 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), annual losses due to fouling of fishing equipment reported by a single fish farm amounted to at least USD 50,000 (IUCN 2009).

The costs of inaction related to addressing marine litter as a vector for IAS are related to the costs associated with IAS invasions. In addition to economic and well-being impacts there are significant costs linked to the attempts to eradicate or control IAS when they become 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 (Shine et al., 2010). 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 around USD 930,000 (EUR 670,000). This expenditure was seen as economically justified, since allowing the species to spread and smother organisms and marine habitats would have cost local mussel fisheries up to USD 11.9 million (EUR 8.6 million) alone over 10 years (Holt 2009). Whilst there are no dedicated estimates of the costs of failing to address marine litter as a vector for IAS, existing information on other IAS indicate that preventative actions could be the most cost-effective means of addressing the risks.

1.3

CONCLUSIONS

The following chapters of this report aim to bring together existing evidence on the socio-economic consequences of marine litter that often stem from the environmental and ecosystem impacts of litter, as in the case of fisheries, tourism and well-being. Although the scale of the marine litter problem – both in terms of its environmental and socio-economic impacts – is increasingly understood at a global level, a better understanding of both of these dimensions of marine litter is still needed across countries and regions as well as across sectors. Furthermore, while the *possible* impacts of marine litter on species and ecosystems have been identified, empirical studies providing further insights on the scale and severity of these impacts are still rather limited. In general, the impacts of larger litter items are rather well documented but information is still lacking related to the impacts of nanoplastics and microplastics. Furthermore, whilst ingestion by and entanglement of species is well documented, limited information is available on the knock-on impacts of marine litter at habitat and ecosystem level, as shown by the example of IAS above, which demonstrates significant gaps in information in terms of the scale of the problem and possible outcomes.

2

2. PRODUCER RESPONSIBILITY AND CONSUMER BEHAVIOUR

2.1

INTRODUCTION

This section addresses the issues related to both producers and consumers when it comes to tackling and preventing marine litter. In today's society, the roles and responsibilities of producers and consumers are inextricably linked; consumer choice is influenced by what producers produce, whilst producers naturally tend to make the items that consumers demand. This means that both groups have an important role to play in tackling marine litter, and that concerted action is needed by both producers and consumers if quantities of marine litter are to be significantly reduced. The actions that can be taken by both producers and consumers are many and varied. This section attempts to outline some of the main types of actions, where possible highlighting the impacts of past initiatives and outlining some of the related costs.

2.2

PRODUCTION AS A SOURCE OF MARINE LITTER

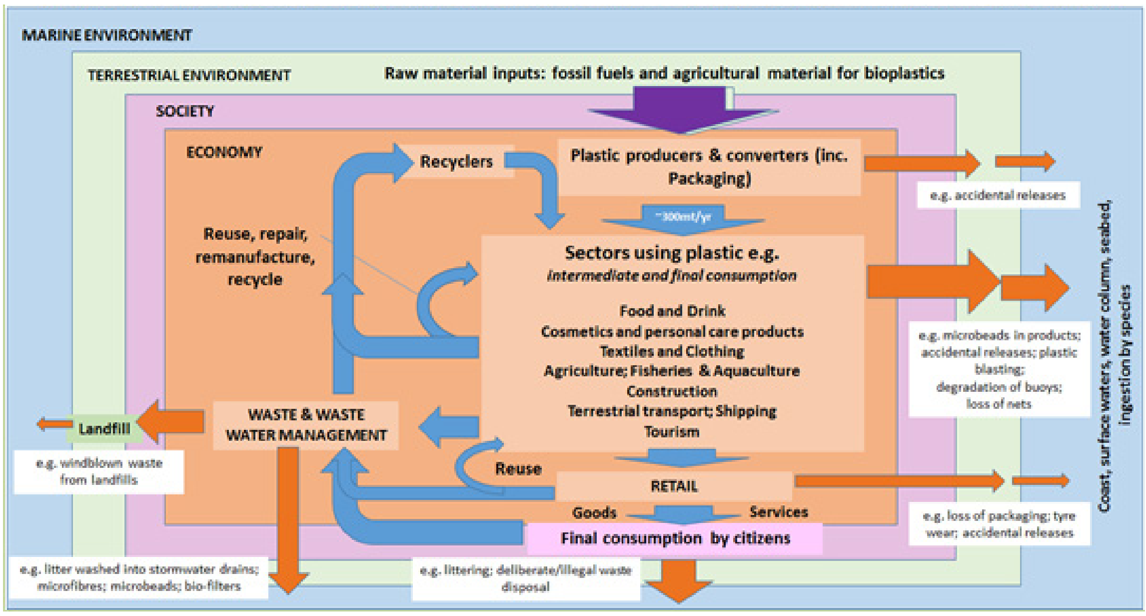
The worldwide production and trading of many goods is increasing. To take one example of a material critical to marine litter, global **plastics** production has increased from 204 million metric tonnes in 2002 to 299 million metric tonnes in 2013, an increase of almost 47% (Plastics Europe, 2015). This increased level of production, however, has not always been accompanied by a development of waste management practices that are adequate to deal with the new flood of plastics. 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 this plastic waste was recovered for recycling (US EPA, 2014). Some regions do perform better than this, however; in the EU in 2012, 62% of the 25.2 million tonnes of post-consumer plastic waste was either recycled (26%) or treated for energy recovery (36%), whilst 38% was landfilled (Plastics Europe, 2015).

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 Europe, packaging is the most common use of plastic, representing almost 40% of plastics demand (Plastics Europe, 2015). Since packaging is often disposable, or at least treated as such, this means that a significant proportion of the plastic produced may be at risk of becoming marine litter if it is not disposed of and managed carefully. 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 USD 13 billion per year (including financial losses to fisheries and tourism (see following sections) 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 USD 75 billion per year (including the cost of environmental impacts such as greenhouse gas emissions, and loss of resources when plastic waste is not recycled)[2] (UNEP, 2014). An additional problem is that the use of plastic is increasing most quickly in rapidly developing countries, which also tend to have some of the poorest waste collection infrastructures and lowest collection rates worldwide (Ocean Conservancy 2015). If plastic items are not captured by waste infrastructures, they are more likely to become marine litter.
Figure 2.1 below summarises global plastic production, use by economic sectors and citizens, and flows back into the economy or into the environment.

2 The methodology for the UNEP study selected 16 consumer goods sectors that commonly use plastic, quantified their plastic use and its impacts, then applied 'natural capital valuation' to provide a monetary estimate of the environmental and social impacts of plastic use. The methodology took into account the upstream impacts of producing plastic, but not impacts at the manufacturing stage. It is suspected that the downstream impacts (i.e. of plastic waste reaching the ocean when littered) are underestimated due to a lack of robust data and research. Finally, the study looked only at plastic and did not compare plastic use with alternatives (e.g. glass).

Plastics: production, use by sectors, end use by citizens, and flows back into economy or into the environment Figure 2.1



Source: Own representation, Patrick ten Brink

Another example crucial to marine litter is **packaging**. As shown in Table 2.1 below, food wrappers, plastic beverage bottles, plastic bottle caps, glass beverage bottles and beverage cans all featured in the top 10 types of items found during the 2014 International Coastal Cleanup[3] (Ocean Conservancy 2015). In 2012, the global market for consumer packaging was estimated to be worth around USD 400 billion, with the five main types of packaging being paper and board, including bags and cartons (around 34% of the market), rigid plastics including tubs, pots etc. (around 27% and forecast to grow by around 4% per year until 2015), glass (around 11%), flexible plastic (around 10%) and beverage cans (around 6%). Also in 2012, the rapidly growing Brazil, Russia, India and China (BRIC) markets accounted for around 30% of global packaging demand, with demand increasing with economic development due to increased consumption and demand for consumer goods (EY 2013). A more recent study by the Canadean market research group (cited in Packaging Converting & Intelligence 2015) estimated the worth of the global packaging market at USD 151 billion, with the following material market shares by value: paper and board 38%, rigid plastic 20%, flexible plastic 19%, metal 17%, glass 3% and other materials 3%. The study estimated that around 1.6 trillion units of packaging will be produced annually by 2018, with over two thirds of those units being flexible or rigid plastics. The study suggests that increased demand for metal packaging (e.g. due to producers wishing to use it to improve their environmental credentials, since it is fully recyclable) should see the metal packaging industry grow at a rate of 1.66% per annum between 2014 and 2018. However, many manufacturers still prefer other lighter-weight packaging materials (such as plastic), and volatile raw material and energy prices are also likely to constrain the growth of metal packaging.

Packaging Converting & Intelligence (2015) highlights that the demand for plastic packaging in the US is expected to grow by 5.3% annually (driven largely by the food and pharmaceutical sectors), due to the increased popularity of single-serve packaging, and companies replacing metal and glass with plastic packaging. China is the largest consumer of plastics globally, and China and India are the largest markets in the Asia-Pacific region for plastic packaging, with

3 The 2014 International Coastal Cleanup involved 561,895 volunteers in 91 countries around the world, who removed 7,342 tonnes of debris from 13,360 miles of beaches and inland waterways. The top 10 types of items in full were: cigarette butts (2,248,065 items), food wrappers (candy, chips, etc.) (1,376,133), plastic beverage bottles (988,965), plastic bottle caps (811,871), straws/stirrers (519,911), other plastic bags (489,968), plastic grocery bags (485,204), glass beverage bottles (396,121), beverage cans (382,608) and plastic cups/plates (376,479).

demand increasing due to a shift from unpackaged to packaged consumer goods. In Europe, the main driver for growth in plastic packaging is growing demand from food and soft drinks. The study points out that plastic packaging is increasingly subject to environmental concerns and regulations, and that packaging manufacturers are therefore making efforts to improve plastics recycling and encourage consumers to recycle (see below), as well as shifting towards the use of lightweight packaging materials such as flexible packaging (although this is also beneficial economically to producers due to reduced transportation costs).

Other products also pose particular risks to the world's oceans when they are improperly managed at the end of their life. A key example in this respect is waste electrical and electronic equipment such as TVs, computers and smartphones, which typically contain many valuable materials that can be extracted, but also hazardous substances. This means that they are both a sought-after commodity and can create significant pollution if they are not properly processed during their waste phase. A recent report (UNEP and GRID-Arendal 2015) has suggested that as much as 60-90% of the electronic waste generated globally each year is illegally traded or dumped, with a value of between USD 12.5 and USD 18.8 billion. Since around 41 million tonnes is generated annually – possibly rising to 50 million tonnes by 2017 – this can potentially have a very big environmental impact, particularly when such waste is sent for processing in developing countries with poor waste management infrastructures.

It should be noted that as developing countries continue to develop and their economies grow, the demand for consumer products (and associated packaging) will also grow. This will in turn lead to increased consumption, and likely increased waste generation. Many developing countries still have inadequate waste infrastructures; for example, a report in Waste Management World (2013) stated that canals and rivers in the centre of Jakarta, Indonesia, were full of waste and landfills were being burned off. The report claimed that this was due to inadequate funding of infrastructure, with Indonesians paying only USD 8 (EUR 6) per year for their waste services. This example illustrates the inherent risk that without adequate investment in waste management, the increased amounts of waste generated will not be properly captured and treated, and that more waste may be littered or improperly disposed of, with the potential to become marine litter. Investment in sound waste management (collection and treatment) infrastructures will therefore be critical to reducing the risk of a significant increase in marine litter from developing countries in the short and medium term.

2.3

CONSUMERS AS A SOURCE OF MARINE LITTER

Consumer behaviour and practices on land, in coastal zones or on sea have an important impact on the generation of marine litter. Globally, land-based sources are the main contributor, though there are regional variations as regards the importance of different land-based sources (Jang et al. 2014b; Sheavly & Register 2007; STAP 2010). Scientific monitoring and litter collected in beach clean-ups suggest that improperly disposed consumer goods form a significant fraction of marine litter.

Box 2.1

MARINE LITTER IN THE BALTIC SEA – FINDINGS FROM THE MARLIN PROJECT

The Baltic Marine Litter project monitored litter at 23 beaches in Sweden, Finland, Estonia and Latvia from 2011 to 2013. The project aimed to raise awareness on marine litter, increase knowledge on amounts, sources and types of litter, and how to mitigate its negative effects. 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 touristic activities contributes a further 33% (MARLIN 2013).

In some cases, the actions of consumers directly affect the marine environment, such as uncontrolled disposal of packaging or plastic bags in the environment. Some of the most commonly-found items of marine litter are shown in the table below.

Top 10 items collected during the International Coastal Cleanup 2014 (Ocean Conservancy 2015) Table 2.1

Top 10 items collected – ICC 2014	Number
Cigarette Butts	2,248,065
Food Wrappers	1,376,133
Beverage Bottles (Plastic)	988,965
Bottle Caps (Plastic)	811,871
Straws, Stirrers	519,911
Other Plastic Bags	489,968
Grocery Bags (Plastic)	485,204
Beverage Bottles (Glass)	396,121
Beverage Cans	382,608
Cups & Plates (Plastic)	376,479

**Note that over time mega/macro marine litter can become microparticles or even nanoparticles as it breaks down.*

There are several land-based sources for marine litter. Some are direct, such as recreational use of the coast, general public littering and unprotected landfills and dumps located near the coast. Others, such as rivers that can carry litter to the sea, are indirect pathways rather than direct sources, but are still relevant (Galgani et al., 2015).

While the sources of marine litter are relatively clear, it is more complicated to quantify the amount of litter that effectively reaches the marine environment. According to studies conducted to date, it is possible to state that the order of magnitude is of millions of tonnes; one estimate suggests 6.4 million tonnes per year (UNEP, 2005). At the same time, the global distribution of marine litter is difficult to determine, given the specific peculiarities of the ocean. However, some studies of litter density have been carried out. For example, one study found that the sites with the highest litter density in Europe include the Lisbon Canyon (offshore Portugal), the Blanes Canyon (north-west Mediterranean), the Guilvinec Canyon (Bay of Biscay), and the Setúbal Canyon (offshore Portugal), with a density of more than 20 items ha^{-1} (Pham et al. 2014). Gago et al. (2014) report the findings of a 10-year monitoring programme at three beaches in north-west Spain, where the number of items varied from 42-163 per kilometre. A study carried out on the beaches of Armação dos Búzios (Rio de Janeiro, Brazil) showed a litter density of 13.76 items per 100 m^2 (Sigman-Pszczol et al. 2007), while the mean distribution and weight densities of marine litter in Greek Gulfs (Patras, Corinth, Echinades and Lakonikos) was found to range between 72-437 items/km^2 and 6.7-47.4 kg/km^2 (Koutsodendris et al. 2008). In 2008, a study showed that the mean density of marine litter in the coral reef area along the Jordanian coast of the Gulf of Aqaba is 2.8 items/m^2 (Abu-Hilal et al. 2008).

Box 2.2

CASE STUDY SUMMARY – MARINE LITTER CHALLENGES IN CHILE

Chile has a coastline of around 6,400 km and has outposts such as Easter Island that reach far into the Pacific Ocean. Every year, a large quantity of litter is found on Chilean beaches. Most of the litter on the mainland beaches originates from within the country, while on Easter Island and other oceanic islands, fishing litter and litter from other countries and even continents is prevalent. However, different regions of Chile face different challenges. This becomes evident when comparing the regions of Antofagasta (north Chile), Coquimbo (central Chile) and Easter Island (3,700 km from the mainland). Differences exist in the sources and quantity of marine litter, the activities that have already been implemented and should be implemented in order to reduce the phenomenon, and the willingness of the local population to engage in mitigating the problem.

The Antofagasta region, and in particular the Mejillones Peninsula, is especially noteworthy in terms of the quantity of litter encountered. In this area, the litter is almost exclusively of domestic origin and usually abandoned by beach visitors and illegal campers, who often settle next to litter patches. Another problem in the area is the absence of waste disposal systems in remote fishing villages, leading to illegal dumping. Surveys have shown that people in the Antofagasta region are not very interested in the issue of marine litter. According to a survey taken in the area, people living in the region of Antofagasta also feel less ready, less willing, and/or less motivated to take up recycling and participate in environmental activities in their spare time.

In comparison, beaches in the Coquimbo region are among the cleanest of mainland Chile, showing an average of about 1 item/m^2 (Bravo et al. 2009). In this area, there is a well-functioning system of waste collection and most fishing villages are integrated into the municipal waste infrastructure. People are more interested in the marine litter issue, take part in clean-up activities more frequently and are more interested in preserving the good condition of beaches.

Finally, Easter Island is similar to the Mejillones Peninsula as regards the quantity of litter present on beaches, although in the case of Easter Island the majority of litter originates from remote areas. In fact, although the waste management system is not properly developed and functioning, a study of the litter found on the Island's beaches has shown it to be largely from external sources.

In all three of the above regions of Chile, marine litter affects marine life, human health and tourism, though to different extents. To address the problem, different measures are required, depending on the specificities and needs of the different areas. For example, in the Antofagasta region it is necessary to strengthen the participation of citizens in activities linked to marine litter reduction and to increase interest in the topic.

However, some options for action apply to all regions of Chile. It is necessary to raise awareness and to involve citizens in all the activities linked to marine litter, including clean-up activities and proper waste disposal. Municipalities and public authorities in general need to better determine their role in the fight against marine litter and need to take action. More information, data and research are also needed to support the case for action. In addition, proper legislation is necessary, from both a Chilean and international point of view.

In other cases, consumers contribute to marine litter through less obvious pathways such as the use of cosmetics containing microplastics (microbeads) or through wastewater streams that transport microfibers, for example from laundry of textiles, into the sea (Browne et al. 2011, UNEP 2015). The problem with these specific kinds of litter is that they sometimes cannot be retained by existing wastewater treatment systems or by washing machine filters. One estimate suggests that wastewater treatment plants with tertiary treatment can potentially 80-90% of such particles, which suggests that even with highly developed systems, around 10-20% may still escape in the final effluent[4].

Microbeads are very small particles that have a maximum dimension of 5mm (see e.g. GESAMP 2015), are water insoluble, non-degradable and made of non-recyclable plastic. They are used in personal care and cosmetic products (PCCPs) such as toothpaste, shampoos, body creams and exfoliants. Once they reach the marine environment, it is almost impossible to remove them (UNEP, 2015). In the EU, the quantity of microbeads used in personal care products amounts to 4,000 tonnes per year on average, or around 8g per capita (MEPEX 2014), and in 2012, in the EU countries plus Norway and Switzerland, the cosmetic industry used 4,360 tonnes of plastic microbeads (UNEP 2015). Gouin et al. (2011) estimate that the annual per capita consumption of microplastic for personal care products in the US is around 2.4 mg. The 5 Gyres Institute (2013), together with the Plastic Soup Foundation, Surfrider Foundation, Plastic Free Seas and Clean Seas Coalition, published a position paper calculating the percentage of microplastics in three different scrub products. The amount of microplastics ranged between 0.94% and 4.2% of the total product.

Significant action has already been taken to address the problem of microbeads. Several organisations have raised awareness about the topic, for example through the Good Scrub Guide[5] for the UK and Australia, created by Fauna & Flora International, the Marine Conservation Society and Surfrider Foundation to help consumers avoid products containing microplastics. Another prominent example is the Beat the Microbead campaign, which is currently supported by 83 NGOs from 35 countries, and has received promises from 337 brands produced by 67 different manufacturers to remove plastic microbeads from their products (Beat the Microbead 2016). The campaign has developed a smartphone App which allows consumers to scan the barcode of personal care products to check whether they contain plastic microbeads before purchasing. Perhaps the most significant recent development is the adoption by the US House of Representatives of the Microbead-Free Waters Act 2015, which will place bans on the production of personal care products and cosmetics containing plastic microbeads of under 5mm in size from July 2017, on the sale of cosmetics containing microbeads from July 2018, and on over-the-counter drugs containing microbeads by July 2019 (US Government Publishing Office 2015). The UK Government has also recently announced that it backs the idea of a ban on the use of microbeads, and that there may be potential for an EU-wide ban as early as 2017 (Environmental Audit Committee 2016).

Another type of marine litter is microfibers originating from synthetic clothes and indoor household activities. A UK study showed that around 1,600 **microfibers** are released by each cloth per wash (Browne et al. 2011). A similar result was obtained by a Dutch study which reported that a 660g polyester garment releases 260 mg of fibres per wash (Dubaish and Liebezeit 2013). As regards pollutants originating indoors, a Norwegian study estimated that waste water deriving from wet floor washing may contribute to pollution, with around 1-2g of microplastics potentially deposited per m^2 per year. After cleaning, synthetic fibres present on the floor are washed away with the waste water and, if not stopped by waste water treatment plants, may directly reach the ocean (MEPEX 2014). Microfibers are one of the most polluting elements present in the oceans and are extremely difficult to recover. To eliminate the problem, it is necessary to prevent the release of those fibres into the environment, for example by using specific filters applied to both washing machines and wastewater treatment plants.

Consumers therefore contribute to marine litter in different contexts, for example by visiting marine or coastal regions, but also in everyday life through littering on land or in 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, adequate waste collection infrastructure is

4 Personal communication with Gryaab AB, Sweden.

5 http://www.fauna-flora.org/initiatives/the-good-scrub-guide/

needed (e.g. bins at beaches).

2.4

CONSUMER GROUPS IMPACTED BY MARINE LITTER (COSTS OF INACTION)

As the final users of goods, consumers are a major contributor to marine litter. However, they are also the largest single group impacted. Both direct and indirect costs can result from inaction on marine litter (McIlgorm et al. 2009). Impacts on human health and well-being can occur through direct contact with litter resulting in costs of medical treatment (Hall 2000; ARCADIS 2014). The accumulation of harmful substances through the food chain, for example through degrading plastics, could also affect consumers (van der Meulen et al. 2014). Many of these impacts are not yet fully understood, including their magnitude on a global, regional and local scale, and their economic cost. In addition, it has so far proven difficult to identify social groups that are mostly affected by marine litter (e.g. in terms of age or level of wealth) due to a lack of studies and analysis to date.

Direct costs of inaction mainly refer to direct contact with marine litter. One direct cost is the **impact of marine litter on human health**. Individuals could be injured by stepping on broken glass, medical waste or sharp objects on a beach. A similar scenario could occur while bathing (ARCADIS 2014). The Public Health Laboratory Service for the South West Region of England reported that, between 1988 and 1991, 4% of needle stick injuries were sustained on the beach (Philipp 1993). A survey of visitors to Cassino beach in Brazil found that at least 30% had been wounded by glass or other sharp objects abandoned on the beach (Santosa et al. 2005). In Chile, people visiting the beaches of Antofagasta are obliged to wear shoes in order to avoid injuries (see Annex).

Direct health and safety impacts of marine litter can also result through the food chain. Marine litter can enter the food chain when ingested by fish. When humans consume the fish, they also ingest litter particles such as microplastics that can absorb chemicals that are present around them (Engler 2012). Once they reach the human body, the particles can release the absorbed chemicals. Suspected health effects linked to these chemicals include cancer, malformation and impaired reproductive ability (Takada, 2013). Some recent studies have highlighted that chemicals leaching from plastics can produce endocrine disruption, both in humans and animals, with serious health consequences (Thompson et al. 2009; Moore, 2008). In addition, the presence of marine litter in the marine environment may also undermine the psychological benefits usually provided by such areas (Wyles et al., 2015).

Marine litter can also produce **indirect costs** to humans. Indirect costs can occur in the form of reduced aesthetic value of littered beaches, shorelines and marine environments, which lower the recreational value of sites to visitors and local residents, and result in additional costs as visitors relocate to alternative sites (McIlgorm et al. 2011; Birdir et al. 2013). A study carried out in Portugal and Wales (UK) showed that good beach conditions is one of the most important elements when it comes to visitors' beach selection (Vaz et al. 2009). Degradation of marine and coastal ecosystems through litter can lead to further disutility with negative impacts on human health, and undermine some of the broader benefits associated with the recreational use of coastal areas, such as improved physical and mental health (e.g. reduced blood pressure, tension and stress, and improved levels of concentration) (GESAMP, 2015). To address this issue, local authorities engage in often costly clean-up activities, at times with support from local residents and groups interested in protecting coastal environments.

2.5

POTENTIAL MEANS OF ENGAGEMENT/ SOLUTIONS (COSTS OF ACTION)

There are a number of potential ways that producers and consumers can contribute to the prevention and reduction of marine litter. A number of these are discussed in the following sections.

2.5.1. Producers

There are several actions that producers can take to contribute to reducing or preventing marine litter.

In terms of their actual products, one of the main ways is through improved **product design, or ecodesign**. Products can be developed that are more recyclable so that they can more easily be captured for recycling at the end of their life cycle, or products can be designed with an end-of-life use already in mind. In many cases, multi-use products are preferable to single-use ones (e.g. bags for life rather than thin, one-use plastic bags) since they are less likely to be disposed of immediately. Creating products that use less material (e.g. lightweight packaging) ensures that there is less material that has the potential to become litter. Whilst biodegradable plastics may be beneficial in terms of their potential to degrade in land-based waste disposal, the marine environment does not generally provide suitable conditions for the proper breakdown of biodegradable plastics; use of such plastics may therefore even lead to greater fragmentation (and potentially more microplastics in the environment) when the plastics degrade. Voluntary initiatives involving groups of actors can also provide motivation to act (e.g. retailer initiatives to reduce packaging), since they ensure that there are several organisations working towards the same goal.

Several examples of these various types of actions are included in Box 2.3 below.

CASE STUDY SUMMARY – MARINE LITTER CHALLENGES IN CHILE

Box 2.3

The Italian water company *Levissima* has undertaken activities to promote separate collection in parks in Milan and ski resorts in Valtellina and Valchiavenna (Levissima 2015). In addition, the school project R-Generation aims to educate children on PET recycling, encouraging schools to compete to be the best recyclers and 'defenders of the environment', and to win a party for their neighbourhood (https://www.rgeneration.it/).

The water company *Agua Costa Rica* has developed a new bottle that can be up-cycled into a roof tile at the end of its initial use, with the specific goal of reducing the number of PET plastic bottles that end up on beaches and in seas. The bottles have folds and curves that allow them to be bent into a durable tile and filled with recovered paper packing materials that provide extra insulation. Shops that sell the bottled water also become collection points for customers to return the bottles, to ensure that they can be reused easily. Around 110 bottles are needed per square metre of roof, and it is estimated that the tiles could last for between 400 and 1,000 years. These tiles can be used by lower-income families to improve their homes, thereby also contributing to addressing poverty. (Dyer 2014 and Agua Costa Rica 2015)

Agua Costa Rica bottles **Figure 2.2**

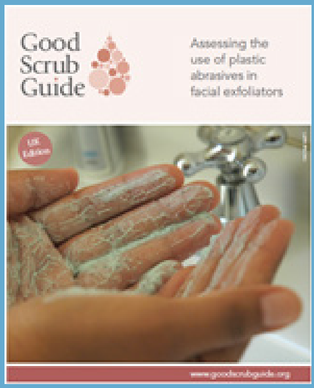
Source: © Agua Costa Rica

Ecover, which produces cleaning products, has for several years produced limited edition ocean plastic bottles made from a percentage of plastics recovered from the ocean (e.g. 10% in 2015). According to Ecover, the aim is to address both ocean plastic and human health effects of microplastics, and for the company to 'be a catalyst for cleaner oceans by raising awareness of the plastic endangering them' (http://uk.ecover.com/en/why-ecover/ecover-ocean-plastic-bottle/).

In 1970, a standardised style of water bottle (the Normbrunnenflasche, known colloquially as the 'Perlenflasche' or 'beads bottle') was put on the market in Germany. The nationwide introduction of a standard bottle, managed by a cooperative, enabled drinks manufacturers to create a standardised distribution system, and the addition of a deposit of USD 0.17 (EUR 0.15) also helps with the levels of collection. The design of the bottle closure enables refilling to take place much more quickly than with other bottle designs, increasing the efficiency of the reuse of the bottles. The glass version of

Box 2.3 *(cont.)*

the bottle also features two raised rings around the outside; these protect the surface of the bottles and labels during refilling, cleaning and transport, and as they wear down also indicate when a bottle should be recycled rather than refilled. A glass version of the bottle tends to be refilled over 50 times before being recycled into new bottles, whilst a returnable plastic (PET) version available since 1996 is typically refilled between 15 and 25 times before being completely recycled. (GDB 2015 and Wikipedia.de 2015)



In June 2015, a number of major UK brands and retailers announced their commitments to phase out plastic microbeads from their own-brand cosmetics and personal care products. The voluntary commitments were made public through the *Good Scrub Guide* initiative of Fauna & Flora International (FFI) and the Marine Conservation Society. Some brands confirmed that they have never used microplastics in their own-brand products (e.g. Ali Mac Skincare Ltd, Neal's Yard Remedies), others confirmed they had recently phased them out (e.g. Boots, Clarins, PZ Cussons, Sainsbury's), whilst others pledged to do so in the near future (the latest date given was 2017) (e.g. Asda, Marks & Spencer, Superdrug, Tesco). FFI argue that whilst voluntary commitments are encouraging, legislation is still needed to ensure a level playing field for producers, and to ensure that brands actually do meet their commitments. (Fauna & Flora International 2015; Good Scrub Guide 2015)

The international *Operation Clean Sweep* programme[6], an initiative by the plastics industry, aims to prevent the loss of plastic pellets, flakes, and powder to the marine environment through good housekeeping and containment practices by all parts of the plastics industry (producers, transporters and processors). A manual has been developed presenting best practice procedures to prevent, contain and clean up spills and losses of pellets, to make employees aware of both their responsibilities and how they can ensure they meet them. Implementing the measures in the manual will of course have cost implications; these costs are funded by those companies pledging their participation in Operation Clean Sweep (Marlisco, date unknown), but no details are available on costs.

In the UK, the *Courtauld Commitment* is a voluntary agreement launched in 2005 aimed at improving resource efficiency and reducing waste in the grocery retail sector. The agreement is government-funded and involves major retailers, brands, producers and suppliers who commit to help deliver the targets. The agreement is now in its third phase, which has two packaging-related targets: to reduce traditional grocery packaging waste in the grocery supply chain by 3% by 2015, and to improve packaging design to maximise recycled content and improve recyclability without increasing the carbon impact of packaging by 2015. (WRAP 2015)

6 http://www.opcleansweep.org/

Additional actions may of course be taken by producers to address the problems of marine litter after it has been generated; some examples of such initiatives are included in section 3.6 below, since they typically address downstream waste rather than upstream product design.

2.5.2 Consumers

Activities that target consumers as a source of marine litter need to address the different roles of consumers, and the different littering contexts and 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. The following sections first provide a background to the process of informing and empowering consumers to achieve behaviour change and then look at the prevention of waste, the prevention of littering in coastal and marine zones, and activities to collect litter that has been improperly disposed of in the environment.

Research insights on behaviour change

Behavioural research has repeatedly shown that information itself will not automatically lead to a change of behaviour. Common sense may suggest that providing information, e.g. on the impacts of plastics on marine fauna, will lead to individuals taking action. This conclusion has proven to be wrong in many contexts, such as environmental protection, health or mobility (Kollmuss & Aygeman 2002). While it is necessary to provide information, it is important that the information is tangible and easy to understand, and ideally it should be personalised and encourage interaction (Abrahamse et al. 2007). The framing of the message is also important (Gonzales et al. 1988). For example, communication on the impacts of marine litter can be more effective if impacts are explained as losses (rather pointing out the gains/benefits of preventing marine litter), since people generally have an aversion to loss.

A second common misconception is that a change in attitudes will lead to a change in behaviour. However, attitudes are not a reliable predictor of action (Niemeyer 2010). In fact, research has often shown that attitudes follow behaviour. For this reason, communicating ‘desirable’ behaviour can be a powerful tool for forming attitudes (Cialdini et al. 2006, Kallgren et al. 2010). When trying to encourage behaviour change, it is advisable to connect to different values among consumers. Some (but not all) consumers will respond to the protection of the marine environment as a major motive to tackle marine litter. For other consumers, values such as limiting waste of resources or limiting economic losses will be more helpful to bring about the desired behaviour.

Finally, mistaken beliefs exist about what motivates people to take action. The role of social norms in shaping behaviour is largely underestimated (Griskevicius et al. 2009). People (and organisations) believe that messages hinting at the importance of certain behaviour for the environment will be effective and lead to behaviour change. Equally, messages relating to how others behave are considered least appealing. However, experimental research has shown that social norms have a strong impact on behaviour (Goldstein et al. 2007). The influence of social norms can be both underestimated and different from many peoples’ expectations. This aspect is important, e.g. in designing campaigns to address marine litter.

These research insights are of importance when discussing consumer-orientated activities to address marine litter. Such activities can take place at different stages of the marine litter management hierarchy (see Figure 3.1). The following discussion looks firstly at options to prevent the generation of waste by consumers, then turns to the means of reducing litter on land, in coastal and marine environments, and finally discusses the role of marine litter collection, including clean-up campaigns involving volunteers.

Prevention of waste generation and littering behaviour

In light of the above insights from research, several different approaches to reducing the generation of marine litter can be discussed. Policymakers can address this by discouraging practices that generate litter or limiting the use of products that contribute to marine litter. **Single-use products** deserve special attention as they are among the most commonly-found items of marine litter when sampling litter in the marine environment or during clean-up campaigns. Moreover, littering leads to a loss of materials from the economy that could be recovered and recycled. Items like single-use plastic bags, food or beverage containers can be addressed not only by communicating the desired practices for disposal, but also with economic instruments (Oosterhuis et al. 2014). Such instruments can provide a disincentive by penalising undesirable practices, for example with a **tax or levy** (for wider discussion on the role of market based instruments (MBIs) see the case study annex on MBIs).

Box 2.4

EXAMPLES OF TAXES AND LEVIES TO ADDRESS SINGLE-USE PRODUCTS

In a number of countries, levies on single-use plastic bags have helped to reduce the number of these items used. The Irish plastic bag levy is a widely discussed and cited example of the successful application of an economic instrument. After introducing a USD 0.20 (EUR 0.15) levy on retail plastic bags, distribution of bags 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). In 2007, the levy was increased to USD 0.25 (EUR 0.22) with the aim of reducing the annual per capita usage of plastic bags to 21 or lower; in 2016, the use of leviable bags was estimated at fewer than 14 per capita (DECLG 2016).

A recent study commissioned by the Welsh Government has shown that, since the introduction of a minimum plastic bag levy of USD 0.08 (GBP 0.05) in 2011, single-use carrier bag (SUCB) use has declined by 71%. Wales was the first UK nation to introduce a levy on the use of SUCBs (Welsh Government, 2015) and charges have since been introduced in Northern Ireland, Scotland and England. In addition, the study shows that the impact of the levy on retailers has been either neutral or positive. Consumer support for the levy, already strong in 2011 (61%) has been growing and has now reached 74% of the population.

In 2007, Belgium introduced a so-called ‘picnic tax’ to be applied to a series of disposable products (plastic carrier bags, plastic kitchen utensils including cutlery, plates, cups and trays, and food wrap). The tax rate for disposable plastic kitchen and tableware is USD 4.08/kg (EUR 3.6/kg), and the tax is due at the time of release for consumption. In 2010, the picnic tax raised a total of over €15 million, with the tax being paid on 1,094 tonnes of disposable plastic tableware and contributing 26% of the total revenues (almost €4 million). (IBGE 2011)

Box 2.5

THE APPLICATION OF DEPOSIT SCHEMES AT DIFFERENT SCALES

State- or country-wide deposit schemes represent one option to reduce the amount of litter reaching the marine environment. For example, Hardesty *et al.* (2014) report that South Australia’s container deposit scheme, which applies a USD 0.09 (AUD 0.10) refundable deposit to beverage containers, resulted in a three-fold reduction in the number of beverage containers lost to beaches. South Australia enjoys an overall return rate for beverage containers of 79.5%; in 2014-15 over 583 million containers (43,807 tonnes) were recovered by collection depots for recycling, and beverage containers made up only 2.2% of litter (EPA South Australia 2016).

However, this instrument can in principle be applied at all scales and in most locations. Hardesty (2015, personal communication) reports an initiative at Boronia West Primary School in Victoria, Australia, where the school introduced a USD 0.09 (AUD 0.10) deposit on candy wrappers sold at the school refectory. The idea originated from the children themselves after learning about the impacts of litter on the marine environment, notably by attending a class with a post-mortem examination of seabirds with plastic material in their stomachs. The children could then connect the impact of litter on wildlife with their school environment. The deposit scheme is now in place and has been extended to a second school.

http://studentplanetsavers.global2.vic.edu.au/2013/03/05/emerald-primary-container-deposit-scheme/

Taxes and levies generate revenues that can be used to fund activities addressing consumer behaviour, but they can also be controversial as regards the use of revenues. An alternative way of providing incentives for desired behaviours is the introduction of **deposits or financial incentives** such as discounts for environmentally friendly behaviour by consumers.

While economic incentives can be powerful to discourage undesirable practices, especially when they are communicated as monetary losses, they come with the caveat that they may reveal that certain practices such as uncontrolled disposal of waste are common or 'normal'. There are alternative initiatives that also emphasise and promote behaviour that is in line with reducing objects prone to littering. For example, **promoting reusable cups or refillable water bottles** (with corresponding infrastructure such as refill stations) can help to establish a culture of reducing waste generation.

Tackling less obvious forms of marine litter is more challenging, since more information is needed to reach out to consumers than with visible litter items. For example, personal care products frequently contain plastics as an exfoliating agent or for other purposes (UNEP 2015). At first glance, it is not straightforward for consumers to detect plastic ingredients in personal care products and further guidance is therefore needed.

There has been a growing tendency during the last few years to use **technology** (e.g. social media, Facebook, Twitter and YouTube) in order to reach a wider public. In 2013, the MARLISCO project[7] organised a video contest for children, challenging them to express what they think about marine litter. 379 videos were submitted involving more than 2,000 students from across the EU (MARLISCO, 2013). The Race 4 Water Foundation is sharing the R4WOdyssey logbook through the support of a YouTube video and pictures and news posted on their website (Race for Water, 2015). Another example is the Marine Litter Network, an online information portal that allows different actors to discuss and share information and knowledge about marine litter. The 756 users of the network (Marine Litter Network, 2015) include individuals, NGOs, private organisations and institutions. The aim of the network is to facilitate contact between the various actors working in the marine litter field to find common and shared solutions.

Box 2.6

PROMOTING REUSABLE EVERYDAY OBJECTS

In February 2014 at the University of Northern Iowa (UNI), the UNI Office of Sustainability collaborated with the UNI Marine Biology Club and the Service and Leadership Council to promote the 'Plastic Bag Exchange' event. The aim of the event was to give students, faculty and staff the opportunity to trade their plastic bags with reusable ones, offered by the University. In four hours, 1,865 plastic bags were collected for recycling. The two main reasons for the event were that plastic bags are a menace for animals and because plastic is the main pollutant of the oceans. (University of Northern Iowa, 2014)

Public authorities and non-governmental organizations are also implementing applications (or 'apps') for smartphones and other mobile devices (see Box 3.7 for some examples). Usually, apps are created to raise awareness about the marine litter challenge and to track marine litter in space and time, but they can also be useful tools for governments. The extent to which an app pursues one or the other of these goals varies among the creators of the apps.

Information and awareness-raising activities are crucial to sensitise consumers about their contribution to marine litter. This is especially the case for marine litter sources and pathways that are not obvious to consumers. To maximise their success, these activities need to identify littering contexts and address specific consumer groups such as schoolchildren, outdoor travellers or interested citizens who want to engage actively for example as citizen scientists (Eastman *et al.* 2014). For example, a study carried out by Hartley *et al.* (2015) showed that, after taking part in an educational intervention regarding marine litter, schoolchildren aged 8-13 years started engaging in more responsible environmental behaviours and encouraged their family and friends to do the same.

7 www.marlisco.eu

Box 2.7

USING TECHNOLOGY TO INFORM AND EMPOWER CONSUMERS

The *Beat the Microbead*[8] campaign has 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 from environmental and consumer groups, and is now supported by UNEP.

The *Marine Debris Tracker* (MDT)[9] is a partnership of the NOAA Marine Debris Division and the Southeast Atlantic Marine Debris Initiative (SEA-MDI). First released in 2011 and updated in 2014, this app was created to raise awareness about marine litter and to help NOAA collect information about the position and condition of marine litter. The MDT and associated web platform aim to engage citizens in a positive manner: they can expand their dedication to an issue and also feel empowered by collecting and presenting data within the MDT community (Jambeck and al. 2015). People and groups using the app receive different animal icons depending on the intensity of their tracking activity: new users start as a starfish and can eventually become a whale. The app has global coverage and to date there have been 12,000 downloads and over 62,400 entries with 539,700 litter items logged (Jason Rolfe, Mid-Atlantic and Caribbean Regional Coordinator). Although the main activity of the app is linked to reporting chronic litter, it has also developed a special role in tracking marine litter reaching US beaches after the Japanese tsunami (2011) and Superstorm Sandy (2012). The app does not require users to collect litter after reporting it.

The *MarineLitterWatch app*[10] was launched in 2014 by the European Environment Agency. The app was created to help collect data about the quantity, quality and distribution of marine litter and to raise awareness among users. Although it is possible for single users to register and download the app, it is mainly designed for user groups. To date, 20 groups have registered to report the locations where marine litter is found and it is possible to follow their activities on the main website connected to the app.

Ocean Conservancy has developed the *Clean Swell* app, which is designed to help volunteers of the annual International Coastal Cleanup. Participants can log the type and amount of marine litter they have collected as well as further information, e.g. time spent on the activities and the route taken during the clean-up. The app helps streamline data collection, which was traditionally done on paper and subsequently entered into databases. Furthermore, volunteers can use this app throughout the year and record their activities over the long-term.

The concept of *Coastbuster*, an app developed by Ocean Networks Canada, follows a slightly different approach by focussing on large items of marine debris that could pose a hazard to coastal communities and infrastructures. For example, such objects were released in the 2011 Japanese tsunami and then transported by Pacific Ocean currents. Volunteers can take photos and provide descriptions of the objects at sea, while the app logs and transmits the geo-location of the objects detected. Staff from Ocean Networks Canada review the incoming reports and report critical items to public authorities.

8 www.beatthemicrobead.org

9 http://www.marinedebris.engr.uga.edu/

10 http://www.eea.europa.eu/themes/coast_sea/marine-litterwatch/get-started/how

Box 2.8

THE 'NO BUTTS ON THE BEACH' AND 'MA IL MARE NON VALE UNA CICCA' CAMPAIGNS

In 2000, Surfers Against Sewage (SAS) launched the ***No Butts on the Beach campaign*** to help people dispose of their cigarette butts responsibly by providing them with small butt bins. The bins are distributed during specific events (12,000 pocket ashtrays have been distributed to date) around the UK, but can also be ordered by mail (SAS, 2015). Butt bins are portable and reusable and allow smokers to collect cigarette butts until they reach a proper bin, instead of dropping them directly on the beach.

Cigarette Butt Bins on a beach in Denmark — Figure 2.4

Every summer since 2009, the organisation Marevivo, in partnership with JTI (Japan Tobacco International), has organised the campaign ***Ma il mare non vale una cicca?*** (Isn't the sea worth a butt?) on Italian beaches. The campaign, supported by several Italian celebrities, provides bathers with reusable butt bins that can be easily emptied and washed. During the 2015 campaign, 120,000 butt bins were distributed, and 2.8 million cigarette butts collected (Marevivo 2015).

Box 2.9

THE ROLE OF AMBASSADORS IN AWARENESS-RAISING

Throughout the years, several celebrities have played the role of ambassadors for the protection of the marine environment. In 2014 Lewis Pugh, United Nations Patron of the Oceans, swam in the Seven Seas to draw attention to the health of the oceans (UNEP NEWS CENTER 2014). In 2015, the swimmer Federica Pellegrini took part in the ***Ma il Mare non vale una cicca?*** campaign organised by the Italian association Marevivo, and famous surfers Ben Skinner and Corinne Evans took part in the ***Save Our Seas Marine Litter Tattoo Campaign***[11], organised by Surfers Against Sewage.

In the same year the multi-platinum recording artist Jack Johnson was appointed Goodwill Ambassador by UNEP. The singer declared that he would focus his activity in particular on three issues, one of which is marine litter[12].

Ambassadors for raising awareness need not be internationally known celebrities. In fact, their effectiveness as a voice for taking action against marine litter stems from them being a role model and inspiration for the local community or region of interest. For example Mama Piru, a native Rapa Nui woman from Easter Island, has become famous for her commitment to cleaning up the coast every day. She has been fulfilling her promise for the last 15 years (see the case study on Chile in the Annex).

11 http://www.sas.org.uk/news/campaigns/save-our-seas-marine-litter-tattoo-campaign/

12 http://www.unep.org/gpa/news/JackJohnsonGWA.asp

For the most problematic types of marine litter or for littering hotspots, bans on certain products and activities can be considered, such as restricting smoking on beaches or banning plastic bags with certain characteristics. For example, a number of US States have introduced bans on microbeads, to bring an end to sales of products containing microbeads by 2020. Similar discussions are ongoing in Canada, where microbeads are a concern for the aquatic environment of the Great Lakes. A study by Environment Canada (2015) recommended classifying microbeads as a toxic substance under the Canadian Environmental Protection Act, which would allow for further action.

Collecting litter from the marine environment

While efforts to reduce the generation of litter and its release into the environment are crucial to tackle marine litter, **clean-up activities** also remain important to collect litter that has already accumulated in the marine environment. Local or regional authorities are often responsible for such activities, but a number of initiatives exist that explicitly involve volunteers. The role of such engagement is two-fold. On the one hand, clean-ups can help to reduce the physical amount of litter entering streams, waterways and oceans. On the other hand, they are an important tool for bringing together communities and stakeholders to generate a common sense of action and to create ownership. They are also one important means of forming constructive attitudes towards marine litter.

Clean-up activities involving volunteers occur at local, regional, national and global scales. They aim to reach coastal communities or visitors generally, but sometimes also focus on specific target audiences to create awareness (see Table 2.2).

Table 2.2 **Selected examples for clean-up activities involving volunteers**

Initiative	Geographical Coverage	Remarks
International Coastal Clean-up (ICC)	Global	Organised by Ocean Conservancy, takes place annually around the world.
Clean-up SA Month	South Africa	Aims to increase awareness by educating the community about the social, environmental and economic benefits of recycling.
The Marine Litter Project	27 countries and territories in the Caribbean region, plus Mexico	Aimed to assist in the environmental protection and sustainable development of the Wider Caribbean region through the implementation of the Regional Action Plan on the Sustainable Management of Marine Litter in the Wider Caribbean (RAPMaLi).
Clean Up Australia Day	Australia	Started in 1989 when Ian Kiernan decided to clean up Sydney Harbour. Since then, the campaign has kept growing and has become the nation's largest community-based environmental event.
Beachwatch	UK	National beach cleaning and litter surveying programme organised by the Marine Conservation Society to help people around the UK to care for their coastline.
MARLISCO	15 European countries	The project aims to increase awareness of the consequences of societal waste-related behaviour on marine socio-ecological systems, to promote co-responsibility among different actors, to define a more sustainable collective vision, and to facilitate grounds for concerted actions through the successful implementation of a 'Mobilisation and Mutual Learning Action Plan' (MMLAP).
Clean Up Arabia	United Arab Emirates (UAE)	Organised by the Emirates Diving Association, Clean Up Arabia is an annual voluntary campaign that aims to clean up dive sites and beaches in the UAE and surrounding regions. At the end of the activity, participants receive a certificate for their participation in the event.
Coastwatch Survey	Ireland, Spain, Portugal	The project aims to identify coastal litter based on a survey carried out by volunteers. The results of the survey are published annually and are used to study the types, characteristics and sources of litter.

Photo: © lcswart /Shutterstock

Although activities carried out by volunteers are fundamental because they help local municipalities and alleviate their costs, it is nevertheless important to underline that volunteers' participation in clean-up events constitutes an opportunity cost, i.e. it takes up time that could be spent on other activities. It has been estimated that the participation of volunteers in two of the largest clean up schemes in the UK, MCS Beachwatch and KSB National Spring Clean, is worth approximately USD 173,500 (EUR 131,000) (Mouat *et al.* 2010).

2.6

CONCLUSIONS ON PRODUCER RESPONSIBILITY AND CONSUMER BEHAVIOUR

Producers tend not to incur any direct costs of inaction related to marine litter. In many cases, once a product is produced and sold, it is no longer the concern of producers (except in cases where extended producer responsibility applies and they are therefore financially and/or logistically responsible for their products at the end of their useful life – see Chapter 3.4). This means that producers frequently do not have a cost-related incentive to act on marine litter. Nevertheless, there are costs associated with inaction; one estimate suggests that environmental damage to marine ecosystems caused by plastics amount to USD 13 billion per year (UNEP, 2014).

There is little data available on the costs of action by producers to prevent and tackle marine litter. Participation in initiatives such as the plastics industry's Operation Clean Sweep or the UK's Courtauld Commitments on reducing packaging waste will of course have some related costs for those choosing to participate, but information on such costs has not been found. The lack of cost information is at least in part due to the fact that producers may not wish to openly share financial information or details of some actions they may have taken due to competitiveness concerns or corporate privacy rules. It may therefore prove challenging, even with concerted efforts in the future, to find information on the cost to producers of actions that are helping, or could help, to address marine litter.

Data on costs incurred by consumers is equally sparse. In principle, some of the direct, health related costs could be collected, in particular costs related to injuries on beaches and in coastal zones. However, such data are rarely readily available. This is also the case for further health-related costs, such as those related to the ingestion of harmful substances through the food chain. In addition to the health dimension, consumers also experience disutility due to littered coastal zones, which might involve additional expenses e.g. as a result of changing location. Overall, such costs are dispersed over a large number of consumers and therefore unquantifiable, although the impacts are noticed.

Creating awareness among consumers and engaging them does require some resources, though the magnitude will differ across the various instruments that can be used. The practical examples above illustrate that sometimes a combination of hardware (e.g. waste collection infrastructure at different sites and scales), and further activities such as awareness-raising or volunteering campaigns may prove most effective. Some solutions such as smartphone apps potentially have a wide reach to many consumers, while other measures will be local in their scope. Awareness-raising and the provision of practical tools to consumers will increase their sense of being part of the solution and supporting intrinsically motivated action.

3

3. WASTE AND WASTE WATER INFRASTRUCTURE AND COSTS

3.1

INTRODUCTION

Much marine litter originates from land-based sources such as littering, landfilling, illegal dumping, poor waste management practices, discharges of storm-water and extreme natural events; a global figure of 80% is frequently cited, although the origins of this figure are somewhat unclear (NOAA 2009) and there may be considerable regional variation.

From 2001-2006, the US National Marine Debris Monitoring Program estimated that 49% of marine litter found on US beaches was from land-based sources (18% from ocean-based sources, and a further 33% for which the source could not be identified) (Ocean Conservancy 2007). Estimates suggest that up to 95% of the litter found on Australian beaches comes from suburban streets through the stormwater system (Clean Up Australia 2009). The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR 2009) states that major land-based sources in the North Atlantic region include tourism, illegal dumping, waste disposal sites and input from rivers. General litter and illegally dumped waste can be blown or washed into watercourses, waste can be blown from poorly managed landfills, and waste items may be inappropriately flushed down toilets or are otherwise improperly managed. For this reason, measures to promote improved waste management on land can play an important role in preventing land-based waste from reaching the seas (Newman et al, 2015). One of the key ways to tackle land-based sources of litter is therefore to ensure that waste collection infrastructures capture the maximum possible amount of waste that is prone to becoming marine litter, so that the waste is intercepted and properly treated, to minimise the amount of waste becoming marine litter.

3.2

A 'HIERARCHY' FOR MARINE LITTER

The concept of a 'hierarchy' for waste management is now commonly accepted in waste policy and legislation. The typical waste hierarchy prioritises prevention as the preferred method of waste management, followed by reuse, material recycling, energy recovery and disposal. Figure 3.1 uses this order and applies it to marine litter to create a suggested ideal hierarchy for the management of marine litter.

In the first instance, measures should be taken to **prevent marine litter being generated** (or at least to reduce the amount generated). This could include, for example, **product design** measures to ensure that products such as packaging are minimised or made more recyclable, to contribute to the development of the circular economy and reduce the amount that accumulates in the marine environment (see section 3.4.1).

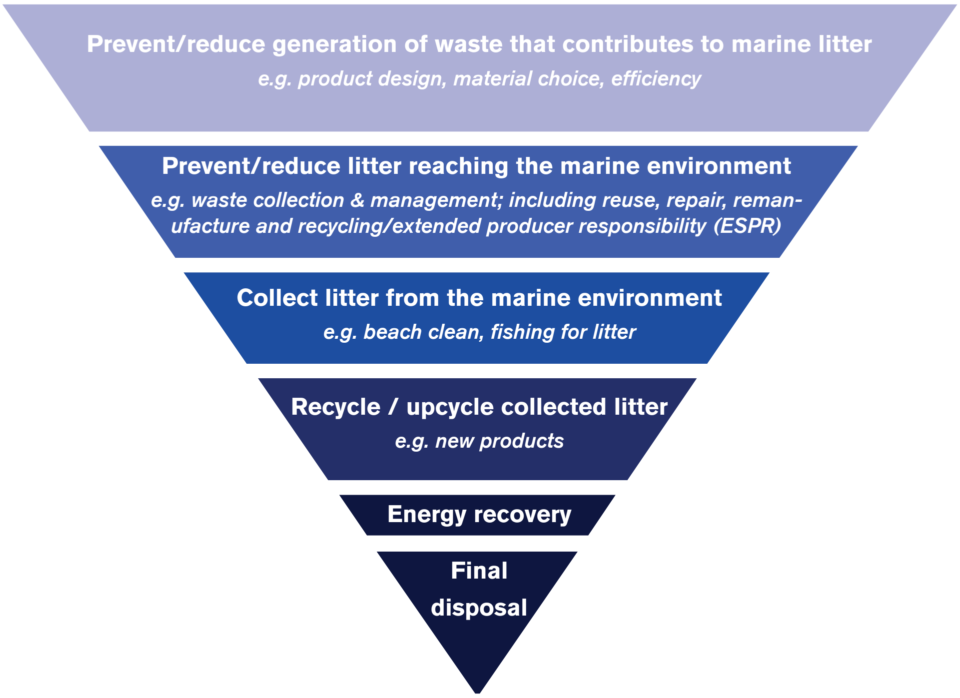
The second level on the hierarchy aims to **prevent waste reaching the marine environment and becoming litter**, or to reduce the amount of waste that becomes marine litter. This could include measures to improve **collection of waste** in general and litter in particular, measures to reduce illegal waste dumping, to improve capture of waste items in wastewater treatment works and storm drains, and to increase numbers of bins/refuse collections in coastal areas and so on. It would also include increased application of extended producer responsibility to make producers (financially) responsible for the waste management of their products at the end-of-life stage (see section 3.4.2). Although there are costs associated with implementing such measures, it is anticipated that these costs would be less than those of having to collect and treat litter that reaches the marine environment.

The third level on the hierarchy would be to **collect litter after it has reached the marine environment**, for example through beach clean-ups, fishing for litter initiatives and so on.

The fourth level on the hierarchy is to **recycle or 'upcycle' marine litter that has been collected** and removed from the marine environment, for example by making it into new products through 'trash to treasure' activities (see section 3.6).

Any collected litter that cannot be used in this way should be disposed of in line with the traditional waste hierarchy, i.e. prioritising **energy recovery** and

Figure 3.1 **A hierarchy for marine litter management**



Source: Own Representation, Emma Watkins

then **final disposal** via incineration or sanitary landfill (see section 3.4.3). In some cases disposal will be required, for example for litter that has partially degraded and/or is too contaminated for processing via energy recovery.

3.3

THE WASTE MANAGEMENT SECTOR AS A SOURCE OF MARINE LITTER

The waste management sector can be a potential source of marine litter, but does not tend to directly suffer the impacts of marine litter. Poor general waste management, illegal or improper waste disposal or movements, windblown waste from landfills or waste trucks, and lack of adequate bins for litter in public places can all contribute to waste becoming marine litter. However since there are no direct costs to the sector if items do become marine litter, it may not always be an issue that is fully taken into consideration.

The global waste market, including both collection and recycling, has been estimated at a value of USD 410 billion per year. As with any valuable economic sector, incentives and opportunities exist for improper or illegal activities throughout the waste chain, for example through poor implementation of waste regulations, illegal dumping to avoid costs associated with proper waste treatment (e.g. landfill taxes), or illegal shipments of valuable waste. In the case of electronic waste, for example, exports from EU and OECD countries to non-OECD countries for disposal are not allowed and are therefore not subject to any of the notification processes that usually apply to shipments of waste. Due to this, large quantities are falsely shipped to developing countries in Africa (major destinations include Ghana, Nigeria, Côte d'Ivoire and the Republic of Congo) and Asia (e.g. China, Pakistan, India, Bangladesh and Vietnam) as second-hand goods, and then have to be either recycled or disposed of in countries with inadequate waste infrastructures, which can lead to the majority of the waste being dumped. Different regulation in exporting and importing countries make it challenging to effectively combat illegal waste shipments. (UNEP and GRID-Arendal 2015)

Whilst it is fair to assume that the provision of dedicated collection and waste management infrastructure is vital in reducing the amount of waste items that become litter, a recent study found that there are very few results to indicate the effect on marine litter of waste disposal infrastructure that is optimized to reduce the littering of items such as metal cans, food packaging and plastic bottles (Arcadis 2014).

3.4

WASTE MANAGEMENT METHODS TO PREVENT MARINE LITTER

3.4.1. Waste prevention

In order 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. In terms of environmental economics, marine litter is facilitated because the marginal price of goods on the market (and of disposable plastics in particular) fails to reflect the full marginal cost to society of producing that good. In short, marine litter has an external cost to society that is not adequately borne by the waste producer (or consumer). It is also easy for some waste producers to 'free-ride' (i.e. to not contribute to litter prevention/ clean up costs whilst others do).

One instrument that could be used to tackle this is **extended producer responsibility (EPR)**, whereby a producer is made financially and/or logistically responsible for the post-consumer (i.e. waste) stage of a product's life cycle. This concept has been widely implemented in EU and OECD countries, and in recent years emerging economies in Asia, Africa and South America have also begun developing EPR programmes (OECD and Japanese Ministry of the Environment 2014). With regards to marine litter, perhaps the most important waste stream that should be addressed by EPR is waste packaging, since it forms a significant proportion of marine litter. Food wrappers, plastic, glass and metal beverage containers (and bottle caps) all regularly feature in the top ten most frequently found items during marine litter surveys; together these items comprised 31% of all items found during the Ocean Conservancy's 2013 International Coastal Cleanup. As a result of EPR for packaging waste, 64% of waste packaging (including composting for biodegradable packaging) was recycled in the 27 EU Member States in 2011, and 77% was recovered (including incineration with energy recovery). In Japan, the level of recycling of containers and packaging waste increased by 27% between 1997 and 2000 (OECD and Japanese Ministry of the Environment, 2014). The fees paid by producers to EPR schemes are used to cover, or contribute to, the cost of 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 can also be used to promote more **environmentally-friendly design**, which again can help to ensure that more waste is captured for recycling. For example, implementation of the 2006 revision of the Packaging Recycling Act in Japan contributed to a significant switch by producers from green PET bottles to clear ones with green labels. This helped reduce the cost of collection by removing the need for green bottles to be collected separately and was also attractive to industry given the higher value of clear bottles. Another example is the 'bonus-malus' scheme introduced by the French packaging producer responsibility organisation Eco-Emballages, which strongly penalises (by up to 100% of their fee) producers that place non-recyclable packaging on the market, whilst reducing the fee by up to 8% for producers who reduce the weight or volume of their packaging (OECD and Japanese Ministry of the Environment 2014).

Wastewater (i.e. used water from households, businesses, industry etc.) is also an important pathway for litter items to reach the marine environment. Steps should be taken to ensure that the minimum possible number of items that could become marine litter pass through the **wastewater treatment process**. Laundry is an important source of microplastics in particular; each time clothes made of synthetic fibres are washed, tiny plastic fibres (less than a millimetre in length) are released (see e.g. Browne *et al.* 2011). Whilst some more advanced wastewater

Box 3.1

COST TO EU PRODUCERS OF PACKAGING EPR SCHEMES

A study by BIO by Deloitte *et al.* (2014) found that the cost to producers of participating in packaging EPR schemes in seven EU countries ranged from just over USD 1.3 (EUR 1) per capita per year in the UK to almost USD 26.5 (EUR 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 were estimated to cover only 10% of the total cost of the system, whereas in most of the other schemes reviewed, 100% of the net costs of collection and treatment of separately collected waste were covered.

treatment plants (e.g. the largest in Sweden, which has a final filter with a size of 15 micrometres, i.e. 0.015 mm[13]) are able to capture these fibres, others cannot, and they therefore end up in rivers, in the sea and on shorelines. One estimate suggests that each second in Europe 3.6 billion synthetic fibres are released into the sewage systems (200,000 fibres per litre of wastewater), with around 10% of these fibres eventually entering rivers and the seas (Life-Mermaids Project 2015). It is estimated that the most advanced wastewater treatment plants with tertiary treatment may be able to capture 80-90% of microfibers[14], but the cost of applying such treatment infrastructure to less advanced plants has not yet been calculated, and it is not completely clear whether the majority of particles are captured by the final filters or earlier treatment phases such as sedimentation. However, around 30% of other particles are typically separated from the water during the primary treatment phase, so plants with only primary treatment (grids and sedimentation reactors) may only retain up to 30% of microplastics[15]. It is of course of paramount importance that the waste water reaches the treatment plant in the first place; if the water can bypass or overflow from the sewage system, particles cannot be captured. Other options to address the issue could include developing filters for washing machines, and innovative technologies such as additives for laundry detergents or textile finishing treatments to reduce the release of plastic microfibers during the washing process (Life-Mermaids Project 2015).

In addition to being a pathway for microfibers and plastic microbeads, the wastewater treatment sector can be a primary source of marine litter in the form of biofilters/ biocarriers. These are small plastic 'wheels' that are used as substrate for micro-organisms, which are used in waste water treatment plants (and certain industries) to break down micro-residues. On occasions where the ponds containing biofilters overflow, the filters can wash into nearby streams and eventually into the ocean. The Surfrider Foundation has found instances of this happening in the Seine (Paris, France), the Oria River (Basque Country, Spain), and the Minho River (Portugal), with hundreds of thousands or even millions of biofilters being released into the environment on each occasion (Surfrider Foundation, 2010a and 2010b). During the 2014 edition of Ocean Initiatives, a clean-up programme run by the Surfrider Foundation aimed at reducing marine litter at source, 9,313 biocarriers were found on beaches, lakes and rivers in 13 marine areas around the world[16]; biocarriers were recorded in 28% of collections (Surfrider Foundation 2014b).

Box 3.2

COSTS RELATED TO REMOVAL/PREVENTION OF LITTER FROM WASTEWATER SOURCES

One estimate suggests that removing litter from South Africa's wastewater streams effectively would cost about USD 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 USD 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)

13 Personal communication with Gryaab AB (regional sewage works of the Gothenburg region, Sweden)

14 Personal communication with Gryaab AB, Sweden

15 Personal communication with Gryaab AB, Sweden

16 The 13 marine areas covered were: Adriatic Sea, Baltic Sea, Bay of Biscay and Iberian Coast, Black Sea, Celtic Seas, North Sea Channel, Ionian Sea and Central Mediterranean, Macaronesia, North Atlantic, Western Mediterranean, Caribbean area, Indian Ocean, South Atlantic.

3.4.2. Waste collection

The responsibility for waste collection typically rests with local and municipal authorities and governments (and in some cases private waste collection companies). Waste collection can contribute to preventing marine litter by capturing as much waste as possible, through timely and secure collections that prevent waste items being carelessly disposed of, washed into water courses, blown by the wind etc. The costs of municipal waste collection vary hugely depending on the means and frequency of collection, size and terrain of the collection area and so on. Local governments have several options available to them that can help to reduce marine litter by ensuring better management of land-based waste. These include promoting waste prevention, reduction and reuse; undertaking land-based clean-ups; and bringing in requirements to reduce or ban certain items (e.g. single-use plastic bags or polystyrene food packaging) (Stickel et al, 2012).

A study of 66 communities on the West Coast of the USA (California, Oregon and Washington) found that each community was spending in the region of USD 13 to 14 per resident per year to tackle and clean up trash that might otherwise become marine litter. These costs related to six main types of waste management activity: beach and waterway clean-ups; street sweeping; installation of storm-water capture devices; storm drain cleaning and maintenance; manual clean-up of litter; and public anti-littering campaigns. The amount spent per resident was similar regardless of the size of community (ranging from just over 200 to over 4 million residents; the largest communities spent just over USD 10 million on average per year whilst the smallest spent around USD 95,000) or the distance from the ocean. Specific costs identified by the study included an estimated USD 6 million per year spent by the City of San Francisco on cleaning up discarded cigarettes, and over USD 18 million per year spent by Los Angeles County to sweep streets,

Box 3.3

COST OF MUNICIPAL WASTE COLLECTION

One study estimated that the costs of residual waste collection in various EU Member States varied from between USD 28 (EUR 30) and USD 119 (EUR 126) per tonne (with rural collections typically being more costly to run than urban collections), or between USD 17 (EUR 18) and USD 71 (EUR 75) per household. The same study found that for separately sorted dry recyclables, less dense materials are typically cheaper to collect, and kerbside/door-to-door systems tend to be more expensive to run than bring schemes/road containers, but also tend to lead to higher recycling rates and a lower risk of illegal dumping/fly-tipping. The collection costs for glass, paper and textiles are typically in the same league as those for residual waste, whereas light packaging materials such as plastics and cans tend to be more costly to collect (varying between around USD 188-282 (EUR 200-300). (Eunomia, 2002)

Table 3.1

Estimated average costs of waste management for communities on the USA West Coast

Waste management activity	Average annual cost per West Coast community
Beach and waterway clean-ups	USD 56,688
Street sweeping	USD 664,580
Stormwater capture devices	USD 165,811
Storm drain cleaning and maintenance	USD 294,935
Manual litter clean-up	USD 304,545
Public education	USD 80,927
Total average annual cost per community	USD 1,567,486

Source: summarised from Stickel et al. (2012)

clear catch basins, clean up litter and undertake public education related to litter. The study suggested that in total, West Coast communities are likely to be spending USD 520 million per year to combat land-based litter and thereby reduce marine litter (Stickel et al, 2012).

Well-developed waste infrastructures can certainly help to reduce marine litter. In parts of the world where such infrastructures do not exist or are inadequate, some initiatives are being introduced to provide waste management at a very local or community level as a means of tackling litter problems. A small number of examples are included in Box 3.4 below.

Box 3.4

EXAMPLES OF SMALL-SCALE WASTE COLLECTION INITIATIVES

TrashCash[17] **is a recycling initiative in Accra, Ghana. Citizens are encouraged to keep their empty cans and bottles until they have at least 1kg of a single type of waste. They can then take their waste to a collection point (e.g. in a shop or major transit point in Accra) and sign up to TrashCash. A mobile phone app helps people to find where they can drop off waste, and to identify what is recyclable. For each quantity of waste returned to a collection point, the person's account is credited with 'cash'. Once at least GHS 30 (USD 7.60) or an individually specified target is reached, the amount is sent to the person automatically through mobile money. It is anticipated that TrashCash will help to collect an average of an additional 2 metric tonnes of plastic waste per week (The Pollination Project, 2014).**

Wecyclers[18] **is a recycling collection initiative in Lagos, Nigeria. Workers ride modified tricycles to around 6,000 homes each month to collect waste. Householders collect points based on the volume and quantity of recyclables they give, and can redeem those points for household items or minutes on their mobile phones. The scheme also provides a reliable supply of materials to the local recycling industry. Wecycle, which is run in partnership with the Lagos Waste Management Authority (LAWMA), collects 40 metric tonnes of recyclables (plastic bottles, plastic bags, and aluminium cans) each month.**

The *Recycle Swop Shop (RSS)*[19] started in Hermanus, South Africa, and is a community development project through which children collect recyclable material and swap it for points once a week at the RSS collection yard. The points can be used to buy items such as clothing, food or school supplies from the on-site shop. Around 17 Swop Shops are currently in operation. The Swop Shop at Du Noon school collected 21,996 kg of recyclable waste from March to December 2014, with each person bringing an average of 20 kg. The project is easy to replicate and adapt to individual communities and each Swop Shop costs less than USD 10,000 to set up.

17 http://crowncitytechnologies.com/trashcash/trashcash.php
18 http://wecyclers.com/
19 http://www.recycle-swop-shop.co.za/index.htm

Recycling captures value from used materials, and can also result in savings for producers. It has been estimated that good management of plastic, including current recycling and energy recovery practices, save consumer goods companies around USD 4 billion per year, with significant savings from initiatives within the food and soft drinks sectors in particular[20] (UNEP, 2014). Recycling also offers the potential to create jobs. Plastics SA reported that 1,084,400 tonnes of plastic waste was landfilled in South Africa in 2014, whilst 1,400,000 tonnes (22.5% of plastic waste produced) were recycled. 32.9% of plastic packaging material was recovered. The company has set up over 450 fishing line collection bins across Cape Town to facilitate recycling[21]. According to Plastics SA, the informal sector of the plastic recycling industry employs 47,420 people, whilst 6,037 people are employed in the formal sector; this represented an 11.4% increase in jobs in the industry in 2014 compared with the previous year. The majority of the 221 plastics recycling companies and estimated 1,800 converters in the industry in South Africa are small, medium and micro enterprises (SMMEs) (Motsoai 2015).

3.4.3. Waste disposal

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 landfill to encourage the diversion of waste to closed-loop waste management processes 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, for example through load management (e.g. minimising the size of a landfill's active face or careful positioning of items liable to be blown by the wind), compaction of waste, use of physical barriers such as soil cover or materials produced from processed waste (e.g. foam, post-consumer paper, chipped wood, processed C&D material), or litter control fences/nets/screens (Martel and Helm, 2004).

Box 3.5

LITTER PREVENTION AND REMOVAL AT LANDFILLS

Methods to minimise windblown litter have a cost, but are effective. Litter netting (typically used at the perimeter of landfills and particularly recommended for landfills adjacent to waterways) can be more expensive than chain-link fencing, but can provide greater litter control efficiency, 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 an open holding bin for spraying litter with water prior to dumping (to minimise windblown litter). The device cost USD 15,000 to construct (USD 12,000 of which was for the compressor) and worked for over seven years with minimal maintenance. (Martel and Helm, 2004)

Box 3.6

COST OF CLEANING UP ILLEGALLY DUMPED WASTE

Recent estimates of the cost to English local authorities of dealing with clearance of illegally dumped waste and associated enforcement range from USD 56 million (GBP 36 million) (NFTPG 2013) to USD 80.7 million (GBP 51.6 million) annually (Environmental Services Association Education Trust, 2014). In addition, the cost to private landowners of clean-up and disposal associated with illegal dumping is estimated to be in the region of USD 78-234 million (GBP 50-150 million) per year (NFTPG 2013).

Landfill taxes can incentivise illegal landfilling and waste dumping (as a means of tax avoidance). Whilst estimates of the amount of marine litter that

20 Benefits taken into account in the UNEP study include: for recycling, avoided impacts of the amount of plastic that would have been produced if recycled material was not available, and avoided impacts of e.g. littering and landfilling if the plastic was not recycled; and for incineration with energy recovery, avoided impacts of grid electricity production.

21 Personal communication with UNEP.

comes from landfill and illegal dumping are limited, the Scottish Government has estimated that around 1.6% of marine litter comes from illegal dumping incidents (Scottish Government 2013). To stop these unchecked methods of waste disposal from resulting in more waste reaching rivers and seas, landfill taxes should be accompanied by measures such as the closure of illegal landfills and fines imposed on illegal dumpers. The producer responsibility schemes mentioned above can also help to promote recycling.

Direct investments in **small/localised waste collection infrastructure**, such as rubbish bins and secure waste collections on beaches and in coastal areas, can help reduce litter in coastal areas and therefore reduce the risk of items reaching the sea. Options for financing such investments include tourist taxes or car parking charges. If fees and fines for littering, illegal waste disposal and fly-tipping are high enough, this can discourage behaviours that lead to waste escaping formal waste management processes, reducing the risk of it reaching the marine environment as litter (ten Brink *et al.* 2009).

3.5

MARINE LITTER COLLECTION COSTS

The economic cost to coastal municipalities of marine litter include the direct cost of keeping beaches clear of litter and its wider implications for tourism and recreation (see section 5). Direct costs include the collection, transportation and disposal of litter, and administrative costs such as contract management. In addition, it should be noted that voluntary organisations also often play a significant role in litter removal, and that some value should be attributed to volunteers' time. Wurpel *et al.* (2011) extrapolated estimates of the cost of cleaning up the UK's coastline to generate a (theoretical) approximate global cost of USD 69 billion (EUR 50 billion) per year to keep all 34 million km of global coastlines clean. More detailed information on the cost of beach clean-ups are presented in the section on tourism (see section 6), a small selection of examples are included here to provide examples of the magnitude of clean-up costs.

3.6

TRASH TO TREASURE INITIATIVES

Box 3.7

COST ESTIMATES FOR LITTER REMOVAL FROM BEACHES

In the UK, the annual cost to coastal municipalities of removing beach litter is estimated at around USD 24 million (EUR 18 million), on average USD 193,365 (EUR 146,000) per municipality, the majority of which is accounted for by labour costs. The estimated cost to Dutch and Belgian municipalities of removing such litter is around USD 13.8 million (EUR 10.4 million) per year, an average of USD 264,885 (EUR 200,000) per municipality, or USD 45,030 (EUR 34,000) per km of coastline, although sometimes as high as USD 128,866 (EUR 97,300)); and the average annual cost of litter removal per km of coastline was between USD 7,270 (EUR 7,000) and USD 9,668 (EUR 7,300) (with a range of USD 226 to 108,600 (EUR 171-82,000)) (Mouat *et al.* 2010).

One Peruvian municipality was estimated to spend USD 200,000 per year on litter (McIlgorm *et al.* 2011).

The cost for the city of Long Beach in California of maintenance to remove beach litter is USD 2.2 million per year (Wurpel *et al.* 2011).

Mouat *et al.* (2010) estimated the value of volunteers' time in two annual beach clean operations in the UK to be around USD 173,500 (EUR 131,000), not taking into account financial assistance or operational management costs.

Whilst marine litter continues to be an issue around the world, the challenge remains of what to do with it once it has been collected. A number of initiatives have grown up around the world aimed at turning marine litter that washes up on beaches or is otherwise collected from the environment into something that has a use or value to society. The geographical spread of a selection of examples is demonstrated in Figure 3.2, with summary details of the initiatives and their achievements presented in Box 3.8. Whilst such initiatives should not necessarily be seen as an end goal for addressing marine litter in the long term (the main aim should be to prevent and reduce marine litter, in line with the hierarchy outlined above), they do provide a useful destination for marine litter that will continue to be collected in the short and medium term until the amount of litter reaching the marine environment is significantly reduced. In some cases (e.g. EcoPost Limited, see Box 3.8 below) the collected litter is processed into items that would otherwise have used raw materials, thereby contributing to the conservation of resources. In addition, such projects often create employment opportunities for local (often deprived) communities, helping to both make communities aware of the issue of marine litter and to allow them to generate some income from recycling or upcycling litter.

EXAMPLES OF 'TRASH TO TREASURE' INITIATIVES

Box 3.8

Ocean Sole[22]**, based in Nairobi, Kenya, creates artworks from rubber flip flops recovered from the Kenyan coast. Around 400,000 items (120,000 kg in weight) are recovered each year, upcycled (e.g. into handcrafted models of elephants, giraffes, dolphins or turtles) and sold online and in 26 countries. Ocean Sole pays per kilogram of flip flop waste collected, and also employs around 50 artists to craft the products. Ocean Sole sells products worth up to USD 500,000 per year. Ten per cent of the product cost of each item made goes to the Ocean Sole Foundation, which supports recycling and marine conservation activities, with a particular focus on educational and awareness-raising activities for schools and local communities.**

The *Net-Works programme*[23] was set up in 2013 and is a partnership between Interface, the world's largest carpet tile producer, the Zoological Society of London (ZSL) and yarn supplier Aquafil. Through the programme, local artisanal fishing communities recover discarded and abandoned fishing nets from shores and reefs. Interface purchases these, resells them to Aquafil to process into nylon yarn, and then acquires the yarn for use in its carpet products. The Net-Works programme in the Philippines (Danajon Bank and Bantayan Islands) has collected 77,792 kg of discarded fishing nets to date, 51,934 kg of which has already been absorbed into Interface's supply chain. The money from net purchases goes into small community banks that provide access to finance (e.g. micro-insurance, savings and loans) for 358 local residents. It is estimated

Figure 3.3 Nets are collected, cleaned and sorted at community level

Source: © 2014 Net-Works™

22 http://www.ocean-sole.com

23 http://net-works.com/about-net-works/

Box 3.8 *(cont.)*

that the funds provided through Net-Works community banks to date would be enough to pay for 268,382 meals. In 2015, Net-Works expanded into a third Philippine collection hub (Northern Iloilo), and also established a programme in Lake Ossa in Cameroon.

Bureo Skateboards[24] has created a skateboard deck (the 'Minnow') made entirely from recycled fishing nets. Nets are collected through the Net+Positiva programme, which has established free and environmentally sound disposal points in Chile for derelict nets from both commercial and artisanal fisheries. The waste nets are then melted down at a recycling plant in Santiago to be made into skateboards. During its first year, Bureo employed two regional managers and eight local workers to run the net collection programme. To date, Bureo has collected over 57,840 square feet of fishing net for recycling; each skateboard deck uses over 30 square feet of fishing net. Over 3,000 skateboards have been sold; prices for the skateboards start at USD 149, and sunglasses with frames made from Net Positiva plastic retail at USD 129. During the first year of operations, USD 2,850 of funds were allocated to community programmes, and Bureo also coordinated 15 beach clean-ups and gave 48 presentations to schools to ensure community engagement.

Repurpose Schoolbags (South Africa) makes schoolbags from waste plastic bags which may otherwise potentially have been littered or disposed of in landfill. The plastic bags are collected with the help of local municipalities and schools, and then upcycled by local workers into the durable and waterproof textile used to make the schoolbags. Each schoolbag is also fitted with retro-reflective material and a solar panel that transforms into a light for children to study with at night. To date around 4,000 bags have been manufactured, resulting in around 160,000 plastic bags being removed from potential littering or landfill (40 plastic bags are used to make each schoolbag). Bags are purchased by NGOs and Giving Partners and given to schools; each schoolbag costs around ZAR 250 (USD 18).

EcoPost Limited[25], a for-profit social enterprise started in Kenya in 2011, recovers plastic waste (e.g. films, bags, bottles and packaging) that is then used to make fencing posts, road signage, planks etc. as an alternative material to raw timber. One fully matured cedar tree is saved for every 25 posts sold (Ecoprofiles, 2015). The plastic waste is sourced both from individuals (provided they can supply over 1.5 tonnes of plastic waste per week) and industries, farms or businesses that generate significant quantities of plastic waste. In this way waste management is improved and jobs are created (mostly for women and young people who collect, transport, sort and clean the plastic waste; EcoPost Ltd aimed to create 100 direct and over 500 indirect jobs in its first three years of operation). EcoPost claims to remove 25 metric tonnes of plastic waste from the environment each month, and so far over 1,000,000 kg of plastic waste has been recycled into 'timber'.

The *Kriki4Shore initiative*[26] turns litter collected from beaches in South Africa into beach cricket sets for local communities. Each beach cricket set (bat, ball and wickets) is made from waste material such as plastic and bottle tops that are collected from beaches in South Africa; the sets are either handmade from 100% waste material or moulded from 60% recycled plastic. The initiative creates employment for craftspeople and waste collectors in coastal areas, and also aims to educate local

24 http://www.bureoskateboards.com/net-positiva.php
25 www.ecopost.co.ke
26 https://www.facebook.com/Kriki4Shore/info?tab=page_info

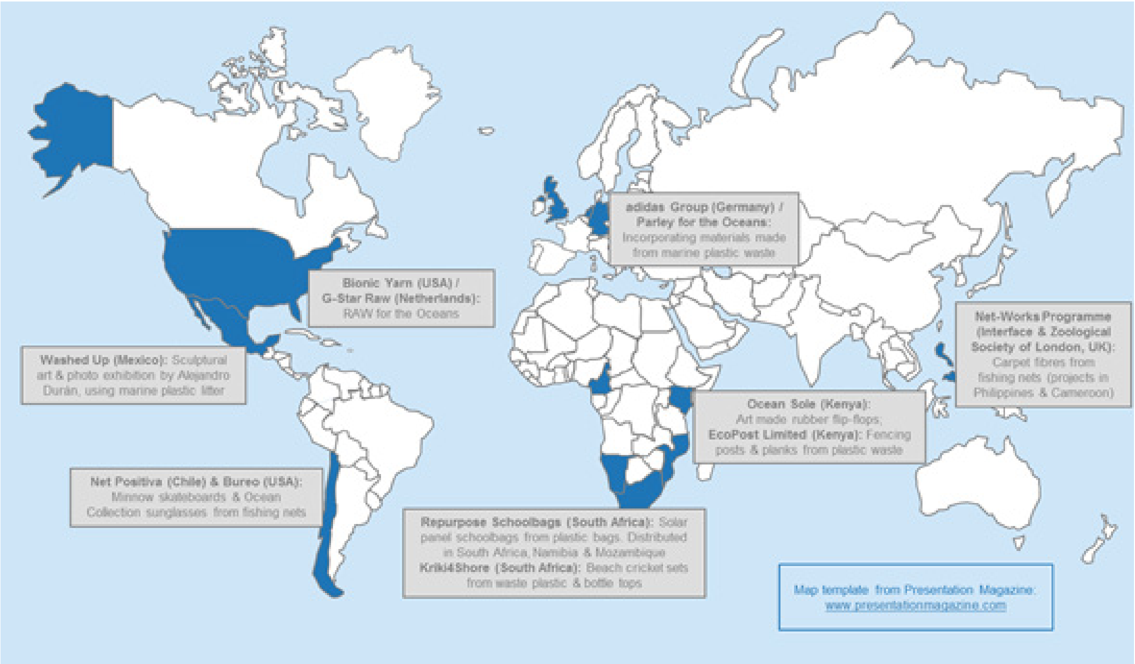
Box 3.8 *(cont.)*

communities on how useful waste can be. Kriki4Shore has so far given 20 adults (14 women who are sole bread winners and 6 disabled crafters) the opportunity to learn skills through their work for Kriki4Shore. Each cricket set takes two days of work to make, and profits from sales of the sets (which retail at around USD 13 (ZAR 185)) are reinvested in the initiative. The initiative is an example of successful collaboration between a major waste management company (EnviroServ, which provides sponsorship), an environmental non-profit organisation (Kommetjie Environmental Awareness Group, KEAG, which oversees the waste collection) and a cultural organisation (the Harlequin Foundation, which works on craft-related skills projects).

In 2015, the *Adidas Group* announced it will partner with *Parley for the Oceans* on a long-term programme that will include direct actions against plastic pollution of the oceans, communication and education, and research and innovation. Part of the collaboration will involve creating innovative products that integrate materials made of ocean plastic waste into the fabrics used for Adidas products from 2016 onwards. (Adidas Group 2015)

Bionic Yarn, a clothing company co-founded by popstar Pharrell Williams, and Dutch designer clothing company G-Star Raw are using fibres made from plastic marine litter to create yarn, denim and other textiles in the *RAW for the Oceans project*[27]. The collected plastic is chipped, shredded into fibres, spun into yarn and mixed with cotton to be woven into fabrics. Around 700,000 PET bottles are recycled into yarn each season. So far, during the production of three denim collections, 2 million plastic containers have been recovered from ocean coastlines. Items in the RAW for the Oceans range retail for USD 77-306 (GBP 45-200).

Examples of 'Trash to Treasure' initiatives Figure 3.2



Source: own compilation

27 http://rawfortheoceans.g-star.com/

3.7

CONCLUSIONS ON WASTE MANAGEMENT INFRASTRUCTURE AND COSTS

Some data are available on the costs of waste management methods to prevent and tackle marine litter. The data found refers to various types of waste management activities; they are not always comparable and indeed may not be costs that are only related to marine litter, i.e. they may be costs related to general waste management that takes place with no specified aim of preventing or reducing the amount of marine litter. However, they do provide an indication of the level of cost of some waste management activities that are relevant to marine litter.

Table 3.2 Summary of identified costs of waste management activities relevant to marine litter reduction/prevention

Waste management activity	Identified examples of costs
Waste prevention	
Participation of producers in extended producer responsibility (EPR) schemes	Cost to producers of between USD 1.3 (EUR 1) and USD 26.5 (EUR 20) per capita per year to participate in packaging collective EPR schemes (Deloitte *et al.* 2014).
Removing litter from wastewater streams	Cost of USD 279 million per year in South Africa (ten Brink et al, 2009). Cost of USD 140 to retrofit a Lint LUV-R filter to a washing machine.
Waste collection	
Collection of residual (i.e. non-recyclable) municipal waste	Between USD 28 (EUR 30) and USD 119 (EUR 126) per tonne, or between USD 17 (EUR 18) and USD 75 (EUR 72) per household per year, in EU countries (Eunomia 2002).
Collection of trash that might otherwise become marine litter	Around USD 13 to 14 per resident (a total of USD 520 million) per year in communities on USA West Coast
Collection of light packaging materials (e.g. plastics, cans)	Between USD 188 (EUR 200) and USD 282 (EUR 300) per tonne in EU countries (Eunomia 2002).
Setting up of a ‘Recycle Swop Shop’	Cost of less than USD 10,000 per Swop Shop, in South Africa.
Waste disposal	
Mechanical litter collection system at a landfill	Cost of USD 15,000 for a tailor-made device at Salina Landfill in Kansas, US.
Clean-up/enforcement activity related to illegally dumped waste	Cost to English local authorities of between USD 56 and 80.7 million (GBP 36 and 51.6 million) per year; cost to private landowners of USD 78 to 234 million (GBP 50 to 150 million) per year (NFTPG 2013).

As outlined in the chapter, there are also a number of initiatives where socio-economic benefits and/or value are generated from collected marine litter, whether in terms of employment created, collected recyclable materials (e.g. plastics) sold, or upcycled products sold. Some of these values are summarised in the table below; again, these should not be taken as presenting a comprehensive or totally representative picture, but they do give a snapshot of several examples where marine litter is converted into socio-economic value.

Summary of identified socio-economic benefits/value generated from collecting and recycling marine litter items Table 3.3

Activity	Socio-economic benefits / value generated
Plastic recycling industry	*Financial savings:* Good plastic management (incl. recycling and energy recovery), estimated to save consumer goods companies USD 4 billion per year globally. *Employment:* Over 6,000 formal jobs and over 47,000 informal jobs in South African plastics recycling.
Small-scale/local waste collection initiatives	*Value to citizens:* Points/money gathered by individuals to be spent on household items, food, clothing, mobile phone credit (e.g. TrashCash in Ghana, Wecyclers in Nigeria, Recycle Swop Shop in South Africa).
Trash for treasure initiatives	*Employment created:* Around 50 artists employed by Ocean Sole (Kenya); Goal to create 100 direct and 500 indirect jobs through EcoPost Ltd (Kenya); 20 people trained in craft skills through Kriki4Shore (South Africa). *Value generated through materials/products:* Ocean Sole sales of up to USD 500,000 per year; Net-Works community banks in the Philippines have provided enough funding to pay for 268,382 meals; Kriki4Shore beach cricket sets sell at USD 13 (ZAR 185); RAW for the Oceans clothing items sell for between USD 77 and 306 (GBP 45-200); Bureo skateboards (over 3,000 sold) sell at USD 149, and sunglasses at USD 129; USD 2,850 allocated to community programmes in 1 year.

4

4. FISHING AND AQUACULTURE

4.1

INTRODUCTION

The fishery sector is both responsible for and negatively affected by marine litter. Lost and discarded fishing gear poses a significant impact on ecosystems and wildlife, which translates into a loss of potential catch for fishermen. Also, marine litter causes damage to fishing nets and vessels and aquaculture installations, and takes up the time of fishermen and aquaculture operators to clean up the litter and address any related damage.

4.2

FISHING AND AQUACULTURE AS A SOURCE OF MARINE LITTER

The fishery sector's largest contribution to marine litter is due to abandoned, lost or discarded fishing gear (ALDFG) like nets, ropes and traps, which can end up indiscriminately catching target and non-target fish for a long time after they are dumped into the sea (a phenomenon known as ghost fishing) (Macfadyen *et al.* 2009; Brown *et al.* 2005). A considerable amount of fishing gear ends up as ALDFG. It has been estimated that 640,000 tonnes of ghost nets are lost or abandoned in the oceans, accounting for approximately 10% of all marine litter (UNEP 2009). For example, an annual loss of 10-20% of the 400,000 pots targeting blue crab has been estimated in Maryland (USA), with a mortality rate of 20 crabs per pot per year (Giordano *et al.*, 2011). More than 12,000 pots are lost each year in Washington State (USA), with an estimated mortality rate of 0.058 crabs per pot per day (4.5% of the value of recent harvests) (Antonelis *et al.* 2011). About 70% of the 9,000 pots targeting blue swimmer crabs in Queensland (Australia) are lost each year, with a mortality rate of between 3 and 223 crabs per pot per year (Campbell and Sumpton 2009). 24% of the almost 218,000 pots targeting octopus in the northeast Atlantic Ocean, near the south coast of Portugal, are lost every year, with a mortality rate of 0.87 individuals per pot per day (Erzini *et al.* 2008).

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. For example, over 32,000 derelict blue crab pots were removed from Chesapeake Bay (Virginia, USA) between 2008 and 2012. They had captured about 40 species and over 31,000 marine organisms, including 900,000 blue crabs, with an estimated economic loss of USD 300,000. In addition, other important fishery species like the Atlantic croaker and the black sea bass, and endangered species like the diamondback terrapin were captured in derelict pots (Bilkovic *et al.* 2014). Also, ALDFG has a direct cost due to the time needed to disentangle it from gears or vessel engines, the lost gear and equipment due to entanglement and the time and fuel needed to search for and recover damaged vessels.

The aquaculture sector also contributes to the production of marine litter. For example, in Korea aquaculture is responsible for a high share of litter (Hong *et al.* 2014), due to Styrofoam (expanded polystyrene), a material used in large quantities in hanging-culture farms for oyster, mussel and warty sea squirt. Styrofoam buoys are easily lost or broken down into small spherules because they are directly exposed to the environment without covers (Lee *et al.* 2013).

Marine litter produced by the fishing sector also has an impact on other sectors. For example, it can become entangled in the propellers of commercial and recreational vessels, causing a direct economic impact and also a potential reduction in maritime safety (see Chapter 7). In addition, marine litter can be a serious issue for the tourism sector by discouraging beach tourism in specific areas (see Chapter 6). Fishing and aquaculture gear is estimated to be the fourth largest type of beach litter in the UK (Marine Conservation Society, 2014), which may result in economic losses for the tourism sector. 30% of the marine litter collected on the Galician Atlantic coast and the Mediterranean coast of Valencia (Spain) during the Pescal project[28] was due to fishery and aquaculture activities (ONAPE and CETMAR 2015).

4.3

IMPACTS OF MARINE LITTER ON FISHING AND

28 The Pescal project ran from 2012 to 2014 and aimed to manage marine litter collected by 62 fishing vessels belonging to the National Organization of Fisheries Associations (ONAPE) during their regular fishing operations.

AQUACULTURE (COSTS OF INACTION)

The impact of marine litter on the fishery sector is due both to the damage to fishing vessels and equipment and to the reduction of potential catch. Regarding 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 can only be estimated. Fanshawe and Everard (2002) calculate that the total impact of damage caused by marine litter to gear in the UK is not less than USD 0.7 million (GBP 0.5 million) per year. Other estimates are shown in Box 4.1, Box 4.2 and Box 4.3.

The impact of marine litter on fish is due to (a) entanglement in plastics floating at the sea surface or in ALDFG (ghost fishing), (b) ingestion and (c) exposure to toxic materials (either embedded into the plastic that is directly ingested by fish, or absorbed by the plastic from surrounding polluted waters) (see e.g. Thevenon *et al.* 2014; Rochman *et al.* 2013).

Box 4.1

THE COST OF A TRAP FISHER

Watson and Bryson (2003) calculated losses of up to USD 21,000 in lost fishing gear and USD 38,000 in lost fishing time due to a single trap fisher in the Scottish Clyde fishery.

Box 4.2

SOME ESTIMATES OF THE COSTS RELATED TO MARINE LITTER

- **Takehama (1990) estimated the costs of marine litter to fishing vessels based on insurance statistics at USD 35.7 million (JPY 4.4 billion) in 1985, i.e. about 0.3% of total annual fishery revenue in Japan.**
- **Based on a survey with Shetland fishermen, Hall (2000) calculates the costs of marine litter at between USD 9,000 (GBP 6,000) and USD 45,000 (GBP 30,000) per year. This figure is obtained by taking into account the time needed to clear litter from nets, the impact of fouled propellers and the impact of contamination (e.g. from oil containers, paint tins, oil filters and other chemicals), both in terms of restricted catch and damage to equipment.**
- **Fanshawe and Everard (2002) estimate the costs related to marine litter in the UK at USD 35 million (GBP 23.4 million) per year. This figure is obtained by multiplying the most cautious of Hall (2000)'s estimates (USD 9,000 (GBP 6,000) per boat per year) by half of the total UK fishing fleet (i.e. 3,900 boats). The same authors estimate the cost of marine litter to UK aquaculture at USD 475,000 (GBP 316,800) for cage clearance (one hour per month, as estimated by Hall (2000) at USD 121 (GBP 80) per hour, multiplied by 330 farms) and USD 890,000 (GBP 594,000) for fouled propellers and intakes (USD 225 (GBP 150) per incident x 330 boats x 1 incident/month).**

Box 4.3

THE COST OF MARINE LITTER TO SCOTTISH FISHERMEN

Based on a questionnaire to Scottish fishermen, Mouat *et al.* (2010) calculated a cost of between USD 22,805 and USD 25,383 (EUR 17,219 and EUR 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 USD 15.5 and USD 17.2 million (EUR 11.7 and EUR 13 million) per year to the Scottish fishing industry, i.e. 5% of overall revenues. Concerning aquaculture, marine litter is estimated to cost the surveyed operators about USD 768 (EUR 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 USD 206,013 (EUR 155,549) per year for the entire aquaculture industry in Scotland, if 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 catch (Matsuoka *et al.*, 2005). Table 4.1 shows some examples of estimated losses in the USA and Spain.

Examples of estimates of losses due to ghost fishing Table 4.1

Species	Impact on commercial species	Location	Reference
Blue crab	USD 300,000 per year, due to an estimated 900,000 blue crab captured in ALDFG.	Chesapeake Bay, Virginia (USA)	Bilkovic et al. (2014)
Dungeness crabs	4.5% annual entrapment rate and annual mortality of approximately 3%.	Southern Alaska (USA)	Maselko et al. (2013)
Crab	USD 304,000 per year, i.e. about 1% of annual commercial blue crab landings.	Virginia portion of Chesapeake Bay (USA)	Havens et al. (2011)
Dungeness crabs	Average annual harvest loss of 4.5% of Dungeness crabs (i.e. about USD 744,000).	Puget Sound (USA)	Antonelis et al. (2011)
Crabs and other species	Estimated annual loss of USD 1.2 million to fishing vessels, due to 372,000 crabs per year killed by derelict crab pots; also USD 1,760 loss due to fish entangled in lost nets.	Puget Sound (USA)	Natural Resources Consultants, Inc. (2007)
Lobster	USD 250 million per year	USA	JNCC (2005)
Monkfish	18.1 tonnes per year (1.46% of total commercial landings in the area).	Cantabrian Sea (Spain)	Sancho et al. (2003)

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). However, Arcadis (2014) attempts a rough estimate of the total cost of marine litter for the EU fishing fleet, based on the results of the survey of Scottish fishermen carried out by Mouat et al. (2010). The result is a cost of USD 81.7 million (EUR 61.7 million) per year, i.e. approximately 0.9% of the total revenues generated by the EU fleet in 2010 (see Table 4.2).

Table 4.2 **Estimated cost of marine litter for the EU fishery sector**

Type of cost	Cost per vessel in USD (EUR)	Estimated cost for the EU in m USD (m EUR)	Calculation method
Reduced catch revenue (contamination forces fishermen to spend more time on selection and discarding of catch)	3,105 (2,340)	37.99 (28.64)	The cost estimated by Mouat *et al.* (2010) for Scottish vessels (USD 2,914 (EUR 2,200) per vessel per year), actualised in 2013 prices, was multiplied by the number of EU trawlers (EU vessels that use seafloor fishing gear), i.e. 12,238.
Removing litter from fishing gear	1,272 (959)	15.58 (11.74)	The time needed to remove litter from fishing gear, as estimated by Mouat *et al.* (2010) for Scottish vessels (41 hours per vessel per year), was multiplied by the average labour cost in the EU countries (USD 30.9 (EUR 23.4) per hour) and then by the number of EU trawlers (EU vessels that use seafloor fishing gear), i.e. 12,238.
Broken gear, fouled propellers	253 (191)	22.28 (16.79)	The cost related to broken gear and fouled propellers, as estimated by Mouat *et al.* (2010) for Scottish vessels at USD 238 (EUR 180) per vessel per year, actualised in 2013 prices was multiplied by the total number of fishing vessels in the EU (87,667, according to Eurostat).
Cost of rescue services	69 (52)	6.02 (4.54)	The average cost of incidents around the British Isles attended by the Royal National Lifeboat Institution (RNLI) in 1998 (USD 6,000 (GBP 4,000) per vessel) was multiplied by the number of incidents (200), and divided by the number of UK fishing boats (7,800), as indicated by Fanshawe (2002). The estimated yearly cost per boat from this calculation was then multiplied by 31.1%, i.e. the share of rescue operations dedicated to fishing vessels, as indicated for the UK by Mouat *et al.* (2010) (year 2008). The result (USD 50 (GBP 32) per vessel) was then actualised in 2013 prices, converted to EUR and multiplied by the total number of EU fishing vessels (87,667, according to Eurostat).
Total	4,699 (3,542)	81.87 (61.71)	

Source: own elaboration, based on Arcadis (2014)

Microplastics also have an impact on the fish stock due to exposure through the gills or ingestion, and they can be transferred through the food web from one trophic level to the next. Microplastics can also be a vector to transport chemicals into marine organisms, including additives, monomers and by-products contained in plastic particles and compounds and metals from surrounding seawater. For this reason, microplastics may have an impact on human health, although this is still to be properly analysed (GESAMP 2015; Wright *et al.* 2013). Although not much information is currently available on the impact of microplastics on human health, concerns about this issue may cause a negative impact on fishery and aquaculture due to a potential drop in demand (see Box 4.4 for an estimate of the related costs in the UK).

Box 4.4

ESTIMATE OF POTENTIAL ECONOMIC LOSSES TO UK OYSTER & MUSSEL AQUACULTURE 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 mussels and oysters (chemical and physical effects) and in turn on human health (through consumption of seafood), which can lead to reduced consumer demand and hence socio-economic costs through loss of sales.

4.4

COST OF ACTION TO ADDRESS THE PROBLEMS

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** include requiring fishing gear to be marked in order to identify ownership, the use of on-board technology to avoid or locate gear, 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 and Box 4.6 for two examples) 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 FISHING BOATS FOR MARINE LITTER COLLECTION IN KOREA

In 2002 the city of Incheon (Korea) established an incentive programme to reward fishermen for collecting marine litter during fishing activities and handing it in at the harbour with a payment of USD 5 per 40 litre bag. The cost was estimated to be significantly lower than the cost of directly collecting and removing derelict fishing gear, i.e. a minimum of USD 48 per 40 litre bag (Cho, 2005). Inspired by this experience, the Korean Ministry of Land, Transport and Maritime affairs has implemented a similar incentive programme since 2003 with a budget of USD 5.2 million per year between 2009 and 2013, and covered 80% of the related costs, the rest being covered by local governments. The programme allows collection of an average of 6,200 tonnes of litter per year (see case study on Korea in the Annex). Both incentives are still in place.

Box 4.6

FISHING FOR LITTER IN BELGIUM

Belgian fishermen commonly find marine litter items in their nets, generally a few kilograms with each catch. In some cases, trawler nets bring in very large items such as fridges and truck tyres. Stichting voor Duurzame Visserijontwikkeling (SDVO), the Belgian Foundation for Sustainable Fishery Development, aims to promote sustainable practices in the Belgian fishing fleet, including minimising environmental impacts. SDVO's Fishing For Litter campaign encourages Belgian fisherman to put any waste they pull up with their catch into on-board containers provided by SDVO, rather than throwing waste back into the sea. SDVO organises the collection of this waste in all three Belgian fishing ports. They then manage the collected marine litter in a waste management park in Oostende. Waste is sorted in terms of its recyclability, and plastics are managed by plastic recyclers, such as European Plastic Converters. The Fishing For Litter project is a voluntary cost sharing scheme. Around 60% of Belgian fishermen participate, and pay a fee depending on the size of their vessel. Although 'free riders' exist, the project covers its costs.

Source: Interview with representatives of SDVO and Waste Free Oceans, June 2015

Box 5.7 provides an example of an innovative project aimed at collecting, recycling and reusing old and discarded fishing gear.

Box 4.7

FISHING FOR ENERGY

The Fishing for Energy project was launched in 2008 in the USA through a partnership between Covanta Corporation, the National Fish and Wildlife Foundation (NFWF), the National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program, and Schnitzer Steel Industries, Inc. The objective is to offer a cost-free solution to fishermen to dispose of old, derelict or unusable fishing gear, thereby reducing the amount of fishing gear in the sea. The project: 1) provides collection bins at strategic ports to collect gear; 2) collaborates with state managers to address legal impediments to derelict fishing gear removal; 3) identifies, tests and deploys innovation to reduce the amount and impact of derelict fishing gear; and 4) increases public awareness of the impacts of derelict fishing gear and ghost fishing. Collected gear is transported to a nearby Schnitzer Steel facility, where the metal is pulled for recycling, and rope or nets are sheared for easier handling for disposal. From there, the gear is brought to a Covanta Energy-from-Waste facility where it is converted into electricity for local communities. To date, the partnership has invested more than USD 2.5 million, collected more than 1,134 tonnes of fishing gear in 41 communities across the country and generated enough electricity to power 183 homes for one year.

Source: http://marinedebris.noaa.gov/current-efforts/fishing-energy

Mitigation measures include the use of non-plastic[29] biodegradable nets and pots (Kim *et al.* 2014), non-plastic biodegradable panels with a cull or escape ring to be placed in crab pots (Bilkobic *et al.* 2012, see Box 4.8) and reducing the diameter of the escape cord/modifying the trap design of crab traps (Antonelis *et al.* 2011). These kinds of measures can either be imposed by regulation or subsidised by government support programmes. Another interesting example can be found in the Dungeness crab fishery (Washington, USA), where trap exits are required to be closed with rot cord that decays in approximately six months (Arthur *et al.* 2014). It should be noted that such measures are generally aimed at reducing the incidence of entrapment of fish, i.e. reducing a specific impact of marine litter, rather than addressing the generation of marine litter *per se*.

Box 4.8

BIODEGRADABLE PANELS IN CRAB POTS

Bilkovitch *et al.* (2012) tested a fully biodegradable panel with a cull or escape ring to be placed on the sides of a crab pot, which completely degrades into environmentally neutral constituents after about one year. The panel is relatively cheap and easy to install. The authors found that the use of this kind of pot did not have a negative impact on the amount and size of the catch in their test case, i.e. blue crab pots in the Chesapeake Bay (USA).

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). Although it would be too expensive to remove all ALDFG, programmes aimed at removing it in the most sensitive areas and in areas with demonstrated high loss rates would help address the problem. The costs related to ALDFG retrieval programmes may differ considerably, depending on the specific characteristics of the geographical areas, scope and duration. For example Wiig (2005) reports estimates ranging from USD 65/tonne in Taiwan to USD 25,000/tonne in Hawaii. Table 4.3 summarises some estimates of costs related to ALDFG retrieval programmes.

Estimates of costs related to ALDFG re

Costs	Location	Source
USD 1,300/tonne	Republic of Korea	Raaymakers (2007), as reported by McIlgorm (2008).
USD 25,000/tonne	North-West Hawaiian Islands	Raaymakers (2007), as reported by McIlgorm (2008).
USD 70,000 for the entire area	Baltic Sea, Sweden	Brown *et al.* (2005), as reported by Macfadyen *et al.*, 2009.
USD 260,000 for the entire area	Norway	Brown *et al.* (2005), as reported by Macfadyen *et al.*, 2009.
USD 185,000 for the entire area	Northeast Atlantic	Brown *et al.* (2005), as reported by Macfadyen *et al.*, 2009.

Source: own elaboration

Campaigns aimed at raising awareness of the impacts of ghost fishing, such as the one carried out by the NGO World Animal Protection (see Box 4.9), can also play a key role in encouraging fishermen to discard fishing gear

29 It is important that the use of biodegradable fishing gear is restricted to non-plastic materials. Biodegradable plastics generally require specific conditions to biodegrade, which are generally not found in the marine environment. Also, when they degrade they break down into smaller plastic particles that contribute to microplastics, and/or emit other chemicals that may have an environmental impact. In addition, when plastics are collected for recycling, it is not possible to distinguish between biodegradable and non-biodegradable plastics, resulting in a less efficient recycling process.

properly and to participate in clean-up programmes. For example Cho (2005) mentions that an awareness raising campaign targeting fishermen allowed a considerable increase in the amount of litter collected through the incentive programme established in Incheon, Korea (see Box 4.5).

Box 4.9

THE SEA CHANGE CAMPAIGN

In order to contribute to reducing ghost fishing, the NGO World Animal Protection launched the Sea Change campaign, which aims to address the problem of ghost fishing worldwide. The project includes the involvement of various groups of stakeholders to stop gear being abandoned, to support ghost gear removal from the sea and to rescue wounded animals.

In general, the costs related to programmes aimed at reducing ALDFG are more than outweighed by the benefits, in terms of reduced damage to shipping vessels and fish mortality. For example, a study by Natural Resources Consultant, Inc. (2007) found a cost-benefit ratio of 1:1.28 for pots/traps and 1:1.27 for nets. The costs were assessed at USD 4,960 per acre of net removed and USD 193 per pot/trap, whereas the benefits were estimated at USD 248 per pot/trap (based on the commercial value of species saved from mortality over a one year period) and USD 6,285 per net (based on the commercial value of species saved from mortality over a ten year period). According to these calculations, the benefits exceed the costs even without taking into account factors like human safety, habitat restoration and reduction in mortality of non-target endangered species.

CASE STUDY SUMMARY - MARINE LITTER IN KOREA

Box 4.10

According to Jang *et al.* (2014c), 48% of the marine litter found in Korean seas is derelict fishing gear and 5% is due to Styrofoam buoys used in aquaculture facilities. As much as 60% of the fishing nets used in Korea are abandoned at sea, resulting in ghost fishing (Jang *et al.* 2014b). Recent surveys show that Styrofoam represents the most abundant litter item found on Korean beaches (Hong *et al.* 2014; Heo *et al.* 2013; Jang *et al.* 2014b; Lee *et al.* 2013). This is because Styrofoam floats are easily lost or broken down into small particles (Lee *et al.* 2013) and also because a great percentage of the 2 million Styrofoam buoys produced annually in Korea are discarded after use (90% according to interviews carried out by Lee *et al.* 2015a, whereas the Ministry of the Environment estimates the recycling rate of Styrofoam buoys to be around 28%).

Derelict fishing gear has a great impact on wildlife (Hong *et al.* 2013; Lee *et al.* 2015), which translates into losses for the fishery and aquaculture sector (Cho 2005), reduced revenues for the tourism sector (Jang *et al.* 2014a), and numerous maritime accidents (Cho 2005).

To address the problem, since 1999 the Korean Ministry of Maritime Affairs and Fisheries has put in place strategies to remove marine litter. The 2nd National Plan for Marine Litter Management (2014-2018) includes a clean-up programme, a survey of the status of marine litter, preventative measures to reduce the discharge of litter from land-based sources to coastal areas and the development of equipment and facilities for deep-sea surveying, recycling and environmentally friendly disposal of collected material (Jung *et al.* 2010). In addition, the Ministry of Ocean and Fisheries has provided financial support to local governments to install Styrofoam compactors, and to fishermen to buy high-density buoys which degrade less easily (Lee *et al.* 2015a). In 2009 the Ministry of Environment also established litter management and cost-sharing agreements in the five major Korean rivers

Box 4.10 *(cont.)*

between local governments that share the same watershed, resulting in local governments in upstream areas transferring funds to those located downstream to perform cleaning works (Jang *et al.* 2014a). Finally, the city of Incheon and the Ministry of Maritime Affairs and Fisheries have put in place incentive programmes that remunerate fishermen to collect marine litter (see above).

The level of effectiveness and cost-efficiency of these policies is still to be evaluated through regular surveys to monitor the sources, types and location of marine litter, in order to assess the trend over time. The costs of the different programmes should also be analysed, and if possible compared with the observed results, to assess whether the available budget is used in the most efficient way.

4.5

CONCLUSIONS ON FISHING AND AQUACULTURE

Marine litter has a great impact on marine wildlife, which translates into a loss of potential catch for fishermen and therefore into a cost for the sector. Litter in the sea also results in costs for the fishery and aquaculture sector due to damage to nets, fishing vessels and aquaculture installations, plus the need to clean up litter to ensure proper functioning.

Information on the impact of marine litter on the fishery and aquaculture sector is not systematically collected. However, a number of studies focussing on the consequences of marine litter, and in particular of ghost fishing in specific locations, show that the impact on commercial species is considerable.

A number of preventative, mitigating and ex-post measures can be used to address marine litter from the fishery sector. The related costs will depend on local specificities, but comparing their cost to the cost of inaction will certainly provide a good argument to strengthen policies already in place and to enact new ones. Assessing the effectiveness and cost-efficiency of such policies is not easy because of the movements of marine litter, which can travel large distances due to marine currents. However, efforts should be made to estimate the costs associated with marine litter for the fishery sector. Unlike other sectors addressed in this study, assessing the costs of marine litter for the fishery and aquaculture sector does not need monetary valuation methodologies, because fish have a market value, but evidence still needs to be collected on the trends of affected species over time.

This kind of analysis needs solid evidence based on studies on changes in the biota of coastal and marine areas over time. Ecological studies should be complemented with surveys of fishermen in different areas, investigating the economic loss they experience due to marine litter, in terms of time taken to clean up litter, damage to fishing vessels/nets/aquaculture installations and loss of catch.

In many cases, such analysis will show that the costs of policies addressing marine litter are outweighed by the benefits in terms of increased income and/or reduced costs for fishermen, tourism operators, shipping and other related sectors.

5

5. TOURISM, AESTHETIC VALUE AND RECREATION

5.1

INTRODUCTION

Impacts on the tourism sector are often cited as an example of the socio-economic costs associated with marine litter. These impacts and associated costs can be quite significant particularly in areas which are heavily focused on coastal tourism that relies on a clean and pristine environment to continue attracting visitors. The increased prevalence of marine litter makes certain beaches less attractive to coastal visitors, reducing their aesthetic value and affecting certain recreational opportunities such as surfing, fishing and diving. This leads to reduced visitors to affected areas, which in turn leads to a loss of revenue and jobs in the tourism sector, requires costly clean-up activities and poses health and safety risks to visitors. At the same time, the tourism industry can also have an impact on the amount of waste that is generated. Small island developing states (SIDS), for example, often lack the necessary space and infrastructure to deal with generated waste if they do not have adequate collection and recycling facilities, which increases the risk of wastes ending up in the ocean. Tourists themselves can also be a source of marine litter. There is therefore a need for preventative measures to reduce marine litter arising from the sector.

5.2

THE TOURISM SECTOR AS A SOURCE OF MARINE LITTER

Coastal tourists including recreational visitors and beach-goers are one of the main sources of land-based marine litter (UNEP, 2009). For example a study on the generation of marine litter on Cassino beach in southern Brazil found that tourism was the main source of marine litter, with litter levels correlated with visitor density. Moreover, the study found that daily litter generation on beaches was much higher in coastal areas frequented by people with lower 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, with self-reported littering less common among the most educated group of visitors (Eastman *et al.*, 2013).

A 2009 global survey by Ocean Conservancy found that shoreline and recreational activities accounted for 64% of total marine litter items collected worldwide (Ocean Conservancy 2010). The top three items collected in international clean-ups in 2014 were cigarette butts, food wrappers and plastic beverage bottles (Ocean Conservancy 2015). In 2010, a study conducted for the implementation of the requirements of the EU Marine Strategy Framework Directive showed that in the Baltic, Black, Mediterranean and southern North Seas, the majority of the marine litter originates from land-based activities, especially from tourism and recreational use of the coasts (Galgani *et al.* 2011b). For example, abandoned, lost or discarded fishing gear (ALDFG) from recreational fishers (e.g. hooks, lines and derelict traps) may entangle marine animals and habitats. Although individual amounts discarded may be small, where recreational fishing is an important activity the combined impacts of individual participants discarding monofilament line can be a significant source of ALDFG (Macfadyen *et al.* 2009).

The tourism industry (hotels, restaurants, bars) and associated amenities (recreational centres, shops) are also a major source of marine litter. Inadequate planning of tourist developments can also generate marine litter, for example through the release of sewage, solid waste and wastewater to beaches and coastal environments in Sri Lanka (UNEP 2009). In certain areas, the number of inhabitants surges in summer months, placing a strain on local waste management infrastructure capacities and leading to an increase in litter generation, for example in the Balearic Islands (UNEP, 2009). This is a particular problem in Small Island Developing States (SIDS). Many SIDS are sought-after tourist destinations, but in a number of cases they have poor waste management infrastructure which is not equipped to deal with large influxes of tourist numbers. For example, Thilafushi Island in the Maldives was transformed into an artificial landfill by the Government in 1992. Since then, the island has received large quantities of solid waste and toxic materials, of which a large part is generated from the tourism industry (Thevenon *et al.* 2014). It has been estimated that each tourist produces around 7.2 kg of waste per day which far exceeds the average amount of waste generated by locals living in urban areas (2.8 kg) and rural areas (1.0 kg) (Peterson 2013).

5.3

IMPACTS OF MARINE LITTER ON THE TOURISM SECTOR (COSTS OF INACTION)

The visible presence of marine litter has an impact on the aesthetic value and attractiveness of beaches and shorelines. This visual dis-amenity can undermine some of the benefits associated with coastal environments (e.g. improved physical health, reduced stress and improved concentration – GESAMP 2015) and may be a reason not to visit certain coastal areas – see Box 5.1.

There is also a strong relationship between the visible presence of marine litter and the **attractiveness of marine waters for recreational purposes** (Fanshawe and Everard 2002). For example, damage to marine ecosystems and the presence of marine litter affects recreational activities such as diving and snorkelling, by fouling propellers and jet intakes of recreational boaters (see section 6 on Shipping) and affecting recreational fishers in terms of contamination of catch, restricted catch and damaged gear (see section 4 on Fishing and aquaculture).

In addition to being unsightly and an inconvenience, marine litter can also pose **health risks and safety hazards** to divers, recreational boaters, fishers and other coastal visitors. Industrial items (e.g. discarded chemical drums, batteries and appliances) leach toxic compounds, while medical/personal hygiene items (e.g. disposable diapers and sanitary products) contaminate the water, posing a health risk to swimmers and other users. Sharp items like metal cans, syringes and broken glass can potentially cut coastal visitors (Ocean Conservancy 2010) while smaller items such as cigarette butts could be swallowed by young children. A survey of visitors to Cassino beach in Brazil found that at least 30% of those questioned had been affected by beach litter, mainly through wounds from glass or sharp objects on the beach (Santos *et al.* 2005). Collisions with larger items of marine litter such as semi-submerged shipping containers, or entanglement with marine litter, can injure or even kill recreational sailors and fishers (Newman *et al.* 2015). The

Box 5.1

HOW MARINE LITTER AFFECTS BEACH CHOICE – SOME EXAMPLES

A study of 31 beaches in Orange County, California, USA (Leggett *et al.* 2014) showed that marine litter had a significant impact on residents' beach choices. The study found that a 50% reduction in marine litter at the surveyed beaches could generate USD 67 million in benefits to residents over a three-month period. It also found that reducing marine litter by 75% on six beaches near the outflow of the Los Angeles River would benefit users by USD 5 per trip and increase visitors by 43% leading to USD 53 million in benefits.

In Cape Town, South Africa, a study estimated that the presence of marine litter is a significant deterrent to visitors, with 40% of foreign tourists and 60% of domestic tourists interviewed claiming that this would prevent them from returning to a beach. The study also examined the densities of litter that had a deterrent effect and found that 97% of tourists would not visit a beach with 10 or more large items of litter per metre. These reduced tourist numbers would have a significant impact on the regional economy with losses estimated to be worth billions of South African Rand each year (Balance *et al.* 2000, cited in National Research Council 2009 and in Eftec *et al.* 2012).

A survey of tourists in Barbados examined the relationship between the quality and cleanliness of beaches and the probability of return visits. The survey results indicate that the amount of litter seen and tourist perceptions of beach quality are significantly related to the probability of return visits, particularly for first-time visitors. Based on the assessment, the author concludes that beach litter has potential economic costs in terms of adverse effects on the probability of tourists returning to a particular destination (Schuhmann 2011)

risk of such collisions could have a significant deterrent effect on recreational users accessing certain waters. For example, Guanabara Bay, Brazil hosted various sailing and water sport events in the 2016 Summer Olympics, but significant marine litter and poor water quality in the Bay has attracted much media attention and led the International Sailing Federation to threaten to move maritime events to the Atlantic Ocean if the problem is not addressed (BBC 2015).

Marine litter can thus discourage visitors from going to certain beaches. Reduced numbers of coastal visitors leads to lost revenues for the tourism sector, which in turn leads to a **loss of revenue and jobs** in the local and regional economy. This can have short-term (e.g. where a specific natural incident such as a flood or tsunami washes up marine litter) and/or long-term impacts (e.g. where consistent levels of marine litter damages the reputation and image of the area as a tourist destination thus discouraging private sector investment in new tourist developments) (McIlgorm *et al.* 2011). These impacts can be quite significant in certain cases, particularly where local economies are heavily dependent on the tourism sector. For example, Hawaii and the Maldives are facing declines in tourist numbers and associated revenues due to marine litter, particularly plastics that threaten to affect the reputation of islands as sought-after tourist destinations (Thevenon *et al.* 2014). Some studies provide quantitative estimates of the costs to the tourism sector of marine litter – see Box 5.2 for some examples.

5.4

COST OF ACTION TO ADDRESS THE PROBLEMS

Addressing marine litter in the tourism sector requires both preventative and responsive measures, which incur associated costs and responsibilities borne by different actors. The costs of **clean-up activities** associated with littering by coastal visitors can sometimes fall on local actors such as municipalities or private actors such as beach managers and hotel

Box 5.2

ESTIMATED COSTS OF MARINE LITTER TO THE TOURISM SECTOR – SOME EXAMPLES

A period of heavy rainfall which led to marine litter washing up on the beaches of Goeje Island (South Korea) is estimated to have led to between USD 27.7 and 35.1 million (KRW 29,217–36,984 million) of lost revenue in 2011 as a result of over 500,000 fewer visitors. The lost revenue per visitor was estimated to be USD 66 (Jang *et al.* 2014).

Damage by marine litter to the tourism sector in the Asia-Pacific Economic Cooperation (APEC) region has been estimated at USD 622 million (McIlgorm 2009).

~~It has been~~ estimated that the presence of beach litter on the Skagerrak coast of Bohuslan (Sweden) decreases tourism by between 1 and 5%, equating to an estimated annual loss of approximately USD 22.5 million (GBP 15 million) and 150 man-years of work to the local community. Local clean-up efforts are estimated to cost approximately USD 1.4 million (GBP 937,000) per annum. Thus, the total cost to the local economy is USD 24 million (GBP 16 million) per year (Fanshawe and Everard 2002).

Van der Meulen *et al.* (2014) estimated that annual costs to the tourism sector in certain sample regions of the UK could range from USD 2.27 million (GBP 1.38 million) to almost USD 823 million (GBP 500 million) in the 2010-2100 period. The study identifies Devon (south-west, Celtic Sea/English Channel) and Norfolk (south-east, North Sea) as relatively vulnerable regions. Total regional beach cleaning costs are projected to be in a range between USD 188,735 and USD 2.5 million (GBP 114,700 and GBP 1.5 million) per year.

Table 5.1 Estimated clean-up and management costs of marine litter – some examples

Country / Region	Estimated cost at national and municipality level	Source
APEC region	USD 1,500/tonne of marine litter in 2007 terms	(McIlgorm 2009)
Bay of Biscay and Iberian coas	A Spanish council with 30 beaches (5 Blue Flags) spends around USD 111,000/year (EUR 80,000/year) on beach cleaning. A French council with 30 beaches (5 Blue Flags) spends around USD 556,000/year (EUR 400,000/year) on 'beach caring' (including beach clearing, monitoring of buoys, coastguards etc.), of which around 20% (USD 111,000 (EUR 80,000)) relates to beach clearing. In Landes, the cost of cleaning up 108km of sandy beaches was USD 11 million (EUR 8 million) between 1998 and 2005. Cost of beach cleaning between USD 6,250-69,460/year/council (EUR 4,500-50,000/year/council) corresponding to average cost of USD 9,000/km (EUR 6,500/km) of cleaned beach/year.	OSPAR 2009
Belgium	USD 13.8 million (EUR 10.4 million) (ave. USD 264,885/municipality/year (EUR 200,000/municipality/ year)	Mouat et al. 2010
Netherlands	USD 13.8 million (EUR 10.4 million) (ave. USD 264,885/municipality/year (EUR 200,000/municipality/ year)) Costs are higher for areas with high visitor numbers; for example Den Haag Municipality spends USD 1.43 million/year (EUR 1,265,500/year) with costs for processing litter (including transport) of about USD 229/tonne (EUR 165/tonne).	Mouat et al. 2010
Oregon, California, Washington (USA)	Annual combined expenditure of USD 520 million (USD 13/resident/year) to combat litter and curtail potential marine litter	Stickel et al. 2012
Peru	USD 2.5 million in labour costs (ave. USD 400,000/year in Ventanillas municipality)	Alfaro 2006 cited in UNEP 2009
Poland	Beach cleaning and removing litter from harbour waters cost USD 792,000 (EUR 570,000) in 2006 (same amount also spent in five communes and two ports).	(UNEP 2009)
UK	USD 24 million (EUR 18 million) (ave. USD 193,365/municipality/ year (EUR 146,000/municipality/ year) (per km cleaning costs range from USD 226-108,600/km/year (EUR 171-82,000/km/ year)). Specific municipality costs: ▪ Suffolk: approx. USD 93,500/year (GBP 60,000/year) on 40km of beaches ▪ Carrick District Council (Devon): approx. USD 56,000/year (GBP 32,000/year) on 5km of beaches. ▪ Studland (Dorset): USD 54,000/year (GBP 36,000/year) to collect 12-13 tonnes of litter each week in the summer along 6km of beaches. ▪ Kent coastline: direct and indirect cost of litter estimated at over USD 17 million/year (GBP 11 million/year). Annual expenditure on beach cleaning in 56 local authorities ranged from USD 23/km (GBP 15/km) in West Dunbartonshire to USD 78,000/km (GBP 50,000/km) in Wyre.	Mouat et al. 2010; Fanshawe and Everard 2002; OSPAR 2009

personnel. Given the importance of the tourism sector in many economies, there is a strong incentive to both public and private actors to ensure that beaches and marine environments are kept clean (McIlgorm 2009).

Clean-up costs can be significant (see Table 5.1) and in some cases can pose an undue burden on local authorities. For example, the estimated coastline clean-up cost for the Ventanillas municipality in Peru is double the annual budget of the municipality for all public cleaning (Alfaro, 2006 cited in UNEP 2009). Revenues from taxes applied on the tourism sector and other recreational users of coastal areas (e.g. car park charges near beaches, fees for recreational fishers) can contribute to funding coastal clean-up, waste collection and treatment, helping to alleviate pressure on local authority budgets. Tourists' willingness to pay such taxes depends on several factors including the age and income of tourists, and whether there is a link between the tax and litter control (Oosterhuis *et al.* 2014).

For most municipalities, the potential impact of marine litter on tourism is the main motivation for removing beach litter, often providing a more powerful incentive for action than legislation (Mouat *et al.* 2010). For example, the tourist trade in Weston-Super-Mare in Somerset (UK) is worth USD 22 million (GBP 14 million) per annum to the local economy. Given the importance of the recreational quality of beaches to the sector, Weston Beach is mechanically raked and swept once or twice daily in the summer and hand-picked in the winter at an annual cost of USD 149,875 (GBP 100,000) (Acland 1995 cited in Fanshawe and Everard 2002). In some cases, clean-up activities are motivated by the need to uphold certain certification standards, voluntary eco-labels and awards – see Box 5.3. At the same time, certain clean-up activities can have a negative environmental impact, e.g. mechanical beach cleaning can disturb nesting areas or remove components of the marine ecosystem food chain (SAS 2014) and thus require careful management.

Box 5.3

ECO-LABELS AND CERTIFICATION PROGRAMMES TO SUPPORT PREVENTION AND CLEAN-UP ACTIVITIES

The Blue Flag Programme is a voluntary eco-label scheme which sets standards in terms of water quality, environmental management, information provision, safety and services. The need to maintain Blue Flag status has been an important factor motivating clean-up efforts in countries across the world. A survey in the UK found that 46% of municipalities removed marine litter to ensure that beaches in their area meet the criteria for the Blue Flag Awards (Mouat *et al.* 2009). The potential impact of microplastics on bathing water quality and potential reputational risk to Blue Flag beaches was calculated in Van der Meulen *et al.* (2014) to cost between 0.09 and 3.4% of tourism revenues in selected coastal regions in the UK with a business-as-usual tourism revenue of USD 24.27 billion (GBP 14.75 billion) per year.

Some municipalities undertake beach clean-up activities to pursue different awards such as Quality Coast Awards, the Green Coast Awards and the Seaside Awards, which are relevant for smaller, less busy coastal resorts. For example, in Ireland, the Green Coast Award is given to beaches with a beach management plan and community engagement to meet standards in the EU Bathing Water Directive, but which do not have the built infrastructure to achieve Blue Flag status.

In Costa Rica, the Blue Flag Ecological Program (Bandera Azul Ecológica) engages coastal communities in protection, clean-up and maintenance efforts. The award is granted annually based on performance against certain criteria covering water quality, waste management, facilities, safety and environmental education, with monthly monitoring to ensure continued maintenance.

There are also a number of **preventative measures** which can help to address marine litter from the tourism sector – some examples are set out in Table 5.2.

Table 5.2 **Preventative measures in the tourism sector to address marine litter**

Type of measure	Real-world example
Biodegradability requirements for recreational fishing gear and accessories	Recreational fishing traps in **Canada** require the section secured by the cord to rot where traps are lost, to prevent ghost fishing (Macfadyen *et al.* 2009). In Queensland, **Australia** a biodegradable baiting bag has been developed for recreational fishers (Macfadyen *et al.* 2009).
Bans	**Smoking bans on beaches** have been introduced by around 100 local governments in the **US**, including the first ban in Hanauma Bay Beach, Hawaii in 1993, and other municipalities in California, Hawaii, Iowa, Illinois, Massachusetts, Maine, Michigan, Minnesota, New Hampshire, New Jersey, New York, Oregon, Rhode Island, South Carolina, Utah and Washington. The state of Maine and Commonwealth of Puerto Rico have also adopted laws prohibiting smoking on beaches. Beyond the US, bans have been adopted in North Vancouver (Canada), Bournemouth (UK), Damp (Germany) and Atami, Shirahama and Kanagawa (Japan) (Ariza and Leatherman 2012). In 2012, **Hawaii** introduced a state-wide **ban on plastic bags** implemented over three years. Several cities and counties in California, Oregon and Washington have implemented plastic bag ordinances (Stickel *et al.* 2012). Bans on certain types of single-use plastic bags have been introduced in many countries worldwide to varying degrees of effectiveness, for example in Bangladesh, Rwanda, India, Italy and Kenya. A study on the cost of banning plastic bags in Los Angeles County concluded that the ban would cost USD 5.72 per capita (AECOM 2010).
Pier-side reception facilities	In several **US** states, pier-side reception facilities are provided for safe disposal of monofilament line by recreational fishers. Collected fishing gear is subsequently recycled (Macfadyen *et al.* 2009). The **'Seabin'** collector of floating waste can be fixed to a pontoon and is immersed in the water. It is connected to an electric pump which creates a flow to attract floating waste and hydrocarbons to the collector; the wastes are collected in a natural-fibre bag which can be emptied periodically by maintenance personnel then replaced in the Seabin. Active marketing of Seabin will begin by the end of 2016 (Seabin and Poralu 2016).
Awareness-raising and targeted education campaigns	The Green Blue initiative in the **UK** led by The Royal Yachting Association & The British Marine Federation, raises awareness of marine litter among the **recreational boating community**, providing education, solutions and toolkits. The Special Monitoring and Coastal Environmental Assessment Regional Activity Centre of the **Northwest Pacific Action Plan** (NOWPAP CEARAC) developed marine litter **guidelines for tourists and tour operations** in marine and coastal areas which set out best practices for tourists participating in marine recreational activities (e.g. cruising, fishing and diving) and coastal recreational activities (e.g. camping, barbequing and bathing) as well as suggested actions for tour operators to reduce tourist-generated marine litter (NOWPAP CEARAC 2011). The Travel Corporation (an international travel group with a number of established brands such as Contiki Tours) established **The TreadRight Foundation** to encourage sustainable tourism within its family of brands. The Foundation supports several projects around the world including a partnership between Contiki's conservation program - Contiki Cares - and Surfrider Foundation **Australia** which sponsors a number of coastal beach clean-ups and awareness raising activities. TreadRight has supported the production and distribution of a documentary - 'Scars of Freedom' – which chronicles a whale's fight for life off the coast of Chile's Juan Fernandez Archipelago after getting caught in drift net.

Preventative measures in the tourism sector to address marine litter Table 5.2 *(cont.)*

Type of measure	Real-world example
Sustainable tourism initiatives	Members of The Caribbean Hotel Association (CHA) established **The Caribbean Alliance for Sustainable Tourism** (CAST) which aims to promote responsible environmental and social management within the hotel and tourism sector. CAST focuses on the development of sustainable tourism certification and standards, provides guidance and expertise in awareness-raising programs, environmental management systems (EMS) and best practices to support sustainable tourism. **In Barbados, Green Globe Certified Hotels** include Almond Hotel Group, The Bougainvillea, The PomMarine Hotel, The Sand Acres Hotel, The Southern Palms Hotel, The Palm Beach Group. Members of the Green Hotels Association of the US and CAST support local programmes for improved solid waste management in beach areas (UNEP-CAR/RCU 2008). In 1999, the Roteiros de Charme Hotel Association in **Brazil** developed a voluntary **Ethics and Environmental Code of Conduct** in co-operation with UNEP's Tourism Programme which provides a benchmark for biodiversity conservation and the quality of holiday destinations. Implementation of the code has helped to reduce environmental pressures, for example preventing pollution from untreated sewage and contamination of waterways and marine environments, reducing solid waste generation and inappropriate waste disposal practices, strengthening public awareness and protecting biodiversity.
Clean-up activities	In the **UK**, there are several voluntary clean-up initiatives such as Adopt-a-Beach which involves local communities, businesses, schools and individuals in regular beach cleans and surveys, **Beach Watch** which is an annual national beach clean activity and marine litter survey organised by the Marine Conservation Society, and community beach clean-up projects organised by **Surfers Against Sewage**. Some clean-up activities engage recreational users in both collecting litter and providing information. For example a number of initiatives engage scuba divers such as **Neptune's Army of Rubbish Cleaners, the Green Fins project, Dive Against Debris** and **Project AWARE** (a global movement of scuba divers). Travel Trawl loans equipment to recreational sailors to collect samples of plastic litter during their own sailing trips and report back to the Algalita Foundation. A number of hotels and travel operators are involved in beach clean-up activities. For example, in 2014, multinational travel operator the **TUI Group** organised a series of Big Holiday Beach Clean events worldwide to raise awareness about marine litter among tourists and local authorities (TUI Group 2014). The **Berjaya Hotels & Resorts** group in **Malaysia** supports annual clean-up events on various beaches such as the Redang Island Clean-up Day and Tioman Island. The **Conrad Hotel Maldives** supports regular beach clean-up activities with SubAqua Dive Center and supports improved waste management practices including reduced use of plastic water bottles.

A mix of different approaches is likely to be needed to address marine litter from the tourism sector. In some cases, such as tackling ALDFG among recreational fishers, the enforcement of regulations is not considered a cost-effective solution, and education together with improved port reception facilities is seen as a more effective approach (Macfadyen *et al.* 2009). Different measures are likely to attract varying degrees of public and political acceptance. For example, in a survey of beach visitors in Chile, the two most supported solutions to 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 to introduce and their enforcement challenging (i.e. requiring resources and legal capability). However, support could be built through targeted campaigns and may increase over time while enforcement can also rely on other means such as peer pressure. For example, in the US, despite initial polarisation of local communities to smoking bans on beaches (see Table 5.2), subsequent surveys of residents indicate that in general, people support the bans. In some cases (e.g. Sarasota, Florida), peer pressure has played an important role in enforcement of the ban, with some tickets issued by local law enforcement officials (Ariza and Leatherman, 2012).

Box 5.4

CASE STUDY SUMMARY - MARINE LITTER IN HAWAII

Hawaii is particularly prone to the accumulation of marine litter given its location in the North Pacific Subtropical Gyre. A hot spot for marine litter accumulation is the North-Western Hawaiian Islands (NWHI). Marine litter also affects other parts of Hawaii, for example Kamilo Beach on the South-East Coast of the Big Island. The main sources of marine litter are ocean-based, in particular fishing activities. Land-based sources include improper waste disposal practices, tourism and recreational activities such as coastal recreational fishing.

Marine litter is considered an important issue in Hawaii and has attracted significant attention from policy makers, private actors, NGOs, academics and the public. An important motivating factor for action to date has been concerns over the environmental impacts of marine litter, in particular on vulnerable or endangered marine species such as Hawaiian monk seals, which have seen declining population numbers since the mid-1950s, due in part to entanglement with marine litter in the NWHI. Economic impacts include costly clean-up activities, with estimates varying from an average of USD 589/tonne to clean-up marine litter from the coastline (Lamson *et al.*, 2011) to USD 25,000/tonne to remove entangled nets from ships at sea in the NWHI (Wiig, 2005). Other impacts include potential effects on the tourism industry, for example affecting recreational activities such as diving, posing a health and safety risk to coastal visitors, and reducing the attractiveness of certain beaches, thus threatening to undermine Hawaii's reputation as a sought-after tourist destination. Although research on such linkages is limited, impacts could be significant given the importance of tourism to the Hawaiian economy. Marine litter can also affect commercial fishing operations in the North Pacific Ocean, not only posing a safety hazard for crews, but also immobilising or slowing down operations, thus having economic impacts on the industry.

A number of preventative and responsive measures and approaches have been adopted over the years including strategic measures such as the Hawaii Marine Debris Action Plan and pioneering legislative approaches at both State and County level, such as bans on smoking on beaches and on plastic bags. In a number of cases, these efforts have been at the forefront of action by US states. Numerous clean-up, removal efforts and data collection efforts have been undertaken which engage both public and private actors. This includes successful collaborative initiatives such as the Nets to Energy Programme and the Fishing for Energy Programme. The public and civil society have also been very active in initiating clean-up activities, awareness raising campaigns and educational programmes, and contributing to data collection, monitoring and reporting exercises.

Despite progress to date and the adoption of a range of innovative measures targeting marine litter, further action can be considered (e.g. effective preventative measures in third countries). Additional research is needed, including on the socio-economic impacts of marine litter on specific sectors of the economy, particularly tourism and fishing. Such assessments can inform policy discussions and provide a further motivating factor for effective action on marine litter. (See case study in the Annex for a more detailed discussion.)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5.5

CONCLUSIONS ON TOURISM, AESTHETIC VALUE AND RECREATIONAL OPPORTUNITIES

The tourism sector is both significantly affected by marine litter and a major contributor to the problem. The presence of marine litter can discourage visitors from going to certain beaches, thus reducing visitor numbers, which in turn leads to lost revenues and jobs in the tourism industry. These impacts can be quite significant in certain cases, particularly where local economies are heavily dependent on tourism. For example, in Geoje Island, South Korea, the presence of marine litter on the beaches following a period of heavy rainfall is estimated to have led to between USD 27.7 and 35.1 million (KRW 29,217–36,984 million) of lost revenue in 2011 as a result of over 500,000 fewer visitors. The presence of beach litter on the Skagerrak coast of Bohuslan (Sweden) has been estimated to lead to an annual loss of approximately USD 22.5 million (GBP 15 million) and 150 person-years of work to the local community from reduced tourist numbers. In addition to being unsightly and an inconvenience, marine litter can pose health risks and safety hazards to divers, recreational boaters, fishers and other coastal visitors.

The potential impact of marine litter on the tourism sector provides a powerful incentive to both public and private actors to keep beaches and marine environments clean. Responsive measures such as clean-up can have significant associated costs and in some cases can pose an undue financial burden on local authorities (see Table 5.1). However, the potential impact of marine litter on tourism and the need to uphold certain certification standards, voluntary eco-labels and awards provides a powerful incentive for action by municipalities. Some pressure on local authority budgets can be alleviated by sharing clean-up costs with certain private actors (e.g. beach managers, hotels), supported by voluntary efforts by local community groups and NGOs, and using revenues from taxes on the tourism sector to contribute to funding coastal clean-up, waste collection and treatment (see Section 4 on Producer Responsibility and

Consumer Behaviour). Furthermore, given the potential impacts of reduced tourist numbers, a number of private initiatives have been taken by hotels and tour operators such as the Travel Corporation and the TUI Group to increase awareness of marine litter and support beach clean-up initiatives.

It is also important to address tourism and recreational activities as one of the main sources of marine litter. The majority of marine litter is generated from shoreline and recreational activities (Ocean Conservancy 2010) and there is a need for various preventative measures to address the problem at source. Such measures can include regulation (e.g. smoking bans on beaches in a number of US states), market-based instruments (e.g. plastic bag charges or taxes in many countries in Europe, Africa and Asia), infrastructure investments (e.g. pier-side reception facilities for fishing gear in Hawaii, improved waste management practices supported by members of the Roteiros de Charme Hotel Association in Brazil and the Caribbean Alliance for Sustainable Tourism - CAST), product design requirements (e.g. biodegradability requirements on recreational fishing gear in Canada and Australia), and targeted awareness raising and educational activities (e.g. boating safety education classes and fishermen code of conduct in Hawaii).

Assessments of the costs of marine litter on the tourism sector and assessment of impacts of tourism activities on marine litter are limited by a lack of data, information and methodological challenges. Further research is needed on the impacts of marine litter on resident and visitor beach choice and influence on tourists' perceptions of certain areas/countries as attractive holiday destinations (i.e. by acting as a visual dis-amenity, reducing the attractiveness of a country's marine waters for recreational purposes). It will also be important to scrutinise changes in revenues in the tourism sector and the extent to which declines can be attributed to marine litter, estimates of lost tourist revenues (both in the short-term and long-term) and assessment of relative losses between different beach sites (as visitors may travel to another beach with no marine litter) to assess the overall loss of economic value. There is also a need for further information on the costs of prevention and clean-up activities (undertaken by public and private actors, voluntary organisations and local community groups), information on health and safety risks from marine litter (in terms of exposure, accidents and mortality) and associated costs of hospitalisation. An analysis of the role of the tourism industry in fighting and reducing this phenomenon is also needed.

Photo: © US Fish and Wildlife Services

Such assessments can make use of methodologies that have been developed and applied in other fields. This includes, for example, studies which have examined how marine litter affects resident and visitor beach choices (e.g. Leggett *et al.* 2014 and Balance *et al.* 2000) and studies which have examined the impacts of marine litter on tourist numbers and associated revenue losses (e.g. Jang *et al.* 2014; Fanshawe and Everard 2002; Van der Meulen *et al.* 2014). In terms of data requirements, visitor statistics that are regularly collected by the Hawaiian Department of Business, Economic Development and Tourism[30] could be used as a basis to assess trends in visitor numbers, visitor perceptions/satisfaction and how this may be affected by the presence of marine litter on beaches and in surrounding coastal waters. This can be complemented by additional surveys of domestic and international tourists, local authorities and private actors (e.g. hotel owners, beach managers, property developers, shop owners, recreational centres) as well as data gathered on beach characteristics and on the presence and type of marine litter found on beaches, reefs and waters. Such data can inform the design of effective prevention and responsive measures and, given the importance of the tourism sector to the local economy of many countries, can provide a powerful impetus for action.

30 http://dbedt.hawaii.gov/visitor/

6

6. COMMERCIAL SHIPPING

6.1

INTRODUCTION

Commercial shipping, or vessels being used to transport goods or passengers, represents an important sector for the socio-economics of marine litter. Commercial shipping is both a source of marine litter, and is also affected by it. Estimates suggest that shipping is responsible for between 12% (IMO 2012) and 20% (EMSA 2013) of global discharges of waste at sea. However, regional variability and differences in definitions, as well as patchy observations, cause uncertainty in estimates. Complex international, national and regional maritime laws provide a legislative framework which largely forbids the dumping of waste at sea. However, both accidental and deliberate waste dumping continues to drive socio-economic impacts which bring costs upon the sector (Newman *et al.* 2015).

6.2

THE SHIPPING SECTOR AS A SOURCE OF MARINE LITTER

The socio-economic and material development of the shipping industry helps to explain its significant role in driving marine litter. Historically it was common practice to throw waste overboard. However, the globalisation and intensification of shipping traffic[31], coupled with the increasingly inorganic and plastic content of waste being generated[32], have increased both the potential for waste to accumulate in the marine biosphere and the risks associated with the impacts of marine litter (van Franeker *et al.* 2014; EMSA 2013). Hence, whilst commercial shipping is a cornerstone of global economic development, with around 90% of world trade carried out by the shipping industry (ICS 2015), it is also a sector that has the potential to threaten the marine biosphere. Potential risks are already well documented for oil and chemical spills, and now the risks associated with solid waste including plastics are increasingly being identified. Many studies argue that legislation is widely ignored and several million tonnes of plastic enter the oceans from ships each year (Derraik 2002; Sherrington *et al.* 2014).

For shipping operators, discharging waste is advantageous because of the operational costs which can be saved, and the competitive advantage this may provide over compliant operators (EMSA 2009). An OECD estimate suggests compliance with international environmental regulations accounts for around 3.5% of a ship's operating costs (OECD 2003).

Ship construction and recycling represent a further potential source of marine litter, with modern practices generating potentially large amounts of microplastics. At shipyards and offshore sites shot-blasting (with plastic pellets) is often used to remove paints from ship hulls. Similarly, hull coatings applied in shipyards are often polymer-based, such as epoxy. One study in Norway suggested that around 700 tonnes of microplastic particles entered the sea from Norwegian professional and recreational boatyards each year (Miljødirektoratet 2014), although such emissions are very difficult to estimate (OECD 2009).

6.3

MARPOL, MARITIME LAW AND LEGISLATION

Maritime Law, particularly the MARPOL Convention[33] and a number of additional international, national and regional laws, provides the legislative framework for reducing the deposit of marine litter from vessels at sea. As well as stipulating what waste can be disposed of at sea, legislation also provides further guidance, standards on procedures and infrastructure requirements relevant to the management of waste at sea. The maritime sector is somewhat unique in the amount of existing legislation covering marine litter; nevertheless, the persistent flow of waste from this sector into the oceans reflects a clear lack of comprehensive regulations or effective enforcement (Gold

31 World container port throughput exceeded 650 million TEUs (20-foot equivalent units) in 2013 for the first time (UNCTAD 2014).

32 Global plastic production was 288 million tonnes in 2012; this is a result of year on year growth of around 8.7% since 1950 (Plastics Europe 2013).

33 MARPOL 73/78: International Convention for the Prevention of Pollution from Ships.

Box 6.1

et al. 2013).

MARINE LITTER FROM CRUISE SHIPS

The emergence of consumer orientated shipping activities in the cruise line industry presents an important source of marine waste. Cruise ships are unique due to the number of passengers on each ship, the waste they can generate and the resultant strain they can place on port reception facilities (National Research Council (NRC) 1995; Wade 1997). Estimates suggest that a cruise ship typically generates up to 70 times as much waste as a cargo vessel; a large vessel of 2,500 passengers and 800 crew can generate 1 tonne of waste from normal daily operations (EPA 2008).

In 2015, an estimated 23 million passengers were expected to take a cruise, with a total global economic output of USD 117 billion (CLIA 2015).

Cruise ships represent less than 1% of the global merchant fleet, but are arguably responsible for a disproportionate share of marine litter discharge. Some estimates suggest cruise ships account for 25% of solid waste generated by merchant vessels (Butt 2007).

Coastal areas close to the busiest cruise destinations, such as Miami and Alaska (US), Nassau (Bahamas), and Cozumel (Mexico), are also likely to experience high concentrations of marine litter associated with discharges of litter from the cruise sector (Brida & Zapata 2010). Common types of litter generated on board are comparable to domestic waste, including glass, paper, cardboard, aluminium cans and plastics (Brida & Zapata 2010). The persistent expansion of the cruise sector to new markets and locations, particularly in Asia, will equally result in new nuclei of waste production and demands for maritime waste infrastructure (CLIA 2014).

In the Caribbean, where the cruise sector is already established, the waste generated by cruise ships has placed ports under stress, and created tension between island authorities and cruise line operators, and furthermore with neighbouring islands as they compete for traffic. For some small Caribbean islands, cruises represent more than 50% of tourist arrivals and consequently an important (or even primary) source of revenue for local populations (Brida & Zapata 2010). Several attempts at raising passenger head taxes by the Organisation of Eastern Caribbean States (OECS) and the Caribbean Community (CARICOM) to cover the costs of infrastructure, including for managing waste, have been unsuccessful. Cruise operators have removed ports from their routes when local authorities have failed to cooperate with their demands (Chin 2008). For instance, in 1999 Carnival Cruise Lines boycotted Grenada after they introduced a USD 1.50 per passenger tax to fund a World Bank constructed sanitary landfill for the island (Klein 2002). The financial influence of some cruise operators, coupled with their demand for resources and infrastructure, gives them a unique responsibility over the

Box 6.2

FLAG STATES AND FLAGS OF CONVENIENCE

The extent to which a ship is covered by maritime law is determined by the location of the vessel, its flag state, and the class society it belongs to. The geographical and legislative heterogeneity of maritime law means that the extent to which vessels must follow regulations on dumping litter at sea can be patchy and complex.

The practice of using ‘flags of convenience’ further confuses how international maritime law can be implemented and is relevant to the management of marine litter from this sector (Surfrider Foundation 2013). A ship is using a flag of convenience if it is legally registered in a state different to the ship owner’s origin, and hence operates with the ensign of that country. In doing so, commercial shipping operators are able to avoid paying taxes and adhering to the more stringent regulations of their own country, for example by choosing states which have not ratified IMO conventions, including MARPOL.

The fact that Panama, followed by Liberia, have the largest fleets in the world by flag of registration indicates the widespread nature of the practice of flying flags of convenience (UNCTAD 2014). In practice, all of the most popular flags of convenience states have ratified MARPOL, yet the capabilities of a country such as Panama to enforce MARPOL V across a vast fleet are clearly limited (Birnie *et al.* 2009).

waste they generate.

Box 6.3

COMPENSATION FOR CONTAINER LOSS IN THE MONTEREY BAY NATIONAL MARINE SANCTUARY

On 24 February 2004, 15 cargo containers fell overboard from the M/V Med Taipei following a storm in the Monterey Bay National Marine Sanctuary (MBNMS). Although one container with a cargo of 1,159 steel belted car tyres was recovered using deep ocean surveys, the location of the remaining 14 remains unknown. In 2005, NOAA's Damage Assessment Centre (DAC) assessed the likely environmental impacts of the container loss. With this assessment and associated legal fees and costs, the shipping company paid USD 3.25 million in compensation to the MBNMS (NOAA 2014).

Box 6.4

SHIP COLLISIONS WITH MARINE LITTER AND ASSOCIATED COSTS

- **UK** - In 2008, there were 286 rescues to vessels with fouled propellers in UK waters at a cost of between USD 1.1 million and USD 2.9 million (EUR 830,000 and EUR 2,189,000) (Mouat *et al.* 2010).
- **UK** - Estimates of recovery and disposal of litter in ports and harbours, as well as rescue services in relation to marine litter: USD 9 million (GBP 6 million) (MaLiTT 2002).
- **Korea** – From 1996 to 1998, 9% of all Korean shipping accidents involved marine litter. In one case propeller damage capsized a vessel resulting in 292 deaths (Cho 2005).
- **USA** - In 2005, the coastguard reported that collisions with submerged objects caused 269 boating incidents, causing 15 deaths, 116 injuries and USD 2.9 million in property damage (USCG 2005).

Annex V of the MARPOL Convention[34] (IMO 2012) contains regulations for the prevention of pollution by ship-generated waste. The revised version of the Convention entered into force on 1 January 2013, and prohibits the discharge of all types of waste, including plastics, except for some strictly defined types of food and cleaning waste (IMO 2012). Additional international legislation relevant to this sector includes the London Convention (IMO 1972) and Protocol (IMO 2006), the Basel Convention (UNEP 2014), the United Nations Convention on the Law of the Sea[35] (UNCLOS 1982) and Goal B of the Honolulu Strategy[36] (NOAA & UNEP 2011).

Additional conventions, laws and codes of conduct also exist across various governance levels to support good practice in managing waste at sea. In some cases, these exist to enforce international maritime law, such as a number of conventions under UNEP's Regional Sea Programmes[37] (UNEP 2015) or legislation on ports[38] and shipping[39] in Jamaica which are increasingly attuned to marine litter issues (GOJ 2014). In addition, they may provide further guidance or more stringent requirements, such as the EU's Directive on port reception facilities for ship-generated waste and cargo residues (2000/59/EC).

Box 6.5

VESSEL POLLUTION PROGRAM AND THE US DEPARTMENT OF JUSTICE

The USA Department of Justice's Environment and Natural Resources Division (ENRD) has been running a Vessel Pollution Program which targets vessels in breach of the MARPOL Convention. The program relies on information provided by the US Coast Guard and whistle-blowers to bring to court shipping operators who 'illegally discharge pollutants from ships into the oceans, coastal waters and inland waterways'.

The initiative has resulted in multiple criminal proceedings across different maritime sectors including cruise ships, container ships, tank vessels and bulk cargo vessels. It was reported that in 10 years, criminal penalties exceeded USD 200 million, and ship officers and executives faced a total of 17 prison years (DOJ ENRD 2013). The initiative has been particularly controversial because under the Act to Prevent Pollution from Ships, those providing information which leads to criminal proceedings are entitled to up to half of the court fines (U.S. Congress 2000).

Most of the cases brought to court relate to dumping of oily wastewater and sludge, or the incorrect use of Oil Record Books (ORBs). However, some relate to marine litter and the dumping of solid waste. For example in April 2004 the US Coast Guard observed and recorded the crew from the vessel SunCruz VI, which operated twice-daily gambling voyages to nowhere, dumping garbage bags overboard close to Fort Lauderdale (Cruise Junkie 2013).

In 2012, John Cruden, now Assistant Attorney General for the ENRD, commented that there were an increasing number of cases being reported and that he suspected the Coast Guard was only being alerted to part of the criminal behaviour (Greene 2014).

36 See under *"Goal B: Reduced amount and impact of sea-based sources of marine debris, including solid waste; lost cargo; abandoned, lost, or otherwise discarded fishing gear (ALDFG); and abandoned vessels, introduced into the sea"*, Strategies: B1, B2, B3, B5 and B6.

mea Convention); and North-East Atlantic (OSPAR Convention).

38 Port Authority of Jamaica Bill (GOJ 2014).

39 Shipping (Pollution Prevention, Response, Liability and Compensation) Bill (GOJ 2014).

6.4

IMPACTS OF MARINE LITTER ON THE SHIPPING SECTOR (COSTS OF INACTION)

The process of generating, and the presence of, marine litter (including both waste originating and not originating from vessels) bring costs to the commercial shipping sector. The main costs are associated with: the accidental loss of cargos; collisions with marine litter; and indirect costs relating to operational costs, disruption of service, and public image. Clean-up costs in harbours may also indirectly fall on the shipping sector. One estimate placed the total value of litter damage to shipping at USD 279 million per year (APEC 2009).

The intensity of shipping traffic outlined above also increases the risk of accidental discharges of material into the sea, for example the loss of shipping containers or the capsizing of ships resulting in the discharge of large volumes of waste. Estimates for total container losses vary massively between 675 and 10,000 per year (World Shipping Council 2014; Frey & DeVogelaere 2014; Vero Marine 2011)[40]. Vessels and containers are most commonly lost at sea during problematic weather conditions when forces, including parametric rolling, place the hulls, stacked containers, and lashings under excessive stress (Surfrider Foundation 2014; Danish Maritime Accident Investigation Board 2014). In some cases infrastructural failures may also be linked to, or exacerbated by, negligence[41] (Surfrider Foundation 2014). Compensation and insurance pay-outs can be substantial when ships lose cargo[42], and the value of the goods in each container represents further costs. Estimates of the average value per container range from USD 24,494 (Baird 2007) to USD 70,000 per TEU (twenty-foot equivalent unit) (Vero Marine 2011), but values can be as high as USD 1.5 million, for example, if a container is full of laptops (Maersk 2012). The dependency of supply chains, services, brand image and economic output on (especially perishable or time dependent) cargos will further multiply costs[43].

Collisions with marine litter can cause significant damage to vessels and even pose a threat to human health. Firstly, lost containers represent a particular hazard to mariners because of their size and ability to float for several weeks[44]. Smaller items of waste at sea can also damage ships, with costs associated with repairing fouled propellers or blocked outages.

High levels of traffic in harbours and ports increase the risk of collision with waste. Consequently many port authorities actively remove marine litter in order to ensure facilities are safe and attractive to users (Mouat *et al.* 2010). One study of the removal of debris from harbours reported costs as high as USD 86,695 (GBP 57,300) in one year for Esbjerg Harbour in Denmark (Hall 2000).

40 One database of reported cargo losses stated that over the last 25 years, 17,000 containers had been reported as lost at sea (Surfrider Foundation 2014).

41 Ageing eroded containers; poorly executed jumboisation; low quality lashing equipment; poorly trained crew; and ships loaded over their declared weight can all exacerbate the risk of container loss.

42 On 17 June 2013 MOL Comfort (Bahamas) lost 4,293 containers, the largest loss in history. Insurance claims exceeded USD 300 million (Surfrider Foundation 2014; World Shipping Council 2014).

43 One estimate suggested that 70% of cargo lost 25% of its value if it was one week late (Maersk 2012).

44 Vero Marine attempted to estimate how long containers lost at sea could stay afloat before they sank: 57 days for a 20-foot container, and 183 days for a 40-foot container.

6.5

CONVICTIONS AND ENFORCEMENT

Enforcement, including fines and compensation payments, linked to maritime law on marine litter bring further costs to the shipping sector. Compared to other areas of MARPOL, fines for marine litter are relatively uncommon. However, there is a history of cases of prosecution, particularly in the USA and Australia[45]. However, the complexity of maritime law and the scale of shipping operations hinder enforcement, and make it difficult to assess the extent of illegal dumping or the rate of conviction.

The effectiveness of maritime law and guidance on marine litter is determined by two main factors: firstly, the extent to which it covers a source of waste from a particular actor or in a geographic region; and secondly, the level of jurisdiction for enforcement that exists over these sources of waste. In practice, whilst the discharge of waste is largely prohibited, there exist many opportunities for opt-outs or exemptions at multiple governance levels.

For example, MARPOL V does not cover the accidental loss of cargo. Likewise, in some jurisdictions, such as the US and the EU, national level exemptions exist for military vessels (Gold *et al.* 2013). The division of maritime space into territorial waters, exclusive economic zones (EEZs) and high seas places real geo-

Box 6.6

graphical limits on enforcement. In high seas, which comprise most of the world's oceans, only flag states have jurisdiction to enforce maritime law. The practice of using flags of convenience constitutes 'shopping' for the lowest level of enforcement (see Box 6.2). Even in EEZs, the strength of legislation to inspect vessels is limited, and the political stakes often outweigh the motivations to do so (Gold *et al.* 2013).

The scale of the oceans and the difficulty of linking items of marine litter to their sources clearly limit enforcement. In the Benguela Current Large Marine Ecosystem (BCLME), Angolan, Namibian and South African maritime authorities reported that although they followed UNEP guidance on marine litter, there were no prosecutions related to marine litter following dumping from ships due to the vast spatial area involved and difficulties of night-time enforcement (BCLME,2006).

To investigate a case, an authority must typically witness a violator or have sufficient evidence to identify them. Solid waste itself is often difficult to link to a specific vessel, and remote sensing and pollution tracking systems such as *CleanSeaNet*[46,47], now commonly used for other pollutants, cannot detect solid waste discharges (EMSA, 2010). In the few cases when authorities choose to prosecute individuals caught for marine litter-related waste infringements, the effectiveness of this tool is further limited by the rate of conviction and the severity of the penalty. Some argue that the size of penalties remains insufficient to act as a deterrent to non-compliance on waste issues (EMSA,2013; OECD 2003).

6.6

MANAGING MARINE LITTER FROM SHIPS

46 CleanSeaNet is the European satellite-based vessel pollution detection system. The system is able to detect oil spills in near real time, and correlation with vessel traffic reports allows for polluting vessels to be identified (EMSA 2015).

47 The European Commission is currently revising its Directive on Port Reception Facilities (PRF). Annex ii of the PRF Directive is likely to require ships to report on waste delivered at the previous port, and could be used to develop a flagging system of ships at risk of dumping (EC 2015; EMSA 2015).

45 In Australia fines typically exceed USD 3,780 (AUD 5,000). *See table* "Prosecutions for ship sourced garbage pollution Commonwealth and State Legislation from 1997" (AMSA 2015).

Box 6.7

There are a number of actions which the shipping sector can carry out both on board vessels and on land in order to adhere to maritime law on waste, manage waste on board ships effectively, and prevent the flow of waste from ships into the marine environment. The effectiveness of waste management both on board and at port reception facilities is largely seen to determine the levels of marine litter originating from commercial vessels (Sherrington *et al.* 2014; Seas At Risk 2011).

Much of the existing legislation, as well as providing guidelines on what waste can or cannot be discarded at sea, also provides guidelines on waste management practices. For example, the MARPOL Convention (IMO 2015) provides guidance and regulations on the implementation of port reception facilities as well as related training and education. It also stipulates how waste should be managed at sea, including the use of placards, waste management plans, record books, incinerators and control of cargo residues (Øhlenschlæger *et al.* 2013).

In addition to legislation, there are a number of voluntary schemes which provide further guidelines on waste management at sea. The International Organisation for Standardisation (ISO) has two standards relevant to MARPOL V, specifically for ships[48] and ports[49]. Similarly, the Blue Angel offers a label for 'environmentally sound' ship operations [50] (RAL gGmbH 2010). Further certification or guidance may be available to specific industries, such as the *Clean Shipping Index* (CSI)[51] for container ships or the role of the trade association Cruise Lines International Association (CLIA)[52] for the cruise industry. There is no obligation for ships or ports to follow these standards, and there may be costs for implementation and certification, but they may also provide competitive advantage. In addition, specific vessel operators may develop strategies to further differentiate themselves in the market or express their commitment to marine environmental stewardship[53,54]. However, some of these certifications and strategies have come under

48 ISO 21070:2011 Management and handling of shipboard garbage (ISO 2011).

49 ISO 16304:2013 Arrangement and management of port waste reception facilities (ISO 2013).

50 Requirements 3.3.5 Waste Disposal; 3.3.6 Waste Incineration; and 3.3.16 Environmentally Sound Recycling all refer to waste management on ships. In addition to the guidelines included in MARPOL, they recommend actions such as purchasing strategies which aim towards avoiding waste.

51 The CSI provides a tool for cargo operators to calculate and minimise the carbon footprint of their vessels. One of the environmental parameters of the CSI relates to waste control, although it is not apparent that its requirements go beyond those laid out in MARPOL V.

52 Membership to the CLIA.

53 e.g. MATSON Navigation, a shipping operator in the Pacific Ocean, has a Zero Waste Policy, including a number of further waste-related projects. This involved an initial investment of USD 224,000 to include a container designed for storing waste on board each of their vessels (MATSON 2014).

54 e.g. Royal Caribbean Cruises has published a number of reports reporting on their commitment to environmental stewardship, including indicators on waste to landfill, recycling etc. (Royal Caribbean Cruises Ltd. 2014).

criticism for not being more ambitious than the minimum requirements of maritime law (Sherrington *et al.* 2014), and in addition the parity between certification and practice is not guaranteed (Klein 2011).

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 (Newman *et al.* 2015). 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 (Øhlenschlæger *et al.* 2013). MARPOL V requires the provision of facilities for the reception of ship generated residues and litter (IMO 2012). The IMO has also published a Comprehensive Manual on Port Reception Facilities (IMO 1999), giving guidance on waste management strategies, types of waste, collecting and treating waste, financing and cost recovery. Since 2006 the IMO has also integrated a port reception facility module, the Port Reception Facility Database (PRFD), into its Global Integrated Shipping Information System (GISIS) (IMO 2015).

CASE STUDY SUMMARY - PORT REFORM AND PORT RECEPTION FACILITIES IN NIGERIA

Nigeria is Africa's largest economy and most populous country. Large urban coastal populations and a high level of shipping traffic mean that without effective waste management, Nigeria could be acutely affected by marine litter. Recent estimates suggest that Nigeria ranked ninth globally for its potential contribution to global marine litter levels (Jambeck *et al.* 2015).

In Nigeria, port reforms since 2000 have resulted in significant public private investments in port infrastructures. The Nigerian Government has supported reforms by reviewing shipping legislation. Today, the MARPOL Convention and other international maritime laws have entered into national law, and the Nigerian Maritime Administration and Safety Agency (NIMASA) acts as a regulatory authority.

Since 2000, the private waste management agency African Circle Pollution Management Ltd. (ACPML) has had a 20 year contract for operating port reception facilities in Nigeria's six largest ports. This includes Apapa – Lagos, the largest port by throughput in West Africa. By 2012, they had invested an estimated USD 70 million in shipping waste management infrastructure (Obi 2009).

At Nigerian ports, in addition to harbour dues, vessels are charged an indirect fee which covers the costs of using port reception facilities. Vessels are charged on the basis of the size of the vessel or its cargo, and then again for the vehicle to transport the waste. Vessels are charged USD 0.12 per tonne of cargo, or USD 4.45 per TEU, and USD 2.76 per vehicle used to transport the waste (NIMASA 2015; NPA 2015). At ports in Lagos (Apapa and Tin Can Island) it is estimated that 20 tonnes of waste are collected from vessels monthly (NIMASA 2015). NIMASA support ACPML by enforcing compliance with legislation on ship-generated waste. This includes regular patrols of waterways and inspections of ships (NIMASA 2015).

NO SPECIAL FEE IN THE HELCOM REGION

Following high levels of illegal waste discharges in the Baltic Sea during the 1990s, HELCOM (the 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 *et al.* 2013). In these cases, the port fee includes 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 USD 0.18-0.82 (EUR 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 *et al.* 2013; HELCOM 2012; Seas At Risk 2011). However, the system remains complex as its application is inconsistent between ports, and despite attempts at harmonisation a number of exemptions exist.

7

The percentage of ships covered by the system can vary between 2 and 100% from port to port (Arcadis 2013).

Using port reception facilities to dispose of waste generally includes a fee for the service. The price is often determined by several variables such as the size of the ship, the volume of waste, and the type of waste. In some cases, reductions may be offered for ships with better developed waste management strategies (EMSA 2005). For instance, at the Port of Rotterdam vessels pay between USD 299 and USD 418 (EUR 225 and EUR 315) for handling 6m^3 of waste, dependent on their main engine capacity (MEC) (Port of Rotterdam 2014). In some ports, the costs of waste disposal can act as a barrier to their use and may incentivise dumping.

There is potential for ship-based solutions to complement national waste management systems. For example, the Lindenau Waste-Recycling-Ship-System (WRS) is converting merchant ships with German state-of-the-art waste processing technology to create mobile, ship-based waste management systems. A feasibility study in the Cabo Verde islands, financed through a public-private partnership scheme, suggests that this option may be particularly valid for island nations. The waste can be systematically collected from each of the island ports by the waste collection ship and delivered to the country's main port where all waste is transferred to a further two moored ships with facilities to recycle and process the waste (both waste to energy (WTE) and material recovery) (Lindenau 2016).

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 for employees, following leverage from the Dutch Government and the ProSea Foundation on the IMO to amend the International Convention on Standards of Training (STWC) (ProSea 2011). Such training, as well as the enforcement of good practices, will also be associated with a number of costs, which should also be included in a more thorough socio-economic assessment.

Strategies for commercial vessels to collect waste or even engage in clean-ups may also be considered, although are yet to proceed beyond prototype experiments[55]. Similarly, opportunities for finding secondary markets for waste may also offer opportunities for recovering the costs of effective waste management, although this is yet to be explored in any detail in the shipping sector[56],[57].

6.7

CONCLUSIONS ON SHIPPING

The socio-economics of marine litter for commercial shipping can be understood to reflect the scale of the industry and its determination to minimise operational costs. However, the costs associated with marine litter suggest that the sector should make further efforts to reduce its impact on the marine environment through this form of pollution. The intensity and coverage of global shipping activities means that the once common practice of throwing waste overboard presents a real threat to the marine environment. Indeed, data on ship-originated litter suggest that the shipping sector continues to contribute significantly to global levels of marine litter. The main results in this section can be summarised as follows.

Maritime Law effectively bans the dumping of litter at sea, and provides guidance on strategies to avoid waste entering the marine biosphere. However, the geographical scale of the oceans and the use of flags of convenience mean that for much of the globe, maritime law and flag states have inadequate resources to support enforcement. In territorial waters, where enforcement efforts are more concentrated, examples of convictions further suggest that the dumping of waste is still practiced.

55 The creation of the world's largest solar boat and the first to circumnavigate the globe, the MS Tûranor, represents one example of efforts to explore how ships could engage in clean-up operations (Lombardo 2013).

56 The Port of Rotterdam is exploring how circular economy approaches could be applied to logistics, including transforming plastic back into oil (Port of Rotterdam 2014).

57 Maersk Line has adopted a cradle-to-cradle approach to managing the recycling of its decommissioned boats (Maersk 2014).

Table 7.1 *(cont.)* **Measures in the marine litter management hierarchy and associated costs – selected examples**

Better awareness of the costs of marine litter to the shipping sector could help support improved waste management practices. Costs are associated with loss of cargo, collisions with waste, and legal action against illegal dumping. Due to the dependency of global supply chains on logistics from shipping, the costs from any disruption to services can be considerable. Further data on how such costs can accumulate could support the development of an agenda for marine litter in the shipping sector.

The shipping sector should be responsible for developing both sufficient waste management infrastructures on board vessels and at port reception facilities, which are the main tools for preventing marine litter at source. This could help to avoid the negative impacts on the sector, as well as on wider economic sectors and the environment. The cruise industry, because of its disproportionate share of waste production, has a unique responsibility in this respect.

Going beyond simply following the minimum level of maritime law, for example by gaining additional certification and training of workers, could help to give shipping operators competitive advantage over more lax enterprises. Some actors are already starting to do this, but rhetoric must be followed up with best practice.

Additional studies on best practice and the effectiveness of various strategies and instruments both at port and at sea could support improvements in these areas. Similarly, more transparency[58] is needed between operators on the costs of waste management. Thus far, studies have largely focused on shipping in developed countries; however, rapid growth in communications globally means that any dialogue on these issues must be inclusive and look beyond the usual suspects.

58 In writing this report several shipping operators were approached for data on the costs of waste management, but none were willing to share this information as it was seen to be competitively sensitive.

7. CONCLUSIONS AND RECOMMENDATIONS FOR ACTION

7.1

MAIN CONCLUSIONS

Marine litter is an increasing threat to the international community and there is a growing body of evidence on costs related both to inaction (i.e. not addressing the issue and impacts of marine litter) and action (i.e. addressing the issue), although there remain considerable gaps in the knowledge. This study has looked at the socio-economic aspects of several specific sectors, namely producers and consumers, waste and wastewater management, fishing and aquaculture, tourism, and shipping. Some of these sectors, such as fishing and aquaculture, tourism and shipping, are both sources of marine litter and suffer from its impacts (see Table 8.3 and discussions further below). In other cases, some sectors that are responsible for the generation of marine litter are not directly burdened by the problem, for example certain producers, consumers (e.g. cosmetics, retail, packaging etc.) and the waste management sector (e.g. through poor infrastructure or practices). Since these sectors do not incur direct costs from inaction on marine litter, they often do not have an inadequate incentive to take action, even though they could significantly contribute to the prevention or reduction of marine litter. The costs and impacts of marine litter may also 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.

The potential and actual **costs of inaction** are both environmental and socio-economic. Ecological impacts include ingestion by and entanglement of species, the facilitation of the spread of invasive (alien) species and bacteria, exposure to chemicals via leachates, and associated knock-on impacts on species and ecosystems. Impacts related to **fishing and aquaculture** include ghost fishing and associated loss of catch due to discarded and abandoned gear, damage to and repair of fishing vessels resulting from entanglement, potential health and safety risks due to collision with larger items of litter, and potential loss of value of sales for certain types of seafood and fish, if consumers become more aware of possible health impacts. **Tourism**-related impacts include reduction in the aesthetic value of areas and associated decreases in visitor numbers, revenues and jobs, health hazards and safety risks from litter, loss of well-being from recreation activities that can no longer be undertaken or enjoyed, and clean-up costs for public authorities and private actors (e.g. hotels). Impacts on the **shipping** sector include damage to ships (e.g. propulsion equipment, hulls) and associated repair costs, disruption to operations, safety risks and related costs of rescue, and in severe cases potential injury or loss of life.

Actions to address marine litter can take many forms and be undertaken at various stages of the marine litter hierarchy proposed in Figure 3.1 in section 3.2, with highly variable associated costs.

The **cost of actions** ranges from those with zero cost (e.g. not littering, avoiding single use everyday items such as cups, bottles), through low cost options (e.g. litter traps, provision of simple waste infrastructure on beaches, volunteer-led clean-up initiatives), more substantive costs (e.g. beach clean-up by municipalities), and high costs (e.g. investments in new waste infrastructures, fishing for litter, cleaning up of waterways). A number of these actions can lead to job creation, either on a large scale (e.g. in the plastic recycling sector, which is growing in many countries across the world) or on a smaller scale (e.g. through local waste collection and recycling/upcycling projects) (see Table 7.1 below). The development of new recycled plastic products, or products created from collected marine litter, can support the development of a circular economy as well as creating value from marine litter (see Table 7.2 below).

Sectors and activities as sources of marine litter, impacted by marine litter and examples of opportunities for action – illustrative summary — Table 7.3 *(cont.)*

Measures in the marine litter management hierarchy and associated costs – selected examples — Table 7.1

Examples of measures and their costs (action)		Costs if measures not applied (inaction)
Prevent/reduce generation of waste that contributes to the marine litter	Application of charges for single-use products: ▪ **USD 0.25** (EUR 0.22) levy on retail plastic bags in Ireland; ▪ **USD 0.09** (AUD 0.10) refundable deposit on beverage containers in South Australia; ▪ **USD 0.09** (AUD 0.10) deposit on candy wrappers at Boronia West Primary School in Victoria, Australia. ▪ **USD 4.08/kg** (EUR 3.6/kg) tax applied to disposable plastic tableware in Belgium. Participation in extended producer responsibility schemes for packaging: Cost to producers of between **USD 1.3 to USD 26.5** (EUR 1 to EUR 20) **per capita per year**.	**Overall:** Estimated cost of environmental damage to marine ecosystems caused by plastics of **USD 13 billion per year** (incl. financial losses to fisheries and tourism and time spent on clean-up). **Fishing:** Total cost of marine litter for the EU fishing fleet: USD 81.7 (EUR 61.7 million) **per year**. Costs to fishing sector related to marine litter: **USD 35 million** (GBP 23.4 million) **per year** in the UK; cost to aquaculture sector: **USD 475,000** (GBP 316,800) for cage clearance and **USD 890,000** (GBP 594,000) for fouled propellers and intakes per year in UK. Loss to the UK aquaculture sector due to microplastics: **up to 0.7% of annual income** for the sector. Examples of losses of marketable catch: Lobster in US: **USD 250 million per year**; Dungeness crabs in Puget Sound (USA): **USD 744,000 per year**; Blue crab in Chesapeake Bay, Virginia (USA): **USD 300,000 per year**. **Tourism:** In Goeje Island (Republic of Korea), marine litter led to lost revenue from tourists of between USD 27.7 and 35.1 million (KRW 29,217–36,984 million) In the Asia Pacific Economic Community (APEC) region, marine litter is estimated to cost the tourism sector approximately USD 622 million per year.
Prevent/reduce litter reaching the marine environment	Collection of municipal waste: **USD 28-119** (EUR 30-126) **per tonne** (USD 17-71 (EUR 18-75) **per household per year**) for non-recyclable waste and **USD 188-282** (EUR 200-300) **per tonne** for light packaging materials (e.g. plastics, cans) in EU countries. Collection of trash that might otherwise become marine litter: around **USD 13-14 per resident per year (a total of USD 520 million)** in communities in three USA West Coast states.	
	Mechanical litter collection system for the Salina Landfill in Kansas (US): **USD 15,000** for a custom-made unit for the landfill. Clean-up/enforcement of illegally dumped waste: cost to English local authorities of **USD 56-80.7 million** (GBP 36-51.6 million) per year; cost to private landowners of **USD 78 to 234 million** (GBP 50 to 150 million) **per year**.	
	Annual costs of removing litter from wastewater streams: **USD 279 million** in South Africa. Cost of **USD 140** to retrofit a Lint LUV-R filter to a washing machine.	
	Cost to set up a Recycle Swop Shop (RSS) in South Africa: **less than USD 10,000**.	

Table 7.3 *(cont.)* **Sectors and activities as sources of marine litter, impacted by marine litter and examples of opportunities for action – illustrative summary**

Examples of measures and their costs (action)		**Costs if measures not applied (inaction)**
Prevent/reduce litter reaching the marine environment	Recovery and disposal of litter in ports & harbours and rescue services related to marine litter: **USD 9 million** (GBP 6 million) in UK; Removal of litter from Esbjerg Harbour, Denmark: **USD 86,695** (GBP 57,300) for one year; Investment in shipping waste management infrastructure by African Circle Pollution Management Ltd. **USD 70 million** by 2012. *Port reception fees to ships:* Environmental levy of **USD 0.12 per tonne** of cargo/ **USD 4.45 per TEU**, and **USD 2.76 per vehicle** used to transport waste at Nigerian ports. Waste handling charge of **USD 299-418** (EUR 225-315) **for 6 m³** at Port of Rotterdam; No Special Fee at Port of Gdansk: **USD 0.18-0.82** (EUR 0.14-0.64) **per gross tonnage** (GT).	*(cont.)* Annual loss of approx. **USD 22.5 million** (GBP 15 million) and 150 person-years of work to local community on the Skagerrak coast of Bohuslan (Sweden) (due to 1-5% reduction in tourism). Annual costs to tourism sector in certain regions of the UK: **USD 2.27-823 million** (GBP 1.38-500 million) in the 2010-2100 period. Potential impact of microplastics on bathing water quality and reputational risk to Blue Flag beaches in the UK: **0.09 to 3.4% of tourism revenues**. **Shipping:** Total value of litter damage to shipping in the APEC (Asia-Pacific) region: **USD 279 million per year**. In 2008, 286 rescues of vessels with fouled propellers in UK waters were carried out at a cost of **between USD 1.1 million and USD 2.9 million** (EUR 830,000 and EUR 2,189,000). **USD 2.9 million** in property (vessel) damage in the USA in 2005. Fines for ship-sourced garbage pollution in Australia typically exceed **USD 3,780** (AUD 5,000).
Collect litter from the marine environment	Theoretical estimated cost of keeping all 34 million km of global coastlines clean: **USD 69 billion** (EUR 50 billion) per year Annual costs of coastal clean-up activities (excluding value of volunteers' time): ▪ **USD 13.8m** (EUR 10.4m) in both the Netherlands and Belgium; ▪ **USD 24m** (EUR 18m) in the UK; ▪ **USD 2.2m** for removal of beach litter in Long Beach, California (US); ▪ **USD 2.5m in labour costs** in the Ventanillas municipality of Peru; ▪ **USD 1.4m** (GBP 937,000) per annum on Skagerrak coast of Bohuslan (Sweden); ▪ **USD 1,500 per tonne** in the APEC region; USD 589 per tonne to clean up marine litter from Hawaii coastline; ▪ **USD 792,000** (EUR 570,000) to clean beaches and remove litter from harbours in Polish ports in 2006. Participation of volunteers in two large clean-up schemes in the UK: estimated value of **USD 173,500** (EUR 131,000).	
	Fishing for litter in Korea: payment of **USD 5 per 40 litre bag** (compared with USD 48 cost of direct collection/removal of ALDFG); total budget of national fishing for litter incentive programme **USD 5.2 million per year** from 2009-2013. Costs related to ALDFG retrieval programmes: **USD 70,000** for Baltic Sea, Sweden; **USD 260,000** for Norway; **USD 185,000** for the Northeast Atlantic.	

Sectors and activities as sources of marine litter, impacted by marine litter and examples of opportunities for action – illustrative summary

Table 7.3 *(cont.)*

Examples of identified socio-economic benefits/avoided costs/value generated from marine litter-related actions

Table 7.2

Activity	Socio-economic benefits / value generated
Significant reduction of marine litter on beaches	*Potential economic benefits:* 50% reduction in marine litter on beaches could generate **USD 67 million** in benefits to residents in Orange County (California, USA) over three months; 75% reduction from six beaches near Los Angeles River outflow could benefit users by **USD 5 per trip** and lead to **USD 53 million** in benefits (from 43% increase in visitors).
Small-scale/local waste collection initiatives	*Value to citizens:* **Points/money gathered by individuals** to be spent on household items, food, clothing, mobile phone credit (e.g. TrashCash in Ghana, Wecyclers in Nigeria, Recycle Swop Shop in South Africa).
Trash for treasure initiatives	*Value generated through materials/products:* Ocean Sole **sales of up to USD 500,000 per year** (with 10% going to the Ocean Sole Foundation); Net-Works community banks in the Philippines have provided access to finance for 358 local residents – enough **funding to pay for 268,382 meals**; Kriki4Shore beach cricket sets sell at **USD 13** (ZAR 185); RAW for the Oceans clothing items sell for between **USD 77 and 306** (GBP 45 and 200); Bureo skateboards (over 3,000 sold) sell at **USD 149**, and sunglasses at USD 129; **USD 2,850 allocated to community programmes** in 1 year. *Employment created:* Around **50 artists employed** by Ocean Sole (Kenya); Goal to create **100 direct and 500 indirect jobs** through EcoPost Ltd (Kenya); **20 people trained** in craft skills through Kriki4Shore (South Africa); **2 regional managers and 8 local workers** employed by Bureo/Net+Positiva (Chile).
Plastic recycling industry	*Financial savings:* Good plastic management (incl. recycling and energy recovery), estimated to save consumer goods companies **USD 4 billion per year** globally. *Employment:* Over **6,000 formal jobs** and over **47,000 informal jobs** in South African plastics recycling.

Table 7.3 *(cont.)* **Sectors and activities as sources of marine litter, impacted by marine litter and examples of opportunities for action – illustrative summary**

Table 7.3 below presents a wider toolkit of measures and how these relate to marine litter issues linked to various sectors. The second column focuses on the contribution of sectors to marine litter and the third column on the impacts faced by the sectors as a result of marine litter, i.e. the former relates to each sector's 'responsibility' to act and the latter to the sectors' interests in marine litter being addressed. The final column highlights the types of actions that can be taken by the various sectors to address marine litter. In addition to the sectors focussed on within this study, the table also summarises the contribution of, impacts on and potential actions by a broad range of sectors, in order to provide a fuller picture of the context for future action on marine litter.

Table 7.3 **Sectors and activities as sources of ma and examples of opportunities for actio**

Red shading indicates a negative impact/burden; green shading indicates no burden.

Sector / activity / stakeholders	**Sector as a source of marine litter: contributing to the problem** ***i.e. 'responsibility' to act***	**Impacts o on the sec waste and** ***i.e. interes solutions***
Plastics suppliers and converters	Production of plastics with the potential to become marine litter.	Loss of mat the sector (becoming staying in th but no direc marine litter Potential in through cor tions of the
Packaging	Plastic bags, PVCs/polystyrene, plastic containers, bottles	No direct in litter on the Potential in through cor tions of the

Sector / activity / stakeholders	**Sector as a source of marine litter: contributing to the problem** ***i.e. 'responsibility' to act***	**Impacts o on the sec waste and** ***i.e. interes solutions***
Sectors using plastic: intermediate and final consumption		

Aquaculture and Fisheries	Accidental loss or intentional discard of fishing gear such as buoys, nets, ropes, traps. Fragmentation of products (e.g. plastic ropes, buoys), through environmental degradation or practices (e.g. pressure washing nets)	Economic losses for the fishing sector due to ghost fishing reducing potential catches. Damage to fishing vessels and equipment, e.g. floating objects affecting engine cooling systems and becoming entangled in propellers. Potential future loss of value of sales for certain seafood and fish if consumers become more aware of possible health impacts; possible increase in negative perceptions of farmed products which are grown in a more plasticized environment. Negative perception of the industry and its products – i.e. role in adding to marine litter (nets, buoys etc.) and contamination of products (seafood).
Agriculture	Plastic covers blow off and/or fragment, reaching marine habitats via runoff and watercourses. Agricultural plastics may be especially high in chemicals from pesticide application.	No direct impact from marine litter (but possible impacts from waste plastic). Potential indirect impacts via impacts on freshwater resources used by agriculture.
Food and Drink	Packaging for food and drink	Potential contamination of a range of foods (fish, shellfish, seaweed).
Textiles & clothes	Textile fibres (nano) from laundry of clothes	No direct impact by marine litter on the secto

- Marking fishing gear to id
ownership.
- On board technology to l
avoid) lost gear.
- Provision of easy-to-use (
collection facilities in port
- Incentive schemes for pro
of gear.
- Link to certification schen
- Spatial zoning to make m
aware of fishing gear.
- Produce fishing gear out
that are safer and more s
- Include plastic litter as a
guidelines for safe seafoo
- Research into the redesig
products.
- Research into and suitab
non-plastic biodegradabl
nents of gear to reduce c
any ghost fishing.
- Awareness-raising and e
- Facilities and/or incentive
collection (e.g. fishing for
- Positive labelling identifyi
have made efforts to redu
exposure.

- Management and suitable
agricultural plastic films/c
- Make plastic used for pla
of more sustainable mate
and recyclable).
- Education

- Substitution of single use
beverage bottles with mu
plastic water bottles or th
using other materials.
- Take back of packaging r
via Extended producer re
(EPR) schemes)
- Design for recycling
- Tax for single use packag
- Reduce use of single-use
and plastics that contain
chemicals that may leach
marine foodweb and henc
products.
- Education

- Filters on washing machi
capture fibres.
- Recycling of plastics (inc
vered marine litter) into cl
Adidas, RAW for the Oce
- Education
- Consumer choice regarding fabrics.
- Produce fibres that are more durable and don't break down as easily during washing.

Sector / activity / stakeholders	**Sector as a source of marine litter: contributing to the problem *i.e. 'responsibility' to act***	**Impacts of on the sec waste and *i.e. interes solutions***
Cosmetics and personal care products	Microbeads (e.g. in exfoliating creams, toothpaste, etc.).	No direct in litter on the Potential inc through cor tions of the
Shipping – commercial and recreational	Throwing litter overboard (deliberate or accidental), release of plastics with waste which is permitted under MARPOL (i.e. food waste). Plastic blasting in shipyards, Accidental release of plastic pellets or lost containers.	Marine litter sion equipm operations, up, repair ar efforts, and of life or inju
Terrestrial Transport	Particles from car wells (nano) Littering from cars/trucks	No direct in litter on the
Recreation and tourism	Littering of plastic bags, bottles, disposable plates/ cutlery, cigarette butts etc.	Pollution/litt areas may r thetic value hazards and visitors, lead tourism reve well-being f activities.

White goods (e.g. washing machines) & Electrical equipment sector (e.g. computers & telephones)	Improper or careless disposal of goods at the end of their life. Use of packaging materials	No direct impact by marine litter on the sector
Retail and distribution		
Retail and distribution	Own emissions e.g. rubber from tyres in transport. Packaging materials. Accidental releases e.g. loads shed from trucks/ ships during accidents.	No direct impact by marine litter on the sector.
Utilities: Water, waste water and waste management		
Waste sector (inc. recycling)	Lack of adequate waste collection/disposal can lead to waste entering the aquatic/ marine environment. Impacts from landfilling (e.g. windblown waste) and waste incineration (e.g. particulate matter).	Loss of materials that could potentially be recycled, composted (in the case of suitable bioplastics) or used for energy recovery. No direct impact by marine litter on the sector; potential indirect impact of having to deal with collected marine litter - marine litter can be difficult and expensive to recycle which can lead to higher costs/lower returns, and inappropriate to incinerate given risk of (carcinogenic) emissions.
Water sector	Mains water supply: No impact of sector Bottled water supply: major impact (see Food & Drink). Wastewater: primary source of bio-carriers/bio-filters; pathway for release of (micro)plastics and fibres. Storm water systems: litter washed into storm water drains.	Increased cost of water pre-treatment e.g. to filter out large items of litter and/ or smaller particles e.g. microbeads.

Sector / activity / stakeholders	Sector as a source of marine litter: contrib-uting to the problem *i.e. 'responsibility' to act*	Impacts o on the sec waste and *i.e. interes solutions*
Final end-use consumption: Citizens		

Consumers	Littering (plastic bags, cigarette butts, single-use packaging); microfibers from textiles; microbeads from personal care products; packaging; lack of use of separate waste collection facilities (e.g. kerbside recycling collections, bring centres)	Potential health impacts through food chain; impacts on well-being from littered beaches/coastal areas etc.

Marine litter items, examples of their Impacts and status of knowledge/uncertainty

Table 7.4

Key: (weight of scientific evidence)	Major knowledge/ evidence gaps	Weak knowledge and evidence	Understanding of causal factors/ relationships but very little evidence	Fair knowledge and evidence	Good knowledge and evidence

MARINE LITTER: SIZE, DETECTABILITY AND EXAMPLES	Marine litter sizes, types and impacts*					
	Marine litter size:	**Nano <1um**	**Micro <5mm**	**Meso <2.5cm**	**Macro <1 m**	**Mega >1m**
	Detection/ identification method:	Needs special detection methods as smaller particles undetected by microscopes – to date have not been detected in environmental samples	Often needs microscopes and instrumentation to confirm it is plastic; *Larger:* visible/ identifiable to naked eye	Visible/identifiable to the naked eye	Visible/identifiable to the naked eye	Visible/identifiable to the naked eye
	Examples of marine litter:	e.g. nanofibres from clothing; rubber dust from tyre wear; nanoparticles in products and pharmaceuticals. Have not yet been detected as litter due to technical limitations, but undoubtedly pres-ent in environment	e.g. microbeads from personal care products; fragmentation of existing (plastic) products; poly-styrene; plastic from blasting in shipyards; partic-ulates from waste incineration	e.g. bottle caps; cigarette filters and butts; plastic pellets; wind-blown/ storm-washed waste	e.g. beverage bottles and cans; plastic bags; food packaging; other packag-ing; disposable tableware/cutlery; beer-ties; fishing lines and floats, buoys; tyres; pipes; balloons; toys; whole textiles	e.g. abandoned fishing nets and traps; rope; boats; plastic films from agricul-ture; construction PVC (Polyvinyl chloride)

- Information, awareness-r behaviour change measu microbeads in personal c recycling.
- Promotion of reusable an items e.g. cups, bottles, ' including infrastructure fo
- Promotion of use of long- (ideally repairable) produ
- Product charges and fee refunds or environmental on products.
- Provision of recycling infr promotion of take-back s for consumer electrical g
- Provision of waste dispos structure where necessar cigarette butt containers)
- Fines e.g. for littering or f comply with selective wa rules and/or recycling.

Table 7.4 *(cont.)* **Marine litter items, examples of their Impacts and status of knowledge/uncertainty**

	Marine litter sizes, types and impacts*					
	Marine litter size:	**Nano <1um**	**Micro <5mm**	**Meso <2.5cm**	**Macro <1 m**	**Mega >1m**
SOCIAL IMPACTS	**Human health**	Risk from nano particles passing cell walls. Potential perceived (subjective) risk from chemical contamination in fish and shellfish eaten in the future, and possible transfer of pathogens.	Perceived (subjective) risk from chemical contamination in fish and shellfish eaten, and possible transfer of pathogens.		Injury on beaches, danger to fishermen, well-being loss / mental health impacts from degraded environment.	Loss of protein (where fish availability is reduced). Physical health risks of boats / individuals becoming entangled, and mental health risks from degraded environment. More indirect: loss of health benefits by avoiding littered coastlines.
	Communities (e.g. coastal fishing communities)	Concern regarding health of the community's environment. Actual impacts unclear.		Cost of clean-up, well-being loss from degraded environment.	Cost of clean-up, well-being loss from degraded environment; risk to community cohesion / local identity / cultural values.	Loss of livelihoods, well-being loss from degraded environment; risk to community cohesion / local identity / cultural values
	Poor / poverty (e.g. lowest income groups)	Loss of well-being in polluted living environments – but given "invisibility" of nano and microplastics – actual perception of well-being loss depends on awareness levels.		Loss of well-being in polluted living environments	Loss of well-being in polluted living environments.	Loss of well-being, fish stocks, tourist revenue in polluted living environments
ENVIRONMENTAL IMPACTS	**Pressure:**	Uptake via absorption, ventilation, and/or ingestion; transfer of chemicals: e.g. mussels, oysters, sponges, fish, corals, phytoplankton	Uptake via absorption, ventilation and/or ingestion; transfer of chemicals: e.g. fish, birds, oysters, corals	Ingestion, transfer of chemicals: e.g. birds, fish and marine mammals	Ingestion, transfer of chemicals; entanglement: e.g. birds, crustaceans, turtles, whales, dolphins, sea lions	Entanglement: whales, dolphins, sea lions, turtles, birds, fish
		Rafting: movement of animals using plastic as a raft e.g. microbes, larvae, jellyfish.				Rafting, movement of animals.
	Impacts: Individual organism	Sub-lethal impacts at lower levels of organization e.g. cellular intrusion, changes in gene expression. Health impacts unclear.	Potential effects from physical presence of ingested plastic, concerns about possible effects from transfer of chemicals: reduced feeding, sub-lethal impacts at lower levels of organization e.g. cellular intrusion, changes in gene expression.	Sub-organismal impacts: e.g. organ damage. Organismal impacts: death, reduced feeding & impairment of digestive process: impacts on fitness & reproduction.	Sub-organismal impacts: e.g. organ damage. Organismal impacts: death, reduced feeding & impairment of digestive process: impacts on fitness & reproduction	

Marine litter items, examples of their Impacts and status of knowledge/uncertainty Table 7.4 *(cont.)*

	Marine litter sizes, types and impacts*					
	Marine litter size:	**Nano <1um**	**Micro <5mm**	**Meso <2.5cm**	**Macro <1 m**	**Mega >1m**
ENVIRONMENTAL IMPACTS	**Impacts: Ecological impacts** **(e.g. population, assemblages, ecosystems)**	Potential for population decline, changes in assemblages and ecosystem functioning e.g. shift in microbial community.	Potential for population decline, changes in assemblages and ecosystem functioning, e.g. endocrine disruption in fish.	Potential for population decline, changes in assemblages and ecosystem functioning, e.g. mass decline in population due to ingestion causing mortality in sea turtles and sea birds.	Evidence of effects on assemblages and ecosystem functioning e.g. plastic bags. Population decline, changes in assemblages and ecosystem functioning e.g. from mass strandings of sea turtles from entanglement; changes in assemblages due to changes in habitat structure.	Population decline, changes in assemblages and ecosystem functioning e.g. changes in populations and assemblages due to ghost fishing. Invasive alien species (IAS) predation / displacement of indigenous species.
ECONOMIC IMPACTS	**Fisheries and aquaculture**	Potential perceived (subjective) risk from chemical contamination in fish, shellfish and aquatic plants that are eaten. Pending perception issues this can lead to lower demand for and/or value of fish/seafood.		Ingestion could lead to lower quality fish and hence lesser market value.	Entanglement in: propellers and damage to fishing vessel; related loss of fishing time, loss of fish and associated revenues. Potential risks to fisheries community cohesion / local identity / cultural values.	Ghost fishing: loss of output and hence livelihoods; damage to boats and equipment.
	Tourism and Recreation	Unlikely to have any discernible impact unless new information comes forward on health impacts.	Only if integrated into beach labelling.	Evidence of marine litter can discourage tourism and recreation on beaches, reducing income and/or well-being.	Reduction in tourist and recreation numbers and hence income / well-being. Increased costs of clean up to maintain activities. Damage to vessels (propellers, cooling systems).	Reduced income from polluted beaches. Increased costs of clean up to maintain activities. Damage to vessels (propellers, cooling systems).
	Shipping	No	No/unlikely	Damage to vessels (cooling systems)	Damage to vessels (propellers, cooling systems); potential loss of productivity and revenues from delays or accidents affecting supply chains.	Damage to vessels (propellers, cooling systems); potential loss of productivity and revenues from delays or accidents affecting supply chains.
	Local authorities and municipalities	Degradation of the natural environment within their jurisdiction. Potential increased cost of waste water treatment.		Degradation of the natural environment/heritage; Cost of clean-up and infrastructures. Loss of income and livelihoods.	Degradation of the natural environment/heritage; Cost of clean-up and infrastructures. Loss of income and livelihoods.	Degradation of the natural environment/heritage; Cost of clean-up and infrastructures. Loss of income and livelihoods.

** note that over time mega/macro marine litter can become microparticles or even nanoparticles as it breaks down – so may have impacts across ranges.*

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