Institute for European Environmental Policy

Plastics Marine Litter and the Circular Economy

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PLASTICS, MARINE LITTER AND THE CIRCULAR ECONOMY

Summary for Policy Makers

We live in the plastic age: **300 million tonnes of plastics** are produced per year globally. Between **5 and 12.5 million tonnes of plastic enters the ocean as marine debris** from mismanaged waste at coasts alone**. There is a need to keep plastic and its value in the economy and out of the oceans.**

Marine litter comes in many forms: They range from **nano-sized particles** such as fleece fibres and tyre dust, to **microbeads** in personal care products, to cigarette butts, plastic bags and bottles. Larger items include polystyrene cooling boxes, plastic sheeting from agriculture, tyres, ropes, and lost or ageing buoys that can degrade and fragment over time. The largest items include abandoned boats and fishing nets.

Marine litter stems from a wide range of products and sectors from packaging, fishing and aquaculture to cosmetics, textiles, transport, shipping, construction, and a wide range of consumer goods.

The Cost of Policy Inaction: The Unsustainability of Marine litter

Environment: **Marine litter creates a range of growing pressures on marine ecosystems and biodiversity –** e.g. plastic bags and abandoned nets pose risks to turtles, dolphins and seals.

Public finances: Marine litter creates an **economic burden on local authorities** through **clean-up costs**, and **potential loss of income from tourism and recreation** activities.

Economic: Plastic waste represents a **loss of material value** to the economy. Marine litter can also create economic pressures on the **shipping sector** (fouled motors, lost output and repair costs), **fishing** ('ghost fishing' by lost and discarded nets), and **tourism** (loss of revenues).

Social: Marine litter creates risks to **human health**, via **injuries and accidents, through the release of chemical substances** (some potentially endocrine disrupting substances and carcinogens) and also through **ingestion of micro plastics**.

People eat plastics, unawares: **An average European shellfish consumer could ingest up to 11,000 pieces of microplastic per year by eating mussels and oysters**. As filter feeds which feed on the algae present in seawater, mussels and oysters are exposed to pollutants such as microplastics in the water. **We do not yet know what effect this has on our health.**

There is increasing global commitment to address marine litter. Commitments were made at: **The United Nations Environment Assembly (UNEA-2)** meeting in Nairobi in May 2016, at the **G7 meeting** in Bonn in May 2015, and within ***Target 14.1*** **of the Sustainable Development Goals**. At the EU level, the **Marine Strategy Framework Directive** (MSFD) commits the Member States to adopt measures to address marine litter (Descriptor 10). The **Directive on Port Reception Facilities** (PRF) and the **Water Framework Directive** (WFD) provide further provisions to reduce marine litter.

The EU Action plan for the Circular Economy (COM/2015/614) **commits the European Commission to help reduce the impacts of marine litter, while increasing the value of materials in the EU economy**. The promised **Strategy on 'Plastics in the Circular Economy'** is one of the main vehicles for addressing marine litter and the **opportunities inherent in the formal consultation**, expected in September 2016, **should be realised by all stakeholders**.

The following **circular economy tools** can usefully be reflected in **The Plastics Strategy:**

1. **Extended Producer Responsibility: Use EPR to avoid certain types of marine litter,** most notably **single-use packaging items.**
2. **Research into product design** to facilitate reuse, repair, remanufacture and recycling, and complement this by providing more **information on the plastic composition of products**.
3. **Bans for unnecessary and damaging products or activities** where viable substitutes exist - e.g. **plastic microbeads in cosmetics** can be replaced by ground nut shells, marble particles or naturally-grown polymers, and plastic blasting in shipyards can be replaced by ultra high pressure water jets.
4. **Improved legislation: Provide clear definitions of polymers, waste and secondary raw materials.** Manufacturers need to design their products and packaging to fit into existing recycling systems.
5. **Economic incentives targeting consumption: Make greater use of economic incentives to make market signals part of the solution** - i.e. 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, disposable cutlery, and other one-use items.
6. **Transparency and labelling:** Improve transparency on the chemicals contained in plastics – to help with decisions on remanufacture and recycling. In addition, transparency on where personal care and cosmetic products (PCCPs) do and/or do not contain plastics. Explore the implications for additives such as flame retardants, plasticisers, pigments, fillers, and stabilisers.
7. **Waste management measures: Invest in waste collection infrastructure and services (at ports), waste management infrastructure and wastewater treatment facilities** to avoid dispersion of litter into the marine environment - particularly in coastal areas or near rivers.
8. **Awareness-raising: Raise awareness among consumers to improve waste disposal** (littering and waste separation), and also **better inform purchasing habits to increase demand for sustainable substitutes** - e.g. cosmetic products not containing microbeads (e.g. via Beat the Bead), multiuse bottles and bags, purchase of washing machines with filters.

In addition there are two further useful measures beyond the Action Plan

9. **Fishing for litter: combined incentives to encourage action, and develop new products from waste.** While this is not the most cost-effective of solution (efforts higher up the hierarchy are preferable), it can create interesting branding opportunities for manufacturers, raise awareness and contribute to reducing pressure on the marine environment in selective places.
10. **Improved implementation: In addition, there is a need for better implementation of existing legislation on the release of litter, from terrestrial sources and at sea** – e.g. The MARPOL Convention, Waste Framework Directive, Directive on Port Reception Facilities**,** Water Framework Directive and, Marine Strategy Framework Directive.

If the above measures are embraced, the EU can take a lead in implementing a transition to a circular economy, which keeps plastic and its value in the economy and out of the ocean.

1. Introduction: Marine litter and the Circular Economy

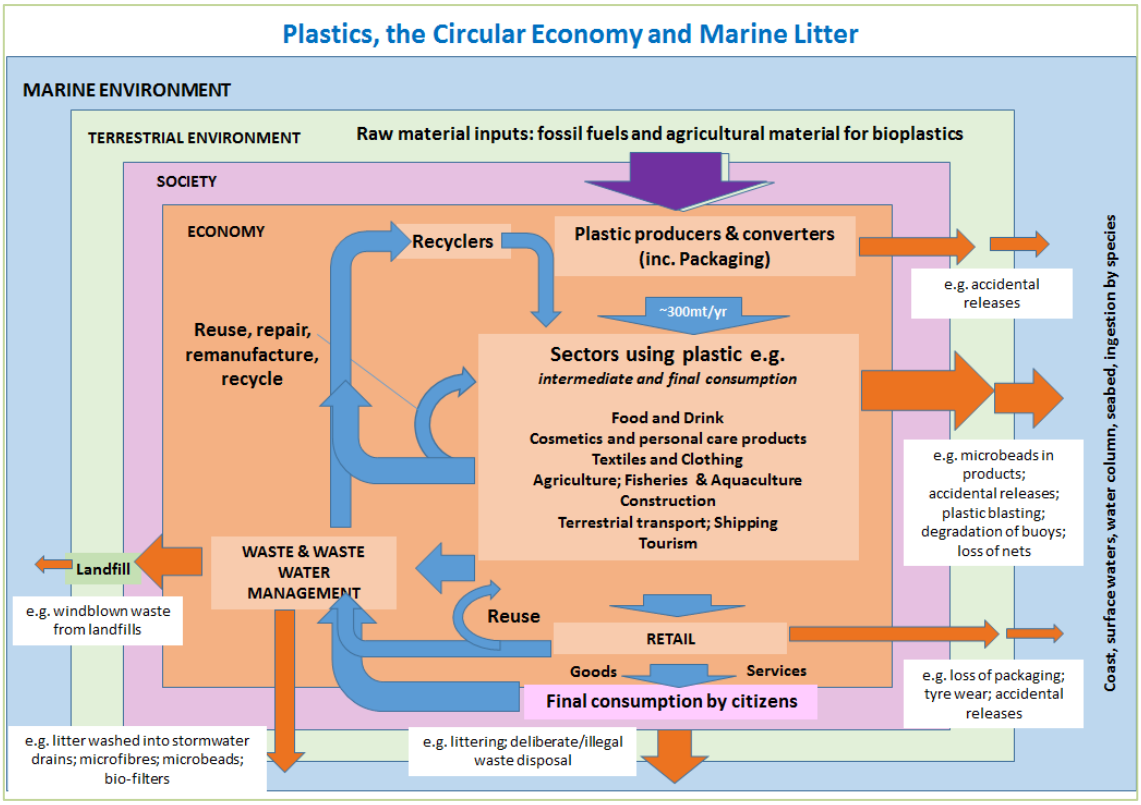
We live in the plastic age

Around 300 million tonnes of plastics are produced per year globally (Plastics Europe 2015). **Plastic has proven to be a very durable and versatile material, used in almost all sectors of the economy**. It plays an essential role in packaging for retail activities and as a day-to-day part of consumer purchases. However, a significant amount of plastic and its value is lost in waste disposal and much becomes marine litter. This, in turn, leads to pressures on ecosystems, society and the economy.

Worldwide it is estimated that **4.8 to 12.7 million tonnes of plastic from mismanaged waste at coastlines enter the ocean annually** (Jambeck et al. 2015). Other inland sources and at sea sources contribute a further 75,000 to 1.1 million tonnes and 0.3 to 3.25 million tonnes of plastic waste respectively (Sherrington et al. 2016). Plastic waste floats in the oceans, can be found on beaches and on the sea floor. 94% of marine plastic waste is estimated to be in the sea floor, whilst the highest concentrations of waste can be found on beaches (~2,000 kg km^{-2})(Eunomia, 2016).

There is a need to keep plastic and its value in the economy and out of the oceans. Figure 1 below illustrates the flow of plastic and plastic products – from raw material extraction to use throughout the economy and by consumers. Some plastic gets recycled or reused and remains in the economy. However, much is lost and ends up in the marine environment.

Figure 1



Source: Own representation, Patrick ten Brink

Plastic also consumes almost 10% of global oil production, either as a feedstock for plastic or in energy used for its production. Furthermore, over a third of produced plastic is used to make packaging, which is often quickly discarded (Thompson et al. 2009).

Plastic is filling our oceans

Plastic waste can persist in the environment for a long time. It is also easily dispersed by wind and water because of its low density, making it particularly challenging for waste management (Ryan et al. 2009). Due to its easy transportation and accumulation within the marine environment, it has become a major local and international concern. Many threats associated with plastics occur at sea, including pollution, entanglement and ingestion (Thompson et al. 2009; Gregory 2009). Plastics also tend to accumulate in ports, along coastlines and throughout oceans. Gyres of high concentrations of marine litter, such as the 'Great Pacific garbage patch' have come to symbolise the issue (Barnes et al. 2009; Ryan et al. 2009). Likewise, the presence of trash on beaches provides a visible reminder of the problem for many coastal communities and visitors.

Marine litter creates a range of growing pressures on marine ecosystems and biodiversity. It also creates an **economic burden on local authorities** through clean-up costs, and **potential loss of income from tourism and recreation** activities. It can create economic pressures on the **shipping sector** (fouled motors), **fishing** ('ghost fishing' by lost and discarded nets), and tourism (loss of revenues). It also creates risks to **human health**, via **accidents, through the release of chemical substances** (some potentially endocrine disrupting substances and carcinogens) and also through **ingestion of micro plastics**.

Marine litter is coming to the fore on national, EU and global agendas

The United Nations Environment Assembly (UNEA-2) meeting in Nairobi in May 2016 issued a **high level resolution** to prioritise tackling marine litter (UNEP 2016). At the **G7 meeting in Bonn** in May 2015, world leaders also committed to addressing marine litter. ***Target 14.1* of the 2030 Sustainable Development Goals** calls for a significant reduction of *"marine pollution of all kinds, in particular from land-based activities, including marine debris*" by 2025.

At the level of the EU, the EU **Water Framework Directive** (60/2000/EC) and EU **Marine Strategy Framework Directive** (2008/56/EC) include provisions on reducing pollution and marine litter respectively. With the launch of the **Circular Economy Action Plan**, the European Commission committed to "*adopt a strategy on plastics in the circular economy, addressing issues such as recyclability, biodegradability, the presence of hazardous substances of concern in certain plastics, and marine litter*" (COM/2015/0614). The plastics strategy is expected in 2017.

A number of regional and international initiatives exist for tackling marine litter that are relevant to Europe. These include the Lanzarote Declaration (2016), the Honolulu Commitment (2011), MARPOL, the London Convention, a number of Regional Seas Conventions (e.g. Barcelona, OSPAR), and other regional initiatives such as the Mediterranean Regional Plan on Marine Litter (2014).

This briefing…. presents key facts on what marine litter is and where it comes from (section 2), its impacts (section 3), and **what circular economy measures can help keep plastic and its value in the economy and out of the seas**. Examples are given of innovative solutions, their costs and benefits (section 4). Finally, section 5 presents a roadmap for a way forward.

2. What is marine litter, where does it come from and where does it go?

What is marine litter?

Marine litter can be defined as "*any persistent, manufactured or processed solid material that has been discarded, disposed of, abandoned in, or eventually reaches the marine or coastal environment*" (Watkins et al. 2016).

Marine litter varies in its origin, size, composition, as well as the pathways it take to the marine environment and the impacts it has on nature, society and the economy.

Litter items can be invisible to the naked eye, such as **nano-sized particles from fleece fibres and tyre dust**. Microplastics such as **microbeads in personal care products** and lost **plastic pellets** are just visible (at <5mm). Larger scale, more easily visible items range from **cigarette butts and bottle caps**, to **plastic bags and bottles.** There are also **polystyrene cooling boxes and** lost or ageing **buoys,** that can degrade and fragment over time. The largest items, including abandoned **fishing nets,** can be problematic for biodiversity, society and the economy. Details are given in Table 1 below.

Table 1 What is Marine litter? Sizes and examples

Nano <1um	Micro <5mm	Meso <2.5cm	Macro <1 m	Mega >1m
• Nanofibres from clothing • Rubber dust from tyre wear • Nanoparticles in products and pharmaceuticals.	• Microbeads from personal care products • Fragmentation of existing (plastic) products • Polystyrene • Plastic from blasting in shipyards • Particulates from waste incineration	• Bottle caps • Cigarette filters and butts • Plastic pellets • Windblown/ storm-washed waste	• Beverage bottles and cans • Plastic bags • Food & other packaging • Disposable tableware / cutlery • Beer-ties • Fishing lines, floats & buoys • Tyres • Pipes • Balloons and toys • Textiles	• Abandoned fishing nets and traps • Rope • Boats • Plastic films from agriculture • Construction PVC (Polyvinyl chloride)

Source: adapted from Watkins et al., 2016.

Where does it come from?

Marine litter has its origins in a wide range of products and sectors from packaging, fishing and aquaculture to pharmaceuticals, textiles, transport, shipping, construction, and a wide range of consumer goods.

Producers, retailers and consumers each contribute to marine litter and have both responsibilities and opportunities to avoid plastic leaving the economy and entering the marine biosphere. See Box 1 for Baltic Sea data on marine litter and its origins.

Box 1. Marine Litter on Baltic Beaches

23 beaches in Sweden, Finland, Estonia and Latvia were monitored for litter over the period 2011 to 2013. **Bottle caps, plastic bags, plastic food containers, wrappers and plastic cutlery** were typical items to be found on the beaches. The researchers estimate that 48% of marine litter in the Baltic Sea originates from household-related waste. Waste generated by recreational or touristic activities contributed a further 33% (MARLIN 2013).

So how big is the problem?

Global plastics production increased by almost 47% between 2002 and 2013 and is still growing (Plastics Europe 2015). **In the EU, around 50 million tonnes are produced every year.** A lot of the plastic produced is used to make single-use products, which quickly lose their value through landfilling, or when they become marine litter.

In the EU, packaging is the most common use of plastic, making up almost 40% of plastics demand (Plastics Europe 2015). **Some progress, albeit insufficient, is being made to keep plastic in the economy.** In the EU in 2014, **just 30% of post-consumer plastic was recycled**, while 40% was treated for energy recovery and 30% was landfilled (Plastics Europe 2015).This represents a 64% increase in the recycling rate for plastics, a 46% increase in energy recovery and a 38% decrease in landfilling since 2006 (Plastics Europe 2015). This means nearly 8 million tonnes of plastic are still going to landfill, equivalent to 100 billion PET bottles by mass (drawing on ImpEE project 2005).

Most plastics cannot be recycled multiple times, which often results in **plastic being downcycled rather than recycled to make the same type of product again**, even though the technology to do this exists. The products created from recycled plastics are often non-recyclable after their useful life, hence the process of plastic being incinerated or landfilled is simply slowed down rather than eliminated (Eureka Recycling 2009). To close the loop, **end uses must be found for recycled plastic**.

In 2012, the **EU-27 countries exported half of the plastics collected for recycling**, equivalent to **3.4 million tonnes** of plastic with an estimated value of **EUR 1.7 billion**. **87% of EU-27 plastic waste exports (by mass) went to China**. Global imports in waste plastics corresponded to around EUR 7.6 billion from 15.8 million tonnes of material in 2012 (Velis 2014).

A significant proportion of the plastic, if not disposed of and managed carefully, may be at risk of becoming marine litter. All European waters have been found to contain marine litter, including along the coasts, the continental shelf, and in deep-sea waters (Pham et al. 2014). **Data on how much of EU plastic becomes marine litter are still limited, h**owever, estimates have been made of the amount of plastic marine litter that exists on a global scale (see Box 2).

Box 2. How much plastic is in the oceans?

A pioneering study published in 2014 made a conservative estimate of the amount and weight of plastic in the oceans. The study involved expeditions from 2007-2013 in which all five sub-tropical gyres, as well as extensive coastal areas and enclosed seas, were surveyed, with a model subsequently generated.

It estimates that there are **5 trillion pieces of plastic in the oceans**, with a weight of **250,000 tonnes** (Eriksen et al. 2014). Data from the model showed that the weight of marine plastic is comprised of 75.4% macroplastic, 11.4% mesoplastic, 10.6% large microplastics (1.01-4.75 mm) and 2.6% small microplastics (0.33–1.00 mm). In the surveys, foamed polystyrene items were found to be the most commonly occurring macroplastics, and derelict fishing buoys accounted for the most weight in terms of macroplastics. The estimate by Eriksen et al. (2014) of 35,540 tonnes of microplastics globally correlates with a similar estimate for microplastics by Cozar et al. (2014) of between 7,000 and 35,000 metric tonnes.

Where does the marine litter end up?

The pathway and destination of marine litter are both important given that impacts on biodiversity, society and the economy can take place at any point along the pathway.

Media attention is given to the gyres of marine debris that form in the world's oceans, but impacts in waterways and coastal areas can be significant due to their proximity to populations, and happen before the marine litter adds to the waste gyres. As well as direct littering in coastal areas, marine litter can also arise from poorly managed landfill sites that allow waste to escape. In turn, storm drains and rivers act as trajectories for land-based litter to reach the oceans.

Marine litter can end up:

- **On beaches** – e.g. beverage bottles, ropes, buoys and nets.
- **In surface waters** – e.g. as plastic bags in bathing waters; in ports; or as plastic gyres in the oceans.
- **Lower in the water column** – e.g. nets floating underwater.
- **Embedded in the seafloor** – analysis of sea-floor sediments has shown that each square kilometre of the deep sea is littered by billions of tiny plastic fragments (Woodall et al. 2014).
- **Ingested by marine life** – e.g. by filter-feeders such as mussels, and by fish, birds and whales. The impact of ingesting larger plastics (>5mm) is well documented. Currently, 60% of seabirds have plastic in their gut, with this figure expected to rise to 99% by 2050 (CSIRO, 2015).
- **Ingested by people** – e.g. from eating affected seafood (see Box 3).

Large pieces of marine debris can be broken down into ever smaller pieces by sunlight and the physical action of waves, in due course **becoming microplastics**. The different sizes of plastic items along this pathway results in different outcomes. In turn, some microplastics enter the marine environment directly as microplastics, for example plastic beads used in personal care products and cosmetics that pass through wastewater treatment uncaptured.

Box 3. People eat plastics, unawares

In their study of microplastics in bivalves (mussels and oysters) cultivated for human consumption, Van Cauwenberghe and Janssen (2014) estimated that an **average European shellfish consumer could ingest up to 11,000 pieces of microplastic per year by eating mussels and oysters**. As filter feeds which feed on the algae present in seawater, mussels and oysters are exposed to pollutants such as microplastics in the water.

We do not yet know what effect this has on our health.

3. What are the impacts of marine litter in the EU and beyond? The costs of inaction

What are the pressures and impacts on biodiversity?

Marine litter creates a series of pressures that can impact biodiversity – from individual organisms to wider populations and the whole ecosystem. It can do this via absorption (e.g. transfer of microplastics and chemicals into mussels and oysters), ingestion (e.g. eating bottle caps or plastic bags) and entanglements (e.g. in waste packaging or discarded fishing nets).

Box 4. Marine litter poses a major danger to charismatic species

Plastic bags and abandoned nets are a risk to turtles, dolphins and seals. Turtles for instance may eat plastic bags because they mistake them for jellyfish (Teuten et al. 2009). Plastic ingestion can lead to ulceration (Fry et al. 1987), gastrointestinal blockages (Baird & Hooker 2000), and internal perforation and death (Mascarenhas et al. 2004).

This can lead to both lethal and non-lethal impacts. Plastics can **release chemicals into the marine environment** and absorb contaminants. Marine plastics can carry small chemical molecules. In turn, these molecules can penetrate cells and chemically interact within them in a way that disrupts the endocrine system.

Box 4. Transfer of toxins from plastics to marine life

Research into the impacts of ingested plastics on fish and other animals is still in its infancy, nevertheless studies have already shown that fish exposed to plastics and chemical pollutants in the marine environment can bioaccumulate them and suffer liver toxicity and stress (Rochman et al. 2013)

There can also be organ damage from ingestion that can lead to disruptions in **feeding, species size, reproduction and death.** There can also be mass strandings or entanglements that lead to death from asphyxiation.

Marine litter from EU member states specifically puts pressures on fragile or at risk species, habitats and environments.

Box 5. Plastic waste from the UK ends up in the Arctic

Modelling of the movement of plastic waste released from the UK coastline demonstrated that most of it that wasn't washed up on beaches ended in the Arctic (van Sebille 2014, van Sebille, Spathi & Gilbert 2016). Other research has already shown that there is a considerable amount of plastic in the arctic region, arguing that currents from the North Atlantic bring a constant supply of litter northwards (Bergmann et al. 2015).

Impacts are not restricted to marine biodiversity. We ingest microbeads without knowing it, and **without knowing of the risks that they pose to our health**. Microbeads are unnecessary as natural low risk substitutes exist (see Box 6).

Box 6. Do we need microbeads in face wash, body scrubs & toothpaste?

Plastic microbeads are used in a range of cosmetics such as exfoliating face creams and toothpaste (Fendall 2009). As microbeads are very small, they may not be caught by water treatment processes and end up in the marine environment.

4,073 tonnes of polyethylene microplastic beads and 287 tonnes of other plastic beads were used in the EU, Norway and Switzerland in 2012 (Gouin and Avalos 2015). To illustrate the scale of the problem, in the North Sea area between 1.5 and 11% of all litter originated from microbeads in cosmetics.

Countries are responding to the problem: In the United States, President Obama signed the Microbead-Free Waters Act into law in December 2015, which requires companies to stop using plastic microbeads in their products by June 2017. A list of companies and producers which have pledged to stop the use of microbeads can be found online, including 337 brands as of June 2016 (Plastic Soup Foundation 2016).

Marine litter burdens a range of sectors of the economy

There are also a series of **impacts on activities of a range of economic sectors – notably fishing and aquaculture, tourism and recreation, and shipping** – see Boxes 7 to 9. One report estimated that global costs of beach clean-up and impacts to fisheries linked to plastic marine litter were roughly EUR 44.2 bn and EUR 4.2 bn respectively (Wurpel et al. 2011). Illustrative examples of specific costs are given below:

Box 7. Impacts and Cost of Inaction on Fisheries and Aquaculture

Marine litter can lead to a **reduction in catch** due to entanglement (i.e. '**ghost fishing**', ingestion and exposure to toxic materials.) There are risks that **consumer demand will decline and prices will drop** due to concern about fish quality and/or health impacts of **eating seafood contaminated by microplastics**. It can also lead to costs related to **damage to vessels**. For example:

- The **annual costs to the UK fishing sector** of marine litter have been estimated at EUR 36.1 million, with annual costs to the **aquaculture sector** EUR 489,050 for **cage clearance** and EUR 916,970 for **fouled propellers and intakes** (Fanshawe and Everard 2002).
- The total cost of marine litter for the **EU fishing fleet** at EUR 61.7m/yr (Arcadis 2014).

Box 8. Impacts and Cost of Inaction on Shipping

Marine litter can damage vessels by fouling ship propellers and cooling systems. This can lead to **productivity and revenue losses** and **disrupted supply chains** from **delays and accidents**. In addition, operators can face **repair costs**, **rescue efforts** and **loss of life or injury**. For example:

- In 2008, 286 rescues of vessels with fouled propellers in UK waters were carried out at a cost of **between EUR 830,000 and EUR 2,189,000** (Mouat et al. 2010).

To cite an international example - between 1996 and 1998, 9% of all Korean shipping accidents involved marine litter. In 1993, derelict fishing ropes entangled shafts and a propeller were a factor in the capsizing of Passenger Ship M/V Seo-Hae Ferry, which caused 292 deaths (Cho 2005).

Box 9. Impacts and Cost of Inaction on Tourism

Polluted beaches can **discourage visitors, reduce their numbers** and lead to **reductions in revenues** and **loss of jobs** in the tourism sector. There may also be increased **clean up costs** to maintain tourism and recreation activities and to **prevent damage to vessels**. For example:

- Annual loss of around EUR 23.16 million and 150 person-years of work to local community on the Skagerrak coast of Bohuslan (Sweden) due to a 1-5% reduction in tourism that is associated with marine litter (Fanshawe and Everard 2002).
- Projections suggest that the annual cost to tourism in the UK could be up to 625.7 million for the period 2010 to 2100 (Van der Meulen et al. 2014).

In addition to these sectors where the link to plastic pollution is fairly evident, there are also potential risks to novel sectors that depend on the health of the oceans. It has been recognised in recent years that **ocean ecosystems could be a source of substantial therapeutic and nutritional benefits for humans** (NRC 1999; Faulkner 2001). Pollution of the marine environment through plastic waste could impinge on harnessing the potential of ocean ecosystems.

Finally, the oceans also contain complex ecosystems, rich in biodiversity. Some of this has proven to have important socio-economic applications. One recent example is the discovery of Ecteinascidin 743, an anti-cancer drug derived from the Caribbean sea squirt (Fleming et al. 2006). There remains significant untapped potential for **biotechnology, bioprospecting and biomimicry** and pressures that compromise the health of marine ecosystems can also create risks to us finding new nature-based solutions.

There are also significant impacts on local authorities and municipalities

Marine litter degrades the natural environment/heritage in their jurisdiction. This can lead to **increased clean-up costs, cost of waste management infrastructures and services**, and potentially **waste water treatment,** which can make it more difficult to balance local budgets. There could also be a **loss of income and livelihoods** where there is a reduced level of tourism or recreational fishing and associated reduction in local income and taxes. Examples of initiatives by local authorities and volunteers and associated costs include:

- **Costs of beach clean-up costs** were estimated at EUR 10.4m annually in both the Netherlands and Belgium, countries with relatively short coastlines (Mouat et al. 2010; OSPAR 2009). Globally, the cost required to keep all coastlines (34 million km) clean have been estimated as high as €50 billion per year (IMSA, 2011). No estimates exist on the cost of cleaning up the oceans.

- **The cost of recovery and disposal of litter in ports and harbours and rescue services** related to marine litter have been estimated at EUR 9.28 million (GBP 6 million) in the UK (MaLiTT 2002); the estimated annual cost of removing litter from Esbjerg Harbour in Denmark has been estimated at EUR 92,260 (GBP 57,300) (Hall 2000).

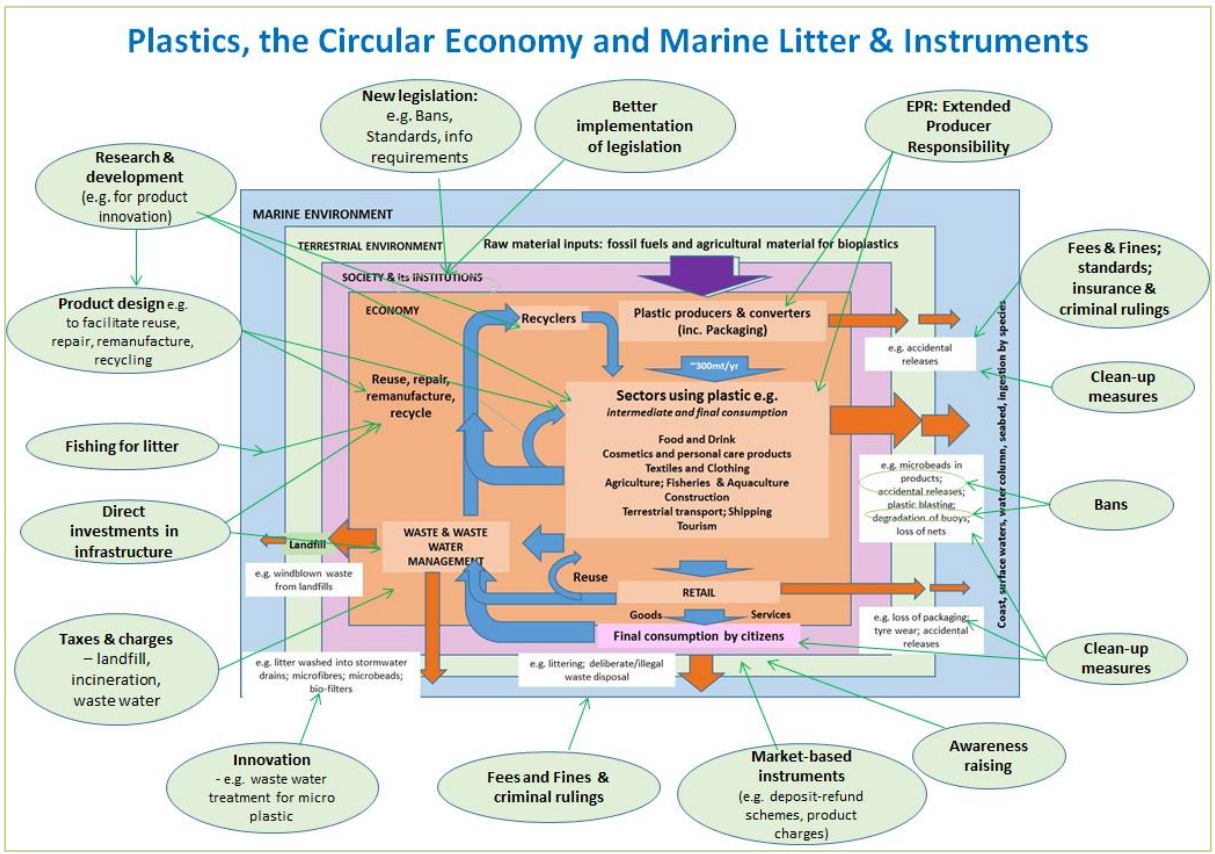
Whilst these activities are important they represent clean-up rather than circular activities. In order to close the loop, waste practices should address plastics before they enter the ocean – hence focusing on application of a waste hierarchy to marine litter management – as discussed in the next section.

4. What existing solutions have been proven effective?

What is the toolkit at our disposal?

A wide toolkit of measures exists to address marine litter – including 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 and smartphone apps) and **clean-up measures** (see Figure 2)**.** Which instrument or instrument mix is best depends on the particular marine litter problem being addressed and the country institutional and regulatory context.

Figure 2 A toolkit of instruments to address marine litter across the circular economy stages

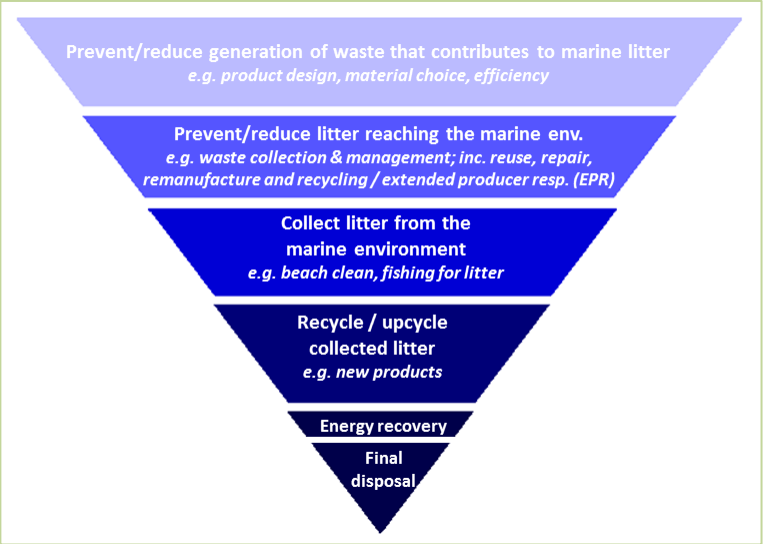


Source: Patrick ten Brink, adapted from earlier figure given in Watkins et al., 2016

The circular economy presents a number of solutions for tackling marine litter in our oceans. They include **material reduction**, **design for end-of-life recyclability**, **green chemistry life-cycle analyses** and the use of bio-based feedstocks (Thompson et al. 2009) whose biodegradability is confirmed in a range of real-world locations where the waste may end up.

The priority solutions will depend on the country in question, but in general terms **a preferential hierarchy should be followed** where possible – see Figure 3 and the roadmap in section 5.

Figure 3 A hierarchy for marine litter management



Source: Watkins et al. 2016

Avoiding waste becoming marine litter: A key measure to avoid marine litter is having an effective waste management infrastructure and services. This, of course, offers wider benefits than just mitigating marine litter. The costs of collecting municipal waste have been estimated at EUR 30-126 per tonne (EUR 18-75 per household per year) for non-recyclable waste and EUR 200-300 per tonne for light packaging materials (e.g. plastics and metal cans) in EU countries (Eunomia 2002). Taxes and charges have proven to be effective tools in a range of countries to fund waste management systems (e.g. cost recovery via pay-as-you-throw schemes in Belgium, Luxembourg and the Netherlands). In addition, EPR schemes can be powerful tools to shifts waste management costs from municipalities to producers. Funds raised should be invested into the circular economy instead of letting them accumulate. An example of EPR is given in Box 10. Other tools include taxes on specific products commonly found as litter (Box 9), and consumer purchase of innovative technologies (Box 11).

Box 10. Extended Producer Responsibility, FOST plus Belgium

Fost Plus is the Belgian accredited body which organises EPR for household packaging waste. It is often regarded as the best value for money EPR system in the EU. Fost Plus, as a not for profit public-private partnership, is in the hands of packagers who are obliged to pay the full cost of waste recovery. Fost Plus covers 100% of Belgian households and 93% of the market for packaging (5,054 member companies). Recycling rates for plastic, metal and drinks (PMD) containers were 86.8% in 2014, with a cost per capita of EUR 5.3-6.2. (European Commission, 2014)

Box 11. Product taxes and behavioural change in Ireland and Belgium

Irish plastic bags - A levy on single-use retail plastic bags was introduced in Ireland in March 2002. Initially, the levy was EUR 0.15 and this was increased to EUR 0.22 in 2007. Plastic bag usage has fallen from around 328 bags per capita before the levy to 14 per capita in 2014. (Department of the Environment, Community and Local Government 2016).

Belgian plastic cutlery - In July 2007, an environmental levy dubbed the **"picnic tax"** was introduced in Belgium on **disposable utensils** (€3.60/kg) as well as on other products such as **cling film** (€2.70/kg) and **aluminium foil** (€4.50/kg) (Service Public Fédérale Finances 2015).

Box 11. Retrofitting washing machines to capture synthetic lint

As clothes are often made from synthetic materials, microplastic fibres emitted in washing machine wastewater are commonly found in wastewater streams. Retrofitting washing machines with a filter to capture microfibers is one solution. One example is the Lint LUV-R filter, which costs EUR 123 to retrofit to a washing machine (Environmental Enhancements 2015). Costs generally fall with innovation and economies of scale, so there is scope for this type of measure to become more affordable over time.

Tackling the problem of marine litter through a circular economy approach presents **clear benefits for the marine environment**, but also helps address **resource scarcity** and **climate change**. It also has the potential **to create jobs** and to **foster innovation** and **market creation** (Ellen MacArthur Foundation, 2016).

While the main focus of initiatives should arguably be upstream (i.e. avoid the problem), there are benefits of addressing marine litter itself - for niche markets as well as awareness.

For example, the **RAW for the Oceans fashion range by G-Star Raw and Bionic Yarn** contains yarn made from PET bottles recovered from the oceans. The Bionic Yarn clothing company, co-founded by popstar Pharrell Williams, and Dutch designer clothing company G-Star Raw have recycled around 700,000 PET bottles into yarn for each season's collection. 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 EUR 67.7-268.9 (GBP 45-200) each.

Box 12. Plastic Whale, Amsterdam

Plastic Whale is a social enterprise based in Amsterdam which has a unique way of tackling water-based plastics. The company 'fishes for plastic' in Amsterdam's canals, sorts the plastic and then recycles PET bottles so that canal boats can be made out of the material. Individuals, groups and companies then take part in fishing on the boats and the plastic they catch goes towards making more boats. So far, Plastic Whale has created a fleet of seven boats from 35,000 bottles. This initiative creates awareness and needed stakeholder engagement and buy-in to address the marine litter problem.

Box 13. Adidas

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, in Watkins et al. 2016).

Initiatives such as these create jobs and new markets for recycled marine litter, awareness of the problem, as well as helping to avoid pressures on the marine environment. They should, however, be seen only as one element of the solution, given limited cost-effectiveness and particular priority should be given to avoiding the generation of marine litter in the first instance. A roadmap indicating which stakeholders can take which actions is presented in section 5.

5. Road map for the way forward: building on circular economy solutions for marine litter in the EU

5.1 The EU Action Plan on the Circular Economy

The EU Action plan for the Circular Economy (COM/2015/614) offers the potential to help reduce the scale and impacts of marine litter, while increasing the value of materials in the EU economy. Particularly important measures that can help address marine litter include:

- ***Strategy on 'Plastics in the Circular Economy' (2017)*** p.14. This could offer an important vehicle for addressing marine litter (see table overleaf). Consultation is expected to be launched in September 2016. It is important that the costs and benefits of action, as well as promising measures and solutions are communicated to stakeholders so that the strategy addresses the problem effectively.
- *Revised **legislation proposals on waste**, a **more ambitious target for the recycling of packaged waste** (see below) (Already passed: December 2015)* p.14 - Addressing downstream waste is a key part of encouraging a circular economy.
- ***Specific action to reduce marine litter** implementing the 2030 SDGs target* p.13

There is also potential to help address marine litter via many other of the circular economy package's actions, as illustrated in Table 5.1 below. They are generally "hooks for action" that are non-specific to marine litter, but remain relevant. **Many of these should be developed and reflected in The Plastics Strategy that has been promised for 2017.**

Table 5.1: The opportunities to address marine litter in the Circular Economy Action Plan

Key	Plastic and marine litter both explicit foci	Plastic an explicit focus, marine litter more implicit (i.e. needs to be integrated)	Plastic and marine litter both only implicit – need for stakeholders to ensure explicit.

Section (pages of action plan)	Issue		Opportunity
Plastics (pp. 13-14)	***Strategy on 'Plastics in the Circular Economy' (2017) - - The Commission will adopt a strategy on plastics in the circular economy, addressing issues such as recyclability, biodegradability, the presence of hazardous substances of concern in certain plastics, and marine litter.***		**This is the main opportunity to ensure that circular economy measures to address marine litter are noted. Essential for stakeholders to contribute to the consultation and ensure key initiatives feature in the strategy**
Product Design (p. 4)	*Promote the **reparability, upgradability, durability, and recyclability of products** by developing product requirements in the **Ecodesign Directive** (2016 onwards)* *Create economic incentives for better product design through provisions on **extended producer responsibility** (COM/2015/595)*		Offer upstream solutions that can reduce single-use or short lifetime products that could or are known to contribute to marine litter
Production processes (p. 5)	*Inclusion of guidance on **best waste management and resource efficiency practices in industrial sectors** in BREFs (e.g. Food, Drink and Milk*		Key aspects here relate to the extent that plastics can be recycled, and the quality of

	Industries; Production of Polymers; Surface Treatment of Metals and Plastics) (2016 onwards)		recycled plastics. Exploring for example the impact of additives such as flame retardants.
Consumption (p. 8)	*Revised waste proposal will provide new rules which will **encourage reuse activities** (COM/2015/595)* *Possible use of **Product Environmental Footprint** to measure and communicate environmental information.* p.6		Engage and provide opportunities for behavioural change, which allow consumers to close the loop on plastics.
Waste management (pp. 8-11)	*Revised waste proposal: **recycling 65% of municipal waste** by 2030; **recycling 75% of packaging waste** by 2030; to **reduce landfill to maximum of 10% of municipal waste** by 2030; **a ban on landfilling of separately collected waste**; promotion of **economic instruments to discourage landfilling**; simplified and improved definitions and harmonised calculation methods for recycling rates throughout the EU. (COM/2015/595)*		Improved recycling reduces the risk of waste becoming marine litter. Implementation of waste hierarchy, see figure 3. Plastic is a formally recognised target area so relevant action easier to promote.
From waste to resource (p. 13)	*Develop **quality standards for secondary raw materials – in particular for plastics**. Improve rules on 'end-of-waste' (2016 onwards)* *Develop analysis on the **interface between chemicals, products and waste legislation** (2017)* *Develop the **Raw Materials Information System** (2016 onwards)*		Provides an economic argument for closing the loop. There is a need to help develop the market by providing information, awareness and legal clarity.
Innovation, investment (pp. 18-20)	*Horizon 2020 WP 2016-2017 – **Industry in the Circular Economy**, with funding of over EUR 650 million (Oct 2015 onwards)* *Pilot 'innovation deals' - to **address regulatory obstacles to innovators** (2016)* *Step up action to **mobilise stakeholders in the circular economy**, as well as targeted outreach to develop circular economy projects through Cohesion policy funds….[inc.] are of plastic recycling (2016 onwards)* *The **global dimension** of the circular economy and **supply chains** is prominent in areas such as sustainable sourcing, **marine litter***		Can catalyse the development of the circular economy and hence keep plastic and its value in the economy. Research objectives and knowledge gaps should also be considered.
Monitoring (p21)	*Monitoring framework for the Circular Economy to be developed with the EEA (2017)*		Monitoring of marine litter, and also level of plastic reuse and recycling will be helpful indicators of circular economy developments
SDGs (p3) (p13)	*This action plan will be instrumental in reaching the Sustainable Development Goals (SDGs) by 2030, in particular Goal 12 of ensuring sustainable consumption and production patterns.* ***Specific action to reduce marine litter** implementing the 2030 SDGs target* p.13		The EU has made global commitments to addressing marine litter (which is a cross border issue) – engagement and collaboration internationally is important.

Specific recommendations for action

1. **Extended Producer Responsibility: Use EPR to avoid certain types of marine litter,** most notably **single-use packaging items.**
2. **Research into product design** to facilitate reuse, repair, remanufacture and recycling, and complement this by providing more **information on the plastic composition of products**.
3. **Bans for unnecessary and damaging products or activities** where viable substitutes exist **-** e.g. plastic microbeads in cosmetics can be replaced by ground nut shells, marble particles or naturally-grown polymers, and plastic blasting in shipyards can be replaced by ultra high pressure water jets.
4. **Improved legislation: Provide clear definitions of polymers, waste and secondary raw materials.** Manufacturers need to design their products and packaging to fit into existing recycling systems.
5. **Economic incentives targeting consumption: Make greater use of economic incentives to make market signals part of the solution** - i.e. 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, disposable cutlery, and other one-use items.
6. **Transparency and labelling:** Improve transparency on the chemicals contained in plastics – to help with decisions on remanufacture and recycling. In addition, transparency on where personal care and cosmetic products (PCCPs) do and/or do not contain plastics. Explore the implications for additives such as flame retardants, plasticisers, pigments, fillers, and stabilisers.
7. **Waste management measures: Invest in waste collection infrastructure (at ports), waste management infrastructure and wastewater treatment facilities** to avoid dispersion of litter into the marine environment - particularly in coastal areas or near rivers.
8. **Awareness-raising: Raise awareness among consumers to improve waste disposal** (littering and waste separation), and also **better inform purchasing habits to increase demand for sustainable substitutes** - e.g. cosmetic products not containing microbeads (e.g. via Beat the Bead), multiuse bottles and bags, purchase of washing machines with filters.
9. **Fishing for litter: combined incentives to encourage action, and develop new products from waste.** While this is not the most cost-effective of solution (efforts higher up the hierarchy are preferable), it can create interesting branding opportunities for manufacturers, raise awareness and contribute to reducing pressure on the marine environment in selective places.
10. **Improved implementation: In addition, there is a need for better implementation of existing legislation on the release of litter, from terrestrial sources and at sea** – e.g. The MARPOL Convention, Waste Framework Directive, Directive on Port Reception Facilities**,** Water Framework Directive and, Marine Strategy Framework Directive.

5.2 A Road Map for the way forward

If the above measures are embraced, the EU can take a lead in implementing a transition to a circular plastic economy, which keeps plastic and its value in the economy and out of the ocean.

This leadership needs to be complemented by actions from a wide range of stakeholders, recognising their strengths in different areas **–** as illustrated in the following ***Plastics, Marine Litter and the Circular Economy Roadmap.***

Table 2: A Roadmap for Plastics, Marine Litter and the Circular Economy: examples of the role of stakeholders, policies and measures

	Knowledge – understanding the problem and solutions	Awareness and integration of knowledge	Policy, objectives, strategies and plans	Instruments, measures and legislation	Financing and investment
Global	GESAMP research into microplastics; UNEP regional seas research into marine litter	UNEA/UNEP and regional seas programmes; MARPOL convention	G7 Leaders' commitment 2015; UNEA-2 Resolution 2/11 SDGs: Target 14.1	Resolutions MARPOL Convention Targets	Regional Seas Programmes
EU	RTD (H2020 calls) re product design, circular economy solutions, health impacts of ingesting microplastics; Thematic studies	Studies on cost of action and cost of inaction; Monitoring of beach quality – surveys; Consultations	Circular Economy package and development of Plastics Strategy (2017) Waste, water, coastal and marine policies	Implementation of the Directive on port reception facilities (PRF) as well as WFD and MSFD; Bans on microbeads and plastic blasting of ships	EU Cohesion policy funding for water and waste water infrastructure, and for industrial symbiosis
National	Health impacts Ecosystem impacts Sources, pathways and sinks Impacts of marine litter on economy and society	Awareness raising initiatives for business, retailers and consumers Stakeholder engagement	Green fiscal reform Green public procurement, EPR Product Policy	Product taxes and charges; Bans on microbeads, plastic blasting of ships, and disposable plastic cutlery; Incentives for fishing for litter; Product labelling standards	Waste collection, recycling and waste water treatment infrastructure and services Clean-up activities Research funding Monitoring
Regions & Cities /ports	Assess cost of inaction on ecosystems, citizens and sectors of the economy Assess costs of clean up	Integration into green infrastructure strategies; Spatial planning and port development plans Information to port users	Green public procurement; Sustainable tourism initiatives/certification	Waste infrastructure & services; Port fees, fines and incentives; Awareness raising; Stakeholder engagement: volunteering	Port infrastructures; Clean-up activities
Private Sector	Research into eco-design possibilities Audit impacts from own activities and fine-tune management systems	Support transparency through increased information on plastic chemical components	Implementing producer responsibility; Sustainable product provision Industrial symbiosis to reuse wastes	Implementing and improving EPR schemes made mandatory by the national or regional government; Innovation re new products and services (inc. voluntary phase out and labelling)	EPR contributions Finance clean-up activities (e.g. hotels); New products and services; Recycling facilities
Civil Society & Citizens	Knowledge of impact of own actions (e.g. littering)	Purchasing decisions; Social norms	Responsible procurement / purchasing decisions; Environmental stewardship (i.e. not littering)	Volunteering for clean-up; Purchasing	Buying sustainable products and innovative recycled products
Research	Health impacts from ingesting microplastics; Ecosystem impacts; Studies on cost of action & inaction	Communicate research to policy dialogues – e.g. submissions to consultations	Research and Development on sustainable products for a circular economy	Labelling and tracking of certain products to understand global flows (e.g. destination of discarded fishing nets)	Scientific research vessels and analysis

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