Study to support the development of measures to combat a range of marine litter sources

Report for European Commission DG Environment

Dr Chris Sherrington

Dr Chiarina Darrah

Simon Hann

George Cole

Mark Corbin

29th January 2016

Report for Michail Papadoyannakis, DG Environment of the European Commission

Prepared by Dr Chiarina Darrah, Simon Hann, George Cole & Mark Corbin

Approved by

Dr Chris Sherrington

(Project Director)

Eunomia Research & Consulting Ltd
37 Queen Square
Bristol
BS1 4QS

United Kingdom

Tel: +44 (0)117 9172250
Fax: +44 (0)8717 142942

Web: www.eunomia.co.uk

Acknowledgements

We would like to thank all the stakeholders who have contributed their time and thoughts over the course of this study. There are too many to mention individually here, but all are listed in the appendices to this report. We would particularly like to extend our gratitude to Michail Papadoyannakis (DG ENV), Anna Bobo-Remijn (DG MOVE) and Iain Shepherd (DG MARE) whose comments on draft versions of the report were appreciated.

Executive Summary

This study investigates two key areas of marine debris research: litter from sea-based sources and microplastic litter from cosmetic products. The aim is to help the European Commission develop measures, including reduction targets, to combat marine litter. The work reviews the scale and nature of each of these sources as well as the measures to reduce them. This process reveals what is known and what is unknown in this field of research.

E.1.1 Incentivising Waste Disposal at Ports

The different types of cost recovery systems (CRS) used to charge vessels for waste disposal at port reception facilities (PRFs) are reviewed and analysed in terms of how they might incentivise waste delivery and therefore reduce illegal discharges at sea. The types of CRS are categorised in the report according to the net financial cost to the vessel. This enables an analysis of the cost saving (i.e. financial incentive) of illegally discharging the waste at sea rather than at the PRF.

The CRS creates an incentive to discharge waste at sea when there is a direct relationship between the quantity of waste and the cost of discharging it at the PRF. When a flat-rate fee is charged to all vessels, whether they deliver a large quantity of waste or none at all, this removes the financial incentive to discharge waste at sea. But this CRS creates no positive incentive to discharge the waste at the PRF either.

The most common types of CRS found in the EU do not provide a positive incentive to discharge waste at the PRF. This would be achieved if the vessel is charged with a significant deposit that is only refunded when it discharges waste at the PRF, or conversely a penalty that is imposed if the vessel does not discharge any waste at the PRF. If the deposit/penalty is large enough then the vessel will lose more money by illegally discharging the waste at sea than it would by paying to discharge the waste at the PRF. This was the only type of CRS found to provide a positive financial incentive to discharge waste at the PRF.

However, PRF costs are small relative to other costs that are incurred in ports and so the financial incentives created by the CRS may be a key factor in the decision to discharge waste illegally at sea or at the PRF. A refundable deposit could be set at a sufficient level to outweigh the other factors which lead vessels to discharge waste at sea.

Other disincentives to using a PRF are discussed in this study, for example administrative burden could be reduced for port users by harmonising the CRS between waste streams or between ports because of the time savings owing to:

- Simpler and potentially more transparent charging systems;
- Standardised and streamlined implementation of communications regarding notification and delivery; and
- Reduced training needs derived from the above.

The amount of waste generated by different sea-based sources is estimated mainly on the basis of the number of persons at sea for each maritime sector. The results are compared to data on delivery of waste at ports and the resulting generation/delivery gap shows the amount of waste from sea-based sources lost or discarded at sea each year. From this we estimate the total amount of marine debris from sea-based sources to be in the order of a few tens to a few hundreds of thousands of tonnes each year.

The proportion of marine debris from sea-based sources is also estimated from beach survey data, which places sea-based sources as causing 20-40% of the total input by weight (also estimated to amount to between tens of thousands to hundreds of thousands of tonnes each year). Survey data suggests that the distribution of this litter varies significantly between marine regions.

This suggests that sea-based sources account for a higher proportion of marine debris inputs than previously thought: the commonly touted, though unsupported, figure attributes 20% to sea-based sources and 80% to land-based sources. All such estimates contain a great deal of uncertainty but the revised figure shows that tackling at-sea sources can make a significant contribution to marine debris targets. Not all of this waste will be intentionally discharged at sea as some is the result of accidental loss. However, illegal discharges are thought to be an important source of marine debris and so the type of CRS used in a port could potentially have a significant impact in terms of reducing the total amount of litter generated each year.

E.1.2 Legal Provisions for Waste from Ships

This study reviews the legislative support for activities which combat sea-based sources of marine debris, from waste reduction through to enforcement. The legal provisions for each of the main waste types and pathways are analysed separately.

There are few gaps in European legislation prohibiting discharge of wastes, setting inspection regimes and imposing sanctions. However, there are weaknesses and ambiguities within the current legislative framework around the delivery by ships of their waste to port reception facilities, obligations for waste management and reporting, and inspection and enforcement. The following remain weaknesses/gaps in the current legal regime:

- Lack of harmonisation in CRS, not sufficiently removing incentives to discharge waste at sea,
- Lack of an effective system for detecting offences; and
- Insufficient resources devoted to garbage-related enforcement.

Actions with the most potential to tackle marine litter that can be addressed through updating the current legislative framework include:

- A harmonised CRS at a regional level that:
    - incentivises both waste minimisation at sea,
    - removes disincentives to deliver at ports, and
    - is tailored appropriately to very different users (for instance, cruise ships).

- Removing exceptions such as those for military vessels, small vessels and fishing vessels. Fishing vessels and recreational vessels account for a large proportion of both the person time spent at sea and the total waste generated at sea.
- Ensuring inspection agencies have accurate information on legal garbage disposal in order to detect infringements. This could be achieved through:
    - The mandatory reporting of waste delivery receipts and centralising handling of waste notification and delivery information at ports, and an effective exchange of this information between inspection authorities
    - Clarifying and harmonising inspection regimes under the PRF so that appropriate numbers of ships can be efficiently assessed for the risk of illegal discharge of garbage and inspected.
    - These changes would also be greatly supported by a higher level of involvement by port authorities in waste management and associated process, which could be more clearly mandated by the legislation.

Furthermore, these actions require not only legislative changes, but also co-ordinated action at a regional level, and between ports. In most cases, further problem definition and further consultation with stakeholders would be necessary in order to recommend specific legislative change to address these gaps. Voluntary measures may also be used to address gaps in addition to, or instead of, legislative approaches.

In addition, more attention could be given to supporting waste minimisation initiative at the level of specific industries, for instance in product standards that take into account potential impact on the marine environment.

Waste generated by offshore platforms is covered by many pieces of legislation, though not often explicitly mentioned, and obligations are not as comprehensive as for vessels. Offshore platforms cannot be covered within the PRF Directive and inspections, or the Port State Control regimes (both port-based systems for ships which call at ports), and can be exempted from requirements for garbage record books. We do not know how much waste is generated nor whether the rules are complied with.

E.1.3 Marine Litter Reduction Actions for the Fisheries and Aquaculture Sectors

Reduction measures tend to act either on reducing the current inflow of litter (prevention) or on the stock that has already accumulated in the ocean (removal), and in many cases they target specific sources and pathways of litter. Litter types, sources and pathways of debris from these sectors are therefore analysed to understand the possible efficacy of such measures. Gillnets and other fishing gear items are known to be especially harmful as they can entangle wildlife, vessels and other fishing gear, and so measures to reduce these litter types will be of particular interest to some stakeholders.

Two litter reduction goals have been assessed in order to determine which measures might be used to contribute towards them:

- A 30% reduction target set in the EU Circular Economy Package (as proposed in COM(2014)398); and
- The OSPAR action to address key waste items from the fishing industry and aquaculture.

Very few reliable data are available on the scale of losses from these sectors. Many of the figures used in the literature are no longer valid or relate only to specific fisheries, item types and pathways of debris, and so have limited use in estimating regional totals. Some of these figures are therefore disregarded and the others are combined with an estimate of intentional dumping of waste to provide an indication of the scale of these losses within the European Economic Area (EEA)[1]. The analysis finds that losses are in the order of 1,700 to 12,000 tonnes of fishing waste and 3,000 to 41,000 tonnes of aquaculture waste per annum. Total stocks of debris already present in the ocean may be in the order of 130,000 to 550,000 tonnes from the fishing industry and 95,000 to 655,000 tonnes from aquaculture.

Fish production data shows that industry is concentrated in a few countries within the EEA: Norway and Iceland being the most important for fishing and Norway alone being by far the most important for aquaculture. The countries with the biggest industries are likely to generate the most waste, but of course the quantity of this waste that is lost as marine debris will depend on various factors such as differences in operational practices and enforcement regimes.

Current and proposed measures to reduce marine litter from these sectors have been assessed. Prevention measures for large inflows of litter are most cost-effective, and litter removal can be made more efficient by targeted activities or working with fishers already removing litter from their nets. The most promising measures are:

1) Reduce losses of equipment from interference with other fishing gear and other navigation hazards:
    - Identify local hotspots for gear conflict. For each hotspot consider zoning controls. Work with fisheries and trade associations to promote and implement zoning restrictions, demonstrating the benefits to fishers to gain support for the system.
    - Mandate all vessels to carry GPS to facilitate location logging of lost gear for later retrieval.

[1] The European Economic Area includes Iceland and Norway which have large fishing and aquaculture industries and are contracting parties of OSPAR making them important to this study.

- Mandate reporting of gear loss and facilitate sharing of this information to reduce gear conflict. The data will also help to fill the knowledge gap of quantities lost. Mapping and reporting navigation hazards through the same system will also help to reduce issues of gear conflict.

2) Reduce dumping at sea:

    - Use market-based instruments such as advanced disposal fees, deposit refund schemes and manufacturer buy-back schemes to reduce litter and raise recycling rates.
    - Remove financial disincentives to bringing waste ashore including marine litter found at sea (litter retention). Port reception facilities play an important role and can be complemented with national recycling and disposal systems for items that require special processing such as nets and gear made from composite materials.

3) Shift consumption away from harmful products:

    - Reduce the use of plastic components of fishing gear that are designed to be lost or break apart during their use, e.g. plastic dolly rope, and polystyrene floats and buoys not sealed in a protective cover. This could be achieved with an outright ban on sale and use of such items, or an environmental tax that will make alternative products cost-competitive (and overcome the convenience factor).

4) Support litter removal programmes targeting litter hotspots or support fishers in handling and disposing of the litter caught in their nets.

E.1.4 Microplastics in Cosmetic Products

Work package two is intended to investigate the extent to which microplastics are used in the cosmetics industry within Europe and to frame this against the overall microplastics issue. Sources of microplastic have been identified through the literature. A quantification of the problem at an EU level has been attempted for the first time.

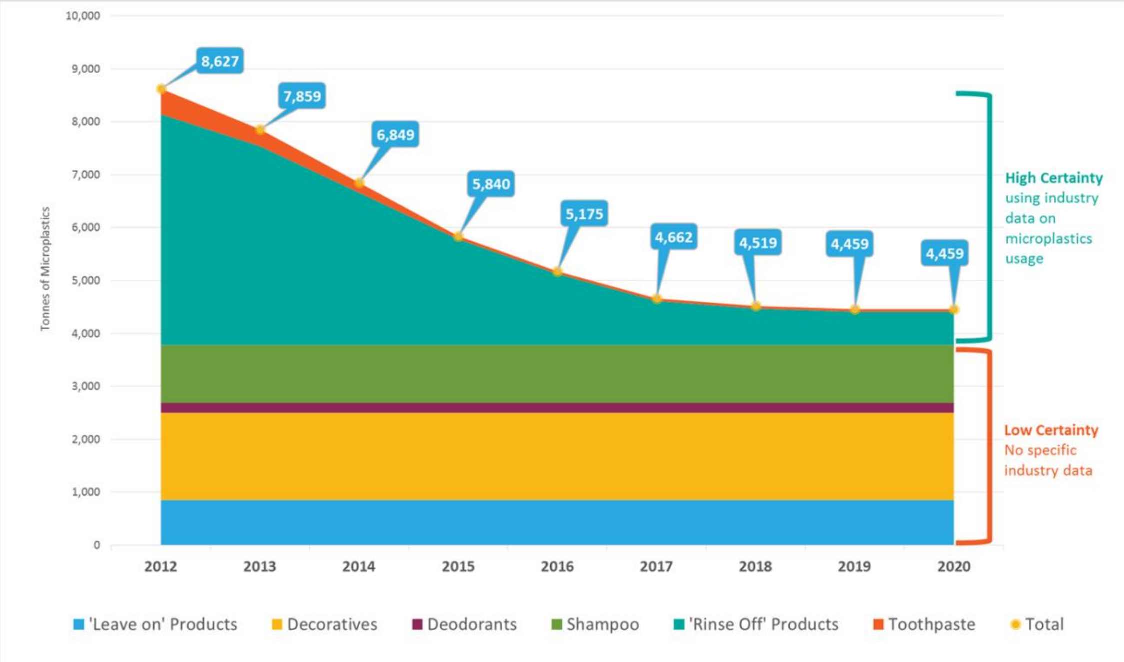
The results show that whilst cosmetic microplastics are far from the largest microplastic source, they are still significant and contribute up to 4.1% (much more than other recent industry estimates)—this is estimated to be between 2,461 and 8,627 tonnes entering the marine environment from Europe every year.

It is recognised that the cosmetics industry is working to reduce this amount, and through engagement with the industry, this report has concluded that a reduction of over 4,000 tonnes can be achieved by 2020.

Figure E-1 shows how this reduction may look. It also demonstrates the significant sources from products and materials that are not currently recognised by the cosmetics industry as a source of microplastic.

The extent to which microplastics are used in these other products is not understood and it is unclear whether they fall under current definitions and should be classed as marine litter. This report looks at this issue and expects that the cosmetics industry will be prepared to engage further to make sure that their products are not a source of microplastic marine litter.

Figure E-1 - European PCCP Microplastics Reduction Timeline



To achieve this it is recommended that the following actions are taken;

Agree on a definition that does not contain 'loopholes' - The current Cosmetics Europe definition is insufficient to adequately cover all of the potential product emissions of microplastic due to;

- biodegradable polymers being allowed with no definition of biodegradability;
- being limited to 'rinse off' products when microplastics are known to be a part of many 'leave-on' products; and
- excluding particles below 1µm (it is to be noted that the 2015 Cosmetics Europe recommendation does not include this threshold) .

Gain understanding of other cosmetics microplastics issues - There may be other polymer ingredients and indeed other products that contain microplastics that fall outside of the Cosmetics Europe definition. It is recommended that further work is conducted with the support of the industry into whether these pose an environmental threat and the magnitude of this threat. Part of this should be the investigation into whether product ingredient labelling is sufficient to aid consumers in understanding what is contained in the PCCP products that they buy; the International Nomenclature of Cosmetic Ingredients (INCI) may not currently be suitable for this.

Ongoing monitoring of European usage to improve data and transparency - Cosmetics Europe has suggested that they intend to conduct their survey of their members on an annual basis. It is suggested that the Commission support and liaise with Cosmetics Europe and other relevant trade associations in the process and that the results are made publically available. There are a number of NGO's such as the Plastic Soup Foundation (under Beat the Microbead) and Fauna and Flora International that have worked in this field and therefore should also be consulted and perhaps provide a portal for updates on progress to the consumer. Furthermore, it is also recommended that this and any other survey looks beyond its current scope to include all cosmetics products.

Ongoing monitoring of commitments - In a similar way, using the contact information that has been gained in the course of this study, the Commission could contact these manufacturers on an annual (or more possibly frequent basis, due to the fact that many have committed to be microplastic-free by the end of 2016) basis to discover whether they are on track with the commitments reported to this study. Furthermore, Cosmetics Europe issued a recommendation to its members to phase out microplastics from certain products by 2020. Any time slippage, without justification, may help the Commission to decide whether more measures are necessary. This process could also be streamlined by combining it with the abovementioned recommendation as Cosmetics Europe could collect this information at the same time.

Contents

Abbreviations

ALDFG = Abandoned, Lost or otherwise Discarded Fishing Gear

CR = Cargo Residue

CRS = Cost Recovery System

EMSA = The European Maritime Safety Agency

GES = Good Environmental Status

GT = Gross Tonnage – a measure of vessel size

ICC = International Coastal Clean-up

kW = kilowatts, a measure of a vessel's engine power

MEPC = Marine Environment Protection Committee

MCS = The Marine Conservation Society

MSFD = The Marine Strategy Framework Directive (2008/56/EC)

MSFD TSG ML = MSFD Technical Subgroup on Marine Litter

PCCP = Personal Care and Cosmetic Products

PE = Polyethylene

PET = Polyethylene terephthalate

PP = Polypropylene

PPE = Personal Protective Equipment

PRF = Port Reception Facility

PS = Polystyrene

PSC = The Port State Control Directive (2009/16/EC)

RSAP = Regional Seas Action Plan

SGW = Ship-generated Waste

SRD = Sewage Related Debris

T = Tonnes (metric)

WP = Work Package

WWT = Waste Water Treatment

1.0 Introduction to Task 1

Marine litter is widely recognised as a significant threat to the marine environment, causing environmental and socio-economic damage on a global scale. Due to its longevity and widely distributed use, plastics generally make up a large proportion of marine litter, posing an additional chemical risk.[2] Small plastic particles and microplastics are a major concern, since they are easily ingested by organisms throughout the food chain and can end up in species destined for human consumption.

The Marine Strategy Framework Directive (2008/56/EC) (MSFD) establishes a framework within which Member States shall take the necessary measures to achieve or maintain good environmental status (GES) in the marine environment by the year 2020. One of the eleven qualitative descriptors for determining GES under the MSFD is: "Properties and quantities of marine litter do not cause harm to the coastal and marine environment" (known as 'Descriptor 10'). This definition includes small particles and microplastics.

The Commission previously carried out three pilot studies on marine litter that primarily focussed on plastics from land-based sources.[3] A further study was carried out that built on these, to support the setting of a quantitative headline target on marine litter.[4]

Further supporting work on sea-based sources, and microplastics, was required to further the work towards the development of a marine litter reduction target, as well as the development of mitigation strategies and tactics. The Commission requested assistance to:

1) Develop possible actions to address sea-based sources of litter (Work Package 1), notably through

---

[2] Leslie, H.A., van der Meulen, M.D., Kleissen, F., Vethaak, A.D. (2011). Microplastic Litter in the Dutch Marine Environment, Providing facts and analysis for Dutch policymakers concerned with marine microplastic litter. Deltares report number 1203772-000, 85 pp.

[3] DG Environment, and Arcadis (2013) *Integration of results from three Marine Litter Studies*, accessed 27 August 2013, http://ec.europa.eu/environment/marine/pdf/Integration%20of%20results%20from%20three%20Marine%20Litter%20Studies.pdf, BIPRO (2013) *Study of the largest loopholes within the flow of packaging material*, Report for DG Environment, 2013, Arcadis (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, http://ec.europa.eu/environment/enveco/water/pdf/report.pdf,(2012) *Case studies on the plastic cycle and its loopholes in the four European regional seas areas*, Report for DG Environment, 2012, http://ec.europa.eu/environment/marine/pdf/Arcadis/Arcadis.zip

[4] Arcadis (2014) *Marine Litter Study to Support the Establishment of an Initial Quantitative Headline Reduction Target*, Report for DG Environment, 2014, http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/final_report.pdf

    a. improved incentivisation for the use of port reception facilities (WP1.1),
    b. reviewing the current global, EU and regional legislation for gaps in provision (WP1.2)
    c. tackling sources of marine litter from the fisheries and aquaculture industries (WP1.3); and
2) Carry out a preliminary scoping exercise for options to achieve a phase-out or ban of microplastics in cosmetic products (Work Package 2).

This document presents the results of Work Package 1.

The incentivisation of the use of port reception facilities (WP1.1) is examined in Section 2.0. The objectives were to establish a series of options to incentivise adequate waste disposal at ports, that respect the polluter pays principle, and evaluate their relative attractiveness and potential impact on marine litter. The work involved a series of subsidiary tasks:

- A review of current charging systems and their prevalence
- A review of existing data on performance of these systems and establishment of further criteria ('performance indicators') for evaluation of environmental outcomes and relative attractiveness of the scenarios
- The definition of four future scenarios for the incentivisation of delivery of waste to ports
- The evaluation of future scenarios according to performance indicators
    - High level estimation of marine litter reduction potential
        - A review of existing data on marine litter amounts and annual input by source
        - The estimation of waste generated at sea and comparison to existing data on waste delivery at EU ports to assess size of current 'delivery gap'

In Section 3.0 current global, EU and regional legislation is reviewed for gaps in provision with respect to waste generated from ships and offshore platforms with the potential to become marine litter (WP1.2). This is presented as a thematic analysis for each relevant type of waste generated at sea. Each element of the regulatory process (e.g. prohibition, waste management and prevention, infrastructure, information and communication, inspection and enforcement) is examined for each waste type and gaps are identified where further regulatory action could result in reductions of marine litter. Voluntary initiatives are also taken into account because they represent an important part of the context of legally binding provisions; in terms of outlining and 'filling' gaps in legal obligations; and in suggesting what may in future become a legal obligation. More detailed information on them is found in the Appendices 1 to 3.

Waste from the fisheries and aquaculture industries (WP1.3) are addressed in Section 4.0. The goals of the task are to identify options that could contribute to the fishing gear reduction goal proposed in the Commission's communication on the circular economy of 2014[5] and to support the European Commission in co-leading the OSPAR action to "identify the options to address key waste items from the fishing industry and aquaculture, which could contribute to marine litter, including deposit schemes, voluntary agreements and extended producer responsibility"[6] The options identified take into account the sources and types of fishing waste present in the marine environment. Cost-benefit analysis of options, including an estimation of the potential reductions in marine litter, was included where possible.

To deliver these goals, inventories of fishing waste types and of distinct abatement measures were made. As many abatement measures have only been piloted in limited circumstances, only example costs are available which cannot be translated to widespread implementation; these have been presented where found. Additionally, the availability of quantitative data on fishing waste and item types of it are so limited, especially in different marine compartments such as the sea floor or floating, that only high level conclusions have been made about potential contributions to the target. All the data available and it implications have been discussed in full. Where possible, evaluation of cost-effectiveness has been made.

The presentation and communication of draft findings during the project is outlined in Appendix A.7.0. In Appendix A.1.1, the stakeholders contacted in the course of Work Packages 1.1, 1.2 and 1.3 are listed. Feedback received and responses are also summarised in Appendices A.1.2 and A.1.3. Tables summarising the Terms of Reference and the work undertaken are presented in Appendix A.6.0.

2.0 Task 1.1: Incentivising Waste Disposal at Ports

WP1.1 is to establish options for the incentivisation of waste disposal at ports, that respect the polluter pays principle, and evaluate their performance in terms of their marine litter reduction impact and relative attractiveness to stakeholders.

---

[5] European Commission (2014) Towards a Circular Economy: A zero Waste Programme for Europe. COM(2014)398

[6] Paragraph 35, Regional Action Plan for Prevention and Management of Marine Litter in the North-East Atlantic: http://www.ospar.org/documents/dbase/decrecs/agreements/14-01e rap marine litter.doc

2.1 Approach

First, waste streams generated at sea are identified and assessed for their potential to contribute to marine debris based on a preliminary assessment of the materials which constitute them, and their fate according to EU legislation. Systems for the payment of waste disposal at ports are inventoried and characterised as to the net financial incentivisation of the discharge of waste at sea; they are then assessed for environmental performance and their relative attractiveness. A series of four future scenarios, chosen to give the widest range of improved environmental performance compared with the *status quo* in the EU, were assessed using the same criteria. Sources of evidence regarding the amount of debris currently in the sea, and inputted on an annual basis, from different sources, were assessed, in order to evaluate the potential contribution of improving the incentivisation of waste disposal at ports to mitigating marine debris. This included the estimation of waste generation at sea and comparing it to delivery statistics in the EU.

To ensure coherence and consistency, we have built on past and ongoing work undertaken for the review of the PRF Directive including:

- The European Maritime Safety Agency (EMSA), and Ramboll (2012) *Study on the Delivery of Ship-Generated Waste and Cargo Residues to Port Reception Facilities in EU Ports*,
- EMSA (2012) '*Addressing Illegal Discharges in the Marine Environment*',
- The IEEP (2013) reports commissioned by Seas at Risk:
    - '*How to Improve EU Legislation to Tackle Marine Litter*' and
    - '*Reducing Ship Generated Marine Litter – recommendations to improve the PRF Directive'; and*
- Panteia, and DG MOVE (2015) *Ex-Post Evaluation of Directive 2000/59/EC on Port Reception Facilities for Ship-Generated Waste and Cargo Residues*.

2.2 Waste Types and Marine Litter Generation

In this section we summarise the types of waste generated by ships and identify which are of relevance to the generation of marine litter. The summary is based primarily on the categories defined by the MARPOL convention and the PRF Directive. These categories delineate the scope of different legislative requirements, as well as the way in which statistics are disaggregated. Understanding them and, because they cut across each other, the relationship between them, allows us to fully assess the scope of legislation and statistics in a transparent way. Any one category normally includes waste streams that are out of scope with respect to marine litter; and no one category includes all of the waste streams that are relevant to marine litter. This section therefore gives a foundation, within the context of this study, for understanding what statistics and information, or parts of them, that are relevant for determining baselines. It is also intended to give some of the background information needed to determine the scope of the design and assessment of the future PRF implementation scenarios.

Each of the MARPOL Convention's technical Annexes covers a different group of waste types and shorthand such as 'Annex V waste' is commonly encountered. In Table 1 we indicate what we consider to be "marine litter generating waste types". The definition of marine litter found in UNEP's 2005 global report on the issue was

> *Any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment.*

Therefore we have used these criteria to assess the different categorisations of waste for relevance.

Table 1. MARPOL Classification of Waste

Annex	Name	Short Description	Notes	Relevance of Annex to Marine Litter
I	**Regulations for the Prevention of Pollution by Oil**	Oily Waste (Oil)	1. Operational a) Oily bilge water – i.e. contaminated water from machinery space b) Oil residue/ sludge from wastage or purification of fuel and lubrication oil c) Oily mixtures containing chemicals 2. Cargo a) Crude or refined oil cargo tank residues – Oily tank washings, scale and sludge from tank cleaning b) Dirty ballast water	N

Annex	Name	Short Description	Notes	Relevance of Annex to Marine Litter
II	**Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk**	Noxious liquid substances (Chemicals)	Applies to list of ~250 noxious liquid substances	N
III	**Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form**	Hazardous waste	Applies to substances identified as Marine Pollutants by International Maritime Dangerous Goods (IMDG) Code or which meet Annex III criteria.	N
IV	**Prevention of Pollution by Sewage from Ships**	Sewage	Grey water, black water.	Y – because black water is potential source of sewage related debris (SRD)
V	**Prevention of Pollution by Garbage from Ships**	Solid Waste	a. plastics b. food wastes c. domestic wastes d. cooking oil e. incinerator ashes f. operational wastes g. any cargo residues not covered in other Annexes e.g. solid residues, whether dry or in washwater h. animal carcasses i. fishing gear j. cleaning waste water	Y – categories a, possibly b (see below), c, f, g, i

Annex	Name	Short Description	Notes	Relevance of Annex to Marine Litter
VI	**Prevention of Air Pollution from Ships**	Air pollution – SOx, NOx, PM, ozone depleting substances	Covers gaseous emissions	N

Sources: www.imo.org; MEPC (2011) Amendments to the Annex of the Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships, 1973. (Revised MARPOL Annex V) Resolution MEPC.210(62). MEPC 62/24. Annex 13; Panteia, and DG MOVE (2015) Ex-Post Evaluation of Directive 2000/59/EC on Port Reception Facilities for Ship-Generated Waste and Cargo Residues, 2015; EMSA and Ramboll (2012) Study on the Delivery of Ship-Generated Waste and Cargo Residues to Port Reception Facilities in EU Ports.

In the legislation and literature the waste types covered by the MARPOL Annexes are sometimes split into two categories: "Ship Generated Waste" and "Cargo residue". The two categories are legislated for differently in the PRF Directive, for example.

Ship Generated Waste

In the PRF Directive 2000/59/EC, ship generated waste is defined as

> *…all waste, including sewage, and residues other than cargo residues, which are generated during the service of a ship and fall under the scope of Annexes I, IV and V to Marpol 73/78 and cargo-associated waste as defined in the Guidelines for the implementation of Annex V to Marpol 73/78* [7]

The definition of cargo-associated waste, a sub category of ship generated waste (not to be confused with cargo residue), is

> *materials which have become waste as a result of their use on board a ship for cargo stowage and handling*[8]

and it is a type of operational waste.

---

[7] Article 2 of the PRF Directive 2000/59/EC

[8] The current Annex V implementation guidelines (MEPC (2012) 2012 Guidelines for Implementation of MARPOL Annex V. Resolution MEPC.219(63). MEPC 63/23/Add.1. Annex 24) do not contain a definition of cargo-associated waste. However the definition has been found in other references and is a sub-category of "operational wastes" i.e. "Operational wastes are all cargo associated waste, maintenance waste, and cargo residues defined as garbage" IMO. *Comprehensive Manual on Port Reception Facilities*. IMO Publishing, 1999.

The category of ship generated waste relates to MARPOL waste types as follows:

- Annex I (oily waste from machinery space),
- Annex IV (sewage - black and grey water); and
- Annex V (garbage – excluding cargo residues and washing waste water)

Cargo Residue

Cargo residue is defined in Directive 2000/59/EC as:

> *the remnants of any cargo material on board in cargo holds or tanks which remain after unloading procedures and cleaning operations are completed and shall include loading/unloading excesses and spillage.*

The category of cargo residue relates to MARPOL waste types as follows:

- Annex I (oily cargo residue);
- Annex II (washing waters containing noxious cargo residues, as specified in MARPOL Annex II (category X, Y, Z, OS))
- Annex V (cargo hold washing waters containing residues and or cleaning agents or additives)
- Annex V (dry cargo residues not covered by other annexes)

Marine litter generating waste types, i.e. solid manufactured or processed material that persists in the environment can thus be found both within “Ship Generated Waste” and "Cargo Residues". Therefore legislation applying to either category is relevant to marine litter. By the same reasoning, any statistics dealing with ‘Ship generated waste’ or ‘Cargo residue’ are also relevant to marine litter.

Of particular note is that fishing gear is included in the Annex V waste that falls within the ship generated waste category. Annex V also includes solid hazardous waste (within the “domestic wastes” and “operational wastes” group particularly, and therefore these also fall within the ship generated waste category. Therefore any legislation that applies to ship generated waste also applies to fishing gear and hazardous waste. We would also expect that in theory, statistics on ship generated waste or Annex V waste, should include fishing gear and hazardous waste.

2.2.1 Fate of Annex IV and Annex V Waste under MARPOL and the PRF Directive

Here we provide a brief outline of what sorts of waste can be legally discharged to provide appropriate context for the assessment of the data on waste delivery to ports and its significance, carried out in Section 2.6.5.4. Legislative provision in terms of prohibition of discharge is dealt with in greater detail in Section 3.2.1.

2.2.1.1 Annex IV Waste

It is important to note that Annex IV allows discharge of sewage if:[9]

- it is treated;
- it is comminuted and disinfected (more than 3nm from land and not in a special area); or
- it is untreated (more than 12nm from land and not in a special area, at a rate that must be both specifically approved and be under a maximum discharge rate).

Sewage related debris (SRD) comprises a significant proportion of debris found in some coastal clean-ups, with prevalence ranging from a few percent up to 29% depending on the time and location (see Section 2.6.3). SRD starts its journey as manufactured items used for cosmetic and sanitary applications being disposed of improperly in toilets rather than via solid waste streams. On land, it is known that SRD reaches the marine environment via wastewater treatment plants that are unable to screen out small items, as well as combined sewage overflows that discharge untreated sewage directly into waterways when surface water flow is very high during heavy rainfall events. [10]

What we know about SRD from land based sources tells us that if treated or untreated sewage is being discharged at sea, from at-sea sources, this therefore presents a marine debris risk. Therefore there is some risk of the dispersal of plastic items in the sea by legal as well as illegal discharge of sewage. However, note that article 7 of the PRF Directive requires that in the EU, all ship generated waste is to be delivered to a PRF before a ship can leave the port and this includes sewage (unless the ship has proven sufficient dedicated storage capacity on board). Furthermore, the ship may be granted an exemption from mandatory delivery under article 9 when it is engaged in regular traffic with frequent and regular port calls and there is sufficient evidence of an arrangement to ensure delivery in a port along the ship's route and payment of the fee. However a vessel may take advantage of opportunities to discharge of sewage legally before it arrives in port.

2.2.1.2 Annex V Waste

The revision of MARPOL Annex V which entered into force in 2013 now means that discharge is generally prohibited except for certain waste types in certain circumstances. However no plastics can be disposed of in any circumstances and this includes solid

[9] www.imo.org

[10] Combined sewage overflow discharge is to avoid sewage backing up into homes in places where surface water drains and foul sewers are connected into the same system.

cargo residues that contains synthetic polymer, rubber, plastic or plastic feedstock pellets, as well as any operational or domestic waste that contains plastic.[11]

We note that food waste can be discharged >12nm from land and >3nm if it is ground/comminuted.[12] The propensity of organic (food and garden) waste to become contaminated by plastic is recognized with respect to municipal waste and has led to reprocessors seeking to establish limits for contamination.[13] Despite Annex V implementation guidelines stating that:

> *Precautions must be taken to ensure that plastics contaminated by food waste (e.g. plastic food wrappers) are not discharged into the sea with other food wastes*[14]

we consider the potential for food waste to be contaminated with plastic to be an additional reason why Annex V type waste is of relevance to marine debris and that there is some risk of contamination here by legal as well as by illegal discharge routes.

As noted above, the PRF Directive states that all ship generated waste, which includes most Annex V waste types, is to be delivered to a PRF before a ship can leave the port, with exceptions in the case of the ship demonstrating adequate onward storage capacity, regular scheduled stops, or proof of delivery and payment elsewhere. Cargo residue, within which category some Annex V waste falls, does not have the same mandatory delivery requirement, and the PRF Directive defers to MARPOL provisions for this waste category. Under MARPOL, some cargo residues, if they could not be recovered using commonly available methods for unloading, and as long as they do not pose a threat to the marine environment, can be legally discharged in specific circumstances.[15] However, as pointed out above, if the cargo residue contains plastic, discharge is not permitted in any circumstances.

---

[11] MEPC (2012) 2012 Guidelines for Implementation of MARPOL Annex V. Resolution MEPC.219(63). MEPC 63/23/Add.1. Annex 24

[12] Incidentally, fresh fish and fish parts generated by fishing and aquaculture are also not included in Annex V at all.

[13]Sources of plastic include: plastic bags used to store waste, plastic coated paper, and direct disposal of plastic items in organic waste. Examples of processor specification in the UK: http://www.resourceassociation.com/recycling-quality-specifications<0.24% for plastics by weight in garden waste; <0.5% for all types of contamination including plastic, in food waste.

[14] MEPC (2012) 2012 Guidelines for Implementation of MARPOL Annex V. Resolution MEPC.219(63). MEPC 63/23/Add.1. Annex 24

[15] Discharge of waste meeting these criteria is permitted outside special areas; and additionally, for cargo residues that are contained within wash water, within special areas at least 12nm from the coast if the ports of departure and arrival do not have adequate port reception facilities available and the vessel does not go outside special areas in transit between the ports.

2.3 Port Reception Facilities in Europe

2.3.1 Legislative Requirements

The PRF Directive 2000/59/EC[16] contains within it a variety of obligations with the objective of improving the delivery and collection of waste at ports, with the ultimate goal of protecting the marine environment from ship-sourced pollution.. Requirements generally apply to all ships, of all flags, and all ports in the EU, although there are exemptions for notification and charges for all fishing vessels and small recreational vessels (<12 people). The requirements, which help to understand the fate of waste and the extent of the incentive to deliver waste to a port, are summarised below.

- Ports must provide facilities for receiving waste (Article 4). They must:
    - Be available
        - Whether provided for in house or externally
        - All accompanying arrangements necessary for proper and adequate use of facilities must be provided.
    - Be adequate
        - Meet the needs of all users (all vessel sizes) with respect to types and quantities of waste
        - Meet the needs of the environment (preamble, paragraph 10)
        - And must do so without causing undue delay to ships
            - Therefore exemptions to the use of facilities must be made possible (see below)
            - Processes must be "simple and expeditious"
            - Member States must ensure that parties can claim compensation for damage caused by undue delay

- Vessels must notify ports of the ship generated waste and cargo residues they intend to deliver (Article 6 and Annex II)
    - Exempts fishing vessels, or 'recreational vessels carrying <12 passengers'
    - Notification can be submitted to the port authority, designated body, or to a waste operator, who must forward it to the relevant authority.
    - Notification requirement includes all waste (ship generated waste and cargo residue) with the exception of sewage ('for which the ship intends to make an **authorised discharge** at sea'). Although in the amended Annex II to the Directive, sewage is included in the Waste Notification Form, in a footnote to the form it states that *"the corresponding boxes do not need to be completed if it is the intention to make an authorised*

[16] Consolidated version: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02000L0059-20081211

discharge at sea"…"in accordance with Regulation 11 of Annex IV of Marpol 73/78".[17] However because of the mandatory delivery requirement of the PRF Directive, this would have to take place before the ship reached the port.

- Mandatory delivery of all *ship generated waste* (Article 7);
    - Unless the vessel has adequate storage capacity until the next port (Article 7 (2))

- Vessels must cover costs for the collection and disposal of *ship generated waste* (Article 8 (1)) and Article 8 (2) goes on to specify that;
    - Cost recovery systems (CRS) should provide no incentive for ships to discharge their waste into the sea and to this end:
    - All vessels must contribute "significantly" to costs whether they use facilities or not and these 'mandatory fees' (also termed 'indirect fees' – see Section 2.3.3.2) collectively should amount to at least 30% of the costs of the facilities[18]
    - This can be included in port dues or included as a separate waste fee
    - Such fees can be differentiated with respect to e.g. category, types and size of ship
    - The collective remainder of the costs for the facilities (i.e. 70% at most) should be recovered by charges set on the basis of the amount and type of waste delivered by the ship (also termed 'direct fees' – see Section 2.3.1).
    - Charges should be fair, non-discriminatory and transparent and reflect the costs of the facilities; the basis on which they have been calculated must therefore be made clear to port users.
    - Ships that produce reduced quantities of waste should be treated more favourably in cost recovery systems.

Fishing vessels, and recreational vessels carrying <12 passengers are exempt from the principles set out in article 8(2) – in effect this means no obligation for the CRS to 'provide no incentive for these ships to discharge their waste into the sea'; exemption from the mandatory component of the fee; and no need to provide favourable treatment for ships of this type producing reduced quantities of waste.

- *Cargo residues* are to be delivered in accordance with the MARPOL convention (to the extent necessary to comply with the tank cleaning requirement) and costs covered by the port user (Article 10).

[17] Directive 2007/71/EC "Amending Annex II of Directive 2000/59/EC of the European Parliament and the Council on port reception facilities for ship-generated waste and cargo residues".
[18] Percentage defined in separate statement http://eur-lex.europa.eu/resource.html?uri=cellar:15945efb-a7e8-4840-ab4d-0535f12692a8.0004.02/DOC_2&format=PDF.

- Inspections must be sufficient in number and penalties must be proportionate and dissuasive i.e. large enough to deter non-compliance (Article 11)
    - Irrespective of the framework of the inspections, a 25% inspection requirement applies as specified in the Port State Control Directive 95/21/EC (i.e. 25% of vessels calling at a Member State's ports must be inspected).[19]

- Exemptions may be granted with respect to notification, mandatory delivery, and mandatory fees (Article 9) if:
    - A ship is engaged in scheduled traffic, with frequent, regular scheduled stops and;
    - There is sufficient evidence of arrangements to ensure delivery of waste and payment of fees in another port on the ship's route

2.3.2 Interpretation Issues

There are various terms not strictly defined in the legislation, and this has led to wide variation and also difficulties in its implementation and evaluation. These include:

- Definition of 'adequate' facilities
- Definition of 'meeting the needs of users'
- Definition of meeting the needs of the 'environment'
- Provision for various authorities to which notification can be submitted, plus lack of definition of 'relevant authority' to which all notifications must be communicated
- Cost recovery systems to provide "no incentive" to discharge waste at sea. This could mean 'no incentive at all' or 'not enough incentive to make discharge at sea worthwhile'. If the former, this would suggest that no proportion of direct charge would be permissible (for the ship generated waste to which it applies).
- Option to include indirect fees in port dues or separate payment
- Indirect fees to cover '30% of the costs of the facilities' – the option is open as to whether it must be true for each type of ship generated waste or as a whole. Cargo residues are not covered by this requirement.

---

[19] Article 11.2.b). The Port State Control Directive (1995) states that "The competent authority of each Member State shall carry out an annual total number of inspections corresponding to at least 25 % of the number of individual ships which entered its ports during a representative calendar year." The recast Directive (2009) says that the number of inspections should correspond to a proportion of the total number of inspections to be carried out annually pro-rated by Member State according to the number of individual ships calling at its ports (the "fair share" scheme). However, in any case, waste management is not in fact a criteria at present for prioritizing "High Risk Ships" for inspection.

- '30% of the costs of the facilities' – some Member States do not view this as legally binding because the statement was issued separately to the Directive.[20]
- "Fair" and "non-discriminatory" charges
- 'Sufficient' number of inspections
- 'Proportionate' and 'dissuasive' level of penalties
- Criteria and method for assessing whether ships produce a reduced quantity of waste and hence may be treated more favourably by cost recovery systems.

It is relevant to note that in paragraph 1 of the preamble of the Directive the statement is made that: [21]

> *Community policy on the environment aims at a high level of protection. It is based on the precautionary principle, and the principles that the polluter should pay and that preventive action should be taken*

We draw attention to this aspect because some cost recovery systems could be construed to flout the 'polluter pays principle', in that fees may not be entirely or at all proportionate to the potential amount of pollution generated by a vessel. However Paragraph 14 of the preamble states that the polluter pays principle is intended to mean that the costs of waste collection and disposal should be met by port users, as opposed to any other stakeholder such as port authorities or Member States. This rules out "free-to-user" systems paid for by other stakeholders. And importantly, it means that a 100% indirect fee, where in principle each user pays the same fee, could still be construed as meeting the polluter pays principle as intended by the legislation. It is clear in the legislation that *all ships* are required to contribute to costs *irrespective of their use of the facilities* and so the fact that a user that does not deliver any waste still has to contribute, does not flout the polluter pays principle as intended by the Directive. Whether, and the extent to which, fees relate to quantities delivered (up to the 70% maximum direct fee implied by the 30% indirect fee requirement), is left up to each Member State – they are not required to include any direct fee at all, and we assume therefore in the event that a Member State did so, they would still be in line with the legislation.

It is also important to acknowledge that as well as the polluter pays principle,

- the policy aims at a high level of environmental protection;

[20] UK Maritime Coastguard Agency (2003), The Informal Guidance on the Mandatory Charge Element of the Port Waste Facilities Regulations 2003 issued on November 2003 by Shipping Policy 2 Division, DfT/ Maritime and Coastguard Agency November 2003. Cited in Panteia (2015) Evaluation of PRF Directive - Interim Report, Annex 2.
[21] PRF Directive 2000/59/EC, consolidated version: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02000L0059-20081211

- the precautionary principle should apply; and
- preventative action should be taken,

and there is no *a priori* reason why broader interpretations of the polluter pays principle should take precedence over all these other goals, especially when the legislation takes care to define the scope of the polluter pays principle more specifically.

Even if the legislation had not defined the scope of the principle in this way, where there are circumstances in which these principles enter into conflict, i.e. If a 'high level of protection' cannot be obtained by adhering to the other aims simultaneously, it can be argued that some discretion should be applied in order to achieve the ultimate goal of a high level of protection.

Regarding the lack of guidance about what 'meeting the needs of the environment' means (preamble, Paragraph 10), the only requirement is that waste should be handled and disposed of in accordance with EU legislation on waste (Article 12.g) of the PRF Directive). In Annex I of the Directive, on waste reception and handling (WRH) plans for ports, it is stated that

> *The procedures for reception, collection, storage, treatment and disposal should conform in all respects to an environmental management scheme suitable for the progressive reduction of the environmental impact of these activities. Such conformity is presumed if the procedures are in compliance with the Council Regulation (EEC) No 1836/93 of 29 June 1993 allowing voluntary participation by companies in the industrial sector in a Community eco-management and audit scheme*

However this allows a wide range of outcomes in practice. In contrast, some description of what adequacy means with respect to the user's needs is provided in Article 4 of the Directive, as well as further guidance issued by MEPC.[22]

2.3.3 Features of Cost Recovery Systems

In this section the different features of cost recovery systems are noted and discussed. These different features are to a large extent either entirely or partially combinable in one cost recovery system, as indicated. This introduction is to provide context and scope for assessing the provision of PRFs and the different cost recovery systems that currently exist in Europe. This will provide a baseline against which to assess future implementation scenarios.

[22] MEPC (2000) Guidelines for Ensuring the Adequacy of Port Waste Reception Facilities. Resolution MEPC.83(44/20). Annex 2.

2.3.3.1 Direct Fees

A 100% direct fee is one where all of the cost of collection and treatment of a port user's waste is borne by the individual user. Charges vary in proportion to the amount of waste delivered by the user, and there are no charges if the user delivers no waste.

2.3.3.2 Indirect Fees (and Reverse Fee Systems)

A 100% indirect fee[23] is a standard charge paid irrespective of the amount of waste delivered, including if no waste is delivered. Indirect fees can either be applied equally to all vessels, or they can be banded according to size thresholds (e.g. gross tonnage/engine power) and/or vessel types. Indirect fees can be included in port dues or as a separate waste fee.

The reverse fee system is very closely related. An example of this system is provided by Bremerhaven, where an indirect fee is paid upfront but this confers no discharge rights; the user then pays the waste operator direct fees, and then claims back all or some of the direct fees from the port authority. When looking at net costs, it is essentially a form of 100% indirect fee, and does not constitute a deposit system, though it may resemble it because of the upfront payment of the indirect fee; this indirect fee is in fact not refunded.[24] The user pays more upfront costs than the port authority, and both are subject to additional administrative burden when the user goes to the port authority and claims back the costs paid to the operator, rather than the port authority having to arrange payment to the waste operator out of the indirect fees which could theoretically be invoiced monthly.

2.3.3.3 Partial Indirect Fees

Partial indirect fees are where a standard charge is applied (indirect fee component) and is combined with a proportional charge (direct fee component) e.g. for waste delivered over a certain volume/tonnage or a certain vessel size threshold.[25] The indirect fee component may still be differentiated according to a vessel attribute such as size or vessel type. It can, again, be included in port dues or as a separate waste fee.

One example would be a CRS that charges an indirect fee and grants the user the right to discharge, for example, 3 tonnes of garbage at no additional cost (this threshold being related to quantity of waste that could have reasonably been generated since the port of last call). Any waste discharged above this threshold is charged using a direct fee component.

---

[23] Synonyms: no special fee (NSF), fixed fee, NSF/Unlimited use system

[24] This has been titled an 'Administrative Fee/Deposit with full refund' in other reports but here we wanted to distinguish between the reverse fee system and what we consider to be true deposit refund systems, as they differ in terms of their capacity to incentivise correct discharge of waste in port.

[25] Synonym: NSF/Reasonable use system

Currently the legislative requirement is that at least 30% of the total cost of facilities for ship generated waste should be covered by indirect fees. This does not necessarily translate to at least 30% indirect fees for each waste stream received by the facility, but can be interpreted as applying to the costs of managing all relevant waste streams (ship generated waste) summed together.

Rights Conferred by Indirect Fee Component and Calculation of Direct Fee Component

In some cases, the standard charge confers the right to deliver an amount of waste up to a certain threshold. Where the charge does *not* confer the right of any waste delivery it is sometimes termed an 'administrative fee' (ADM). This increases the number of different methods that can be used for calculating the direct fee component of a partial indirect fee. It may simply be calculated based on the total quantity of waste. Alternatively, where the standard charge gives delivery rights, the direct fee can still be calculated either based on the total quantity of waste, or the remaining quantity of waste.

2.3.3.4 Deposit Refund Systems

Our definition differs from previous papers with regards to the term 'deposit',[26] in that we use it only to signify a refundable deposit that is paid back in full when a vessel shows proof of waste delivery. This is not to be confused with previous papers on the subject which used the term 'deposit' to refer to both charges that are refundable and non-refundable, and refundable deposits that are paid back in full or in part, sometimes in proportion to the quantity of waste delivered. For the purposes of this study

> *A deposit refund system is where a deposit is returned in full on proof of delivery of waste at that or another port, whether to an in-house or external operator.*

The effect of being able to claim back the deposit is that it acts as an incentive for the vessels to deliver waste to port, and so the deposit is most effective when it is greater than the cost of the vessel's waste delivery. Otherwise vessels would still stand to gain from discharge at sea, to an extent equal to the difference between the higher delivery cost and the lower deposit cost. The level of the deposit might therefore be determined according to some vessel attribute, in order to set the deposit amount appropriately in relation to the general waste volumes and costs for vessels of a particular type or size. It can be applied alongside a partial indirect fee; in conjunction with a 100% indirect fee; or with a 100% direct fee system.

[26] Synonym: Administrative Charge (ADM)/Opposite Fee system.

2.3.3.5 Penalties

Penalties can be imposed for non-delivery of waste, or non-notification and non-delivery of waste.[27] They are charged unless proof of delivery at that or another port can be demonstrated (for some ports, it has to be at that port). These can be administered alongside direct or indirect fee systems. The penalty can be fixed, be similar in magnitude and calculation to an indirect fee, or calculated in proportion to likely waste generation e.g. the estimated amount of waste based on journey time from last port (e.g. 50% of estimated cost for that amount of waste).

2.3.3.6 Voucher Systems

A voucher system is where a ship entering a port must pay for a voucher that is redeemable, at that or another port, against the cost of waste disposal, at that or another port. Its value is determined by the estimated amount of waste disposal required for the ship based on ship attributes. It can be a way of ensuring payment (because it is upfront) under a direct fee system, and thus removing the cost saving from discharging waste at sea, whilst providing flexibility for vessels that prefer not to deliver waste on every port call. It could also be implemented alongside an indirect fee system, to provide the same flexibility, although as upfront payment is already provided for in the indirect fee system it would be redundant with respect to ensuring payment. It bears some resemblance to deposit and penalties systems in terms of net effect; being equivalent to a penalty or deposit scenario where the level is equal to the direct or indirect fee.

2.3.3.7 Restriction by Waste Type

Cost recovery systems are often restricted to particular waste types, so that for any particular port, multiple fee structures are in use. To recap, the five categories of waste generally catered for are oily waste from machinery space, sewage and garbage (together: “ship generated waste”) plus oily cargo residue and liquid cargo residue from dry cargoes “cargo residue”). We consider garbage to be the most relevant category to marine litter, followed by sewage and cargo residue, (in unascertained order). Therefore in the following sections we will assess prevalence and distribution of systems in detail for these categories only.

A further consequence of the restriction of cost recovery structures to particular waste types is that it makes it difficult to assess compliance with the PRF Directive requirement of at least 30% PRF costs for ship generated waste being recovered as indirect costs. This would necessitate the availability of cost data in a disaggregated form for different waste streams which is an unlikely prospect. Often not even total costs are known, especially when the service is provided in part or entirely by external suppliers.

[27] Synonym: Administrative Charge (ADM)/Opposite Fee system.

2.3.3.8 Exemptions

The legislation allows various exemptions (see Section 2.3.1); to recap, these are:

- All fishing vessels and all small recreational vessels (<12 passengers) are exempt from notification and mandatory i.e. indirect charges, (though delivery of waste is still mandatory and fees charged to these types of vessels should cover the waste reception and disposal costs, leaving direct charging an option in addition to indirect charging);
- Ships with frequent, regular scheduled stops and with sufficient evidence of arrangements to ensure delivery of waste and payment of fees in another port on the ship's route may be exempted from notification, mandatory delivery, and/or mandatory charges; and
- Favourable fees may be applied to ships producing reduced quantities of waste.

2.3.4 Prevalence and Distribution of Port Reception Facilities by Waste Type and Cost Recovery System in Europe

2.3.4.1 Availability of Port Reception Facilities for Marine Litter Generating Waste Types

It is useful to note what is known about the availability of Port Reception Facilities by waste type in Europe. This is a separate issue to that of what incentivisation scenario is employed for the use of the facilities, but it does provide important context for the project; i.e., for baselining the current situation and designing future scenarios.

The 2012 EMSA study on delivery of waste to PRFs found that all ports who responded to their survey (40) provided facilities for Annex V (garbage) waste.[28]This was also the finding of the stakeholder consultation carried out in 2014, which provided information on 10 additional ports.[29] The 2012 study found that all but two ports responding (92%) provided for Annex IV (sewage) waste, although in practice only 27 reported that their facilities were requested by ports users. By 2014 this number had increased to 97% of ports. Annex V (cargo residue) waste is usually dealt with directly by terminal operators, and information on delivery was not often communicated back to the port authorities. However around 80% of the 40 ports provided facilities for it in 2012. An update was not available for 2014. In principle, any type of waste could be disposed of in any port if a private waste operator could be engaged directly by the port user.

---

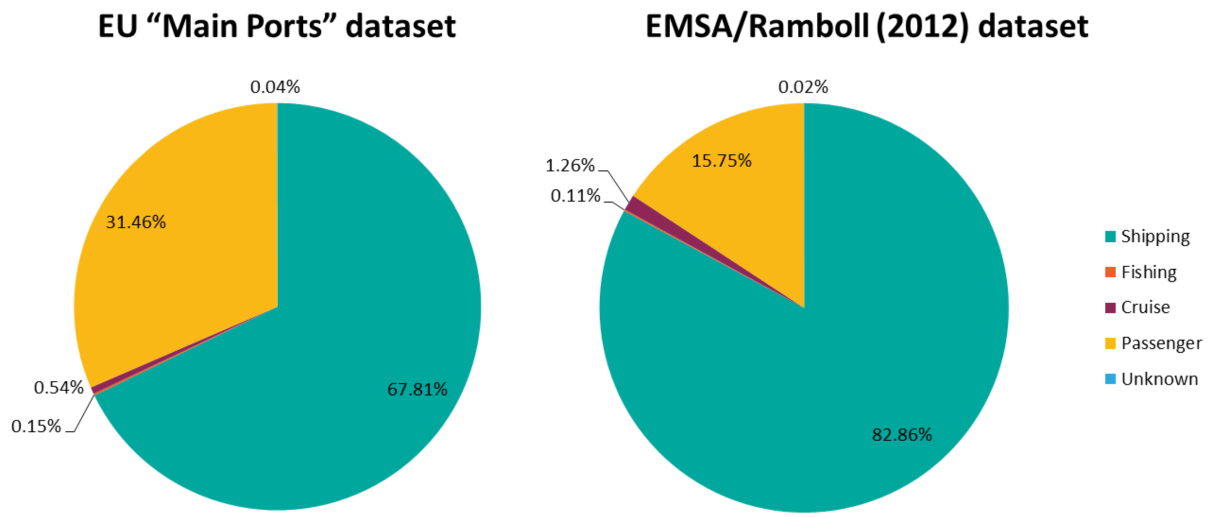
[28] EMSA, and Ramboll (2012) *Study on the Delivery of Ship-Generated Waste and Cargo Residues to Port Reception Facilities in EU Ports*, August 2012, http://www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities/download/1972/1607/23.html

[29] Panteia, and DG MOVE (2015) *Ex-Post Evaluation of Directive 2000/59/EC on Port Reception Facilities for Ship-Generated Waste and Cargo Residues*, 2015, http://ec.europa.eu/transport/modes/maritime/studies/doc/2015-ex-post-evaluation-of-dir-2000-59-ec.pdf

It is important to understand the potential limitations of the data available. The 40 ports included in the 2012 study cover 30% of the port traffic (by number of port calls) in the EU. The 2014 data covered 50 ports - 26-30% of ports in the EU by gross tonnage (the percentage varying year on year). In both cases, the ports constitute the major commercial ports in the EU. However the figures do not include the majority of traffic in the EU: 70% of the port calls (for the 40 port sample), or 70-74% by gross tonnage (for the 50 port sample), respectively.

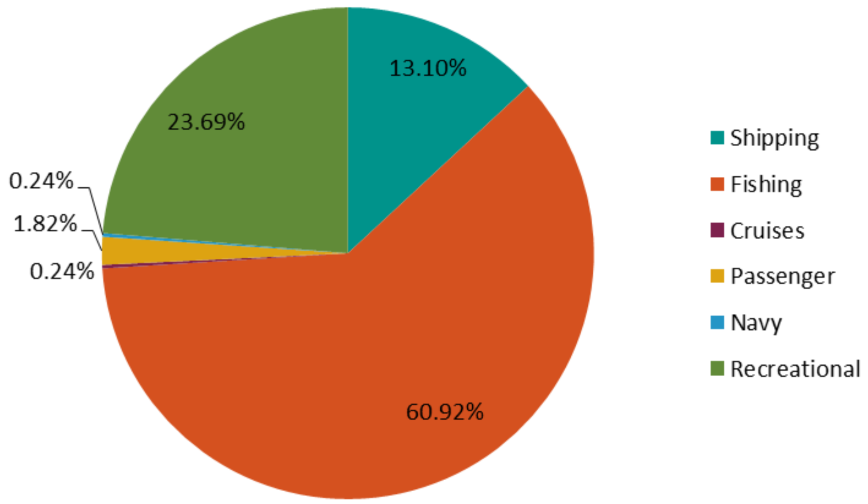
It is important to be aware therefore that this data may not accurately represent the situation in other ports. The way in which waste is received at the other ports represents an unknown and could hide a significant gap in provision. If some types of ports, such as fishing or recreational ports, are disproportionately represented in the ports outside the scope of previous studies, this also may affect how big any such gap in provision might be in terms of waste capture, assuming that different kinds of vessel produce different amounts of waste per call, and that ports catering for different types of vessels have greater or lesser propensities to provide adequate port reception facilities. If the propensity to provide adequate port reception facilities is less for e.g. smaller ports or ports providing for sectors underrepresented in the original sample, then this would lead to an overestimation in provision. Comparing Figure 1 and Figure 2 demonstrates that the fishing sector and the recreational sector are likely to be massively underrepresented in the types of ports sampled. In the two studies in question, Figure 1 shows that 0.11% and 0.15% of the ports in the samples are fishing ports, with no category explicitly for ports catering for recreational vessels; while in Figure 2, our own research leads us to believe that fishing vessels and recreational vessels account for around 85% of the fleet.

Figure 1. Representation of Different Maritime Sectors by Port Call in Different Subsets of EU Ports (2006)



Data from http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=mar_tf_qm&lang=en

Figure 2. Vessel Numbers by Sector, in Vessel-Years (2006) [30]



Data gathered for this study, see Section 2.6.5.1.

On the other hand, we note that in one study's stakeholder consultation, one Member State consulted stated that the PRF directive had had a particularly positive impact on smaller fishing harbours and marinas that previously did not have adequate PRFs.[31]

There is also the possibility that there may be significant gaps in coverage for some specific Annex V wastes that are being overlooked because of the crudeness of categorisations currently used when assessing availability of PRFs. Stakeholders and other previous reports have signalled that provision of hazardous waste, in particular, is an issue:[32] [33]

> *Other organisation: "Collecting facilities in pleasure craft ports are non-existing for most dangerous wastes, especially during winter docking"*
>
> *Port: "Ports cannot feasibly have facilities for all types of waste streams available all the time"*

---

[30] Vessel-years, as a unit accounts for the amount of time a vessel might spend at sea – there are millions of recreational vessels as opposed totens of thousands of fishing vessels, but the recreational vessels only spend a small fraction of their time at sea; so using vessel-yearsavoids the gross distortion resulting when trying to compare relative importance of the fleets of different sectors.

[31] Panteia, and DG MOVE (2015) Evaluation of PRF Directive - Interim Report, Annex 3.

[32] Panteia, and DG MOVE (2015) Evaluation of PRF Directive - Interim Report, Annex 3.

[33] IEEP (2013) *Reducing ship generated marine litter - recommendations to improve the PRF Directive*, Report for SAR, 2013

Port: "Sometimes some classes of waste (mostly dangerous ones) are not accepted at port. As an example, recently our port was not able to accept flares as waste."

Port user: "As an example, not all ports accept wood."

Port user: "Often happening to have itineraries where few ports in a row do not accept all types of wastes"

It is important to bear in mind that assessment of availability also does not take into account issues surrounding sufficient capacity for each waste stream, or acceptable discharge rates. However EMSA (2010) found that "almost all Member States have port reception facilities that are adequate and available, especially when it comes to ship generated waste", although exceptions were found in 5 Member States. [34]

2.3.4.2 Cost Recovery Systems

The different cost recovery systems found for different waste types are summarized in Figure 3. Their distribution is discussed in more detail in this section.

For Annex V (garbage) waste, very few ports implement a direct fee. The 2012 study mentions the following out of forty ports: Costanza, Maltese ports, Marseille and Le Havre. Of these, Malta, Marseille and Le Havre also impose a penalty for non-delivery of waste to incentivise waste delivery. None use a deposit refund system. It is also important to bear in mind that as fishing vessels and small recreational vessels are exempt from mandatory (i.e. indirect) charges, they are effectively under a direct fee.

Most ports have some element of indirect fee; the question is, how much?

From the descriptions provided in the 2012 study, around eleven ports appear to implement a 100% indirect fee for garbage.[35] Five of these, Copenhagen, Tallinn, Karlshamn, Goteborg and Stockholm, are in the Baltic region. The rest are scattered amongst the Black Sea (Burgas), North-East Atlantic and North Sea (Southampton and Dunkerque, Bremerhaven and Immingham), and Mediterranean regions (Algeciras). Dunkerque also implements a non-delivery penalty in addition to an indirect fee.

Around 26 ports impose some restriction on the amount of garbage that can be delivered, and this in effect means that there is a partial indirect fee system in place. None of these implement penalties for non-delivery, though Antwerp and Zeebrugge implement a deposit refund system. The proportion of indirect fee, on an individual port

[34] EMSA (2010) *Horizontal Assessment Report - Port Reception Facilities (Directive 2000/59/EC)*, 2010, http://ec.europa.eu/transport/modes/maritime/consultations/doc/prf/emsa-report.pdf

[35] The categorisation of CRS in the report differs from that used here and so re-categorisation was based on the available descriptions which were occasionally ambiguous for that purpose. EMSA, and Ramboll (2012) *Study on the Delivery of Ship-Generated Waste and Cargo Residues to Port Reception Facilities in EU Ports*, August 2012, http://www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities/download/1972/1607/23.html

user basis, depends on the threshold set (this can be cost or waste volume, which can be tailored for each vessel size or type) as well as the total amount of garbage they have to dispose of. On a port basis, where there is a differentiated threshold, the proportion of indirect fee will equate to an amount determined by the particular threshold, the number of, and types of vessels, and the total garbage the vessels had to dispose of. Where there is no differentiation, this would be easier to determine based on the threshold and the total amount of garbage received. This immediately demonstrates that working out what proportion of costs is covered by an indirect fee is challenging and not straightforward. However it is important to understand this to seek to evaluate the extent to which the fee system is incentivising waste delivery.

In theory, a port's need to meet the requirement of 30% of costs *for all port facilities for ship generated waste combined* can be covered by charging a 100% indirect fee for a waste stream whose facilities comprise 30% of the costs of the port's entire facilities for ship generated waste. As many ports charge direct fees for sewage (Annex IV), Annex I (oily waste from machinery space), which together are delivered in much larger quantities than Annex V (garbage), assuming similar unit costs of disposal, they would be very unlikely to meet the legislative criteria by charging less than 30% indirect fees for Annex V garbage. Therefore we might surmise that 30% represents an absolute minimum for the indirect f level for this waste type.

For Annex IV (sewage), around 14 ports charge a 100% direct fee, many more than for Annex V (garbage). 6 of these are in the Mediterranean and the rest are in the North-East Atlantic region. Again, some of these implement penalties (four: Dunkerque, Le Havre, Marseilles and Malta) or deposit refund systems (one: Zeebrugge). It is also important to bear in mind that as fishing vessels and small recreational vessels are exempt from mandatory charges, they are effectively under a direct fee for Annex IV (sewage) waste.

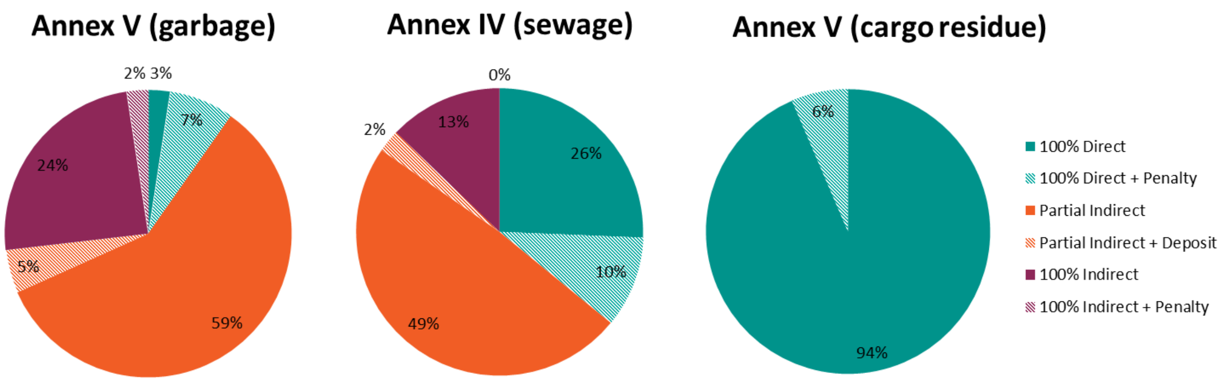
Only five ports charge 100% indirect fees for sewage, four are in the Baltic region and one, the North-East Atlantic. None of these implement penalties for non-delivery or a deposit refund system.

The remainder, around 20 ports, charge partial indirect fees. Delivery is permitted under the indirect fee up to a certain threshold, whereupon direct charges apply. Similar difficulties are thus evident in determining the proportion of indirect fees as for Annex V (garbage) waste for these ports. None of these ports impose penalties or make use of a deposit refund system.

For Annex V (cargo residues), it appears that all ports charge 100% direct fees, as might be expected given they do not fall under the PRF Directive's obligation to charge a 30% indirect fee, which only applies to ship generated waste as a whole. A couple of ports apply a penalty system in parallel to this for non-delivery of waste (Le Havre, Dunkerque) It is assumed that fishing vessels and small recreational vessels do not actually produce any of this type of waste; however more detailed operational knowledge of e.g. storage holds/freezer vessels would be needed to understand whether this is true or not.

Again it is important to be aware that this information covers only 30% of ports by number of port calls, and may not reflect the situation in remaining ports accurately. This leaves a significant unknown in terms of the cost recovery systems used to cover waste types. Because certain vessels are represented disproportionately amongst users of the remaining ports (e.g. fishing and recreational vessels), if the type of vessel that a port predominantly caters for affects the types of cost recovery system the port implements (e.g. because of different legislative requirements for different vessels), this could affect the assessment of the current situation regarding the prevalence of and distribution of cost recovery systems in terms of waste capture.

Figure 3. Prevalence of Cost Recovery Schemes for Marine Litter Generating Waste Types



Annex V (garbage), number of ports in sample = 41; Annex IV, n=39; Annex V (cargo residues), n= 31.

The Ramboll dataset of CRS used in EU ports, presented in Figure 3 was expanded and updated in the DG Move/Panteia (2015) report from 40 to 61 ports by incorporating information from a 2005 EMSA study, and by seeking clarification from port's websites and stakeholder consultation for certain ports.[36] [37] DG Move/Panteia (2015) classifies the CRS according to the port user's experience rather than by the relative extent of the incentive to discharge waste at sea, as is the case in this report. Unlike the Ramboll

[36] European Commission (2015) *Ex-Post evaluation of Directive 2000/59/EC on port reception facilities for ship-generated waste and cargo residues*, 2015, http://ec.europa.eu/transport/modes/maritime/studies/doc/2015-ex-post-evaluation-of-dir-2000-59-ec.pdf

[37] EMSA (2005) *Technical report evaluating the variety of cost recovery systems adopted in accordance with Article 8 of Directive 2000/59/EC on port reception facilities for ship-generated waste and cargo residues*

report, the CRS of each port is not described separately in the DG Move/Panteia report and so the expanded and updated list cannot be integrated into the above analysis.

It is immediately evident from these diagrams that there is a low degree of harmonisation in systems between waste streams.

2.4 Performance of Cost Recovery Systems

In this section, we evaluate cost recovery systems in terms of firstly, their environmental performance, and secondly, their relative attractiveness to stakeholders.

It is recognised that cost recovery systems (CRS) for PRFs can influence the behaviour of how vessels handle their waste. Indeed, the PRF Directive states:[38]

> *In the interest of protecting the environment, the fee system should encourage the delivery of ship-generated waste to ports instead of discharge into the sea.*

And under article 8:

> *The cost recovery systems for using port reception facilities shall provide no incentive for ships to discharge their waste into the sea.*

Of the features of CRS reviewed in Section 2.3.3, the main ones found in ports in the EU can be categorised into three main groups:

- **Direct fee component** – the vessel is charged based on the quantity of waste received.[39]
- **Indirect fee component** – vessels pay a standard fee that is not directly related to the quantity of waste deposited. When this is the only element of the CRS it is also known as the 'no special fee' (NSF) system.
- **Deposit refund** or **penalty component** - where the vessel incurs an extra cost if it chooses not to dispose of any waste at the PRF. This is also known as the 'administrative waste fee deposit / opposite fee system'.

In practice, these are combined to various extents to make up the CRS. In this section we analyse the effect which these features have on compliance with the requirements of PRF Directive outlined above; i.e. the extent to which they influence vessels to dispose of their waste responsibly, as well as their relative attractiveness to stakeholders. Additionally, the effect of different CRS on the delivery of 'fished' litter or retrieved litter such as fishing nets is discussed. Subsequently, in Section 2.5, four CRS scenarios are assessed using the same criteria.

---

[38] The European Parliament and the Council of the European Union (2000) *DIRECTIVE 2000/59/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues*, November 2000, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02000L0059-20081211&from=EN

[39] Note that this CRS is not compliant with Article 8 of the PRF Directive, which requires that all ships make a significant contribution to the costs of the PRF as an indirect fee.

2.4.1 Cost Recovery Systems and their Incentivisation of the Discharge of Waste at Sea

Different pressures apply to each waste stream and lead to different management behaviour by vessels. For example, vessels that manage their waste legitimately tend to dispose of garbage (MARPOL Annex V) in every port due to limits on storage space and to avoid unpleasant smells caused by storing it on board for too long.[40] For oily waste (MARPOL Annex I) vessels tend to have ample storage space, suffer no negative effects from sustained storage and so prefer to store the waste on board and dispose of a large quantity in one go. The CRS employed should recognise the preferred delivery frequency for different waste types, and not unfairly disrupt responsible waste management procedures of compliant vessels. For example, incentivising delivery of oily waste at every port call may not be practical or desirable, and mechanisms such as deposits and penalties would have to be adapted accordingly. For reasons of simplicity and scope we therefore focus on garbage (MARPOL Annex V) as this waste stream contains the greatest quantity of items that become marine debris if disposed of into the sea.

We also would point out that CRS have no influence over individual littering behaviour such as throwing an empty drinks container overboard after use, or any other behaviour which only marginally alters the quantities of waste delivered; its scope is in influencing the general decision to store waste, and to deliver it, versus discharging it at sea. Additionally, CRS can only influence port users if they are aware of the cost structure and implications. One Member State reported that

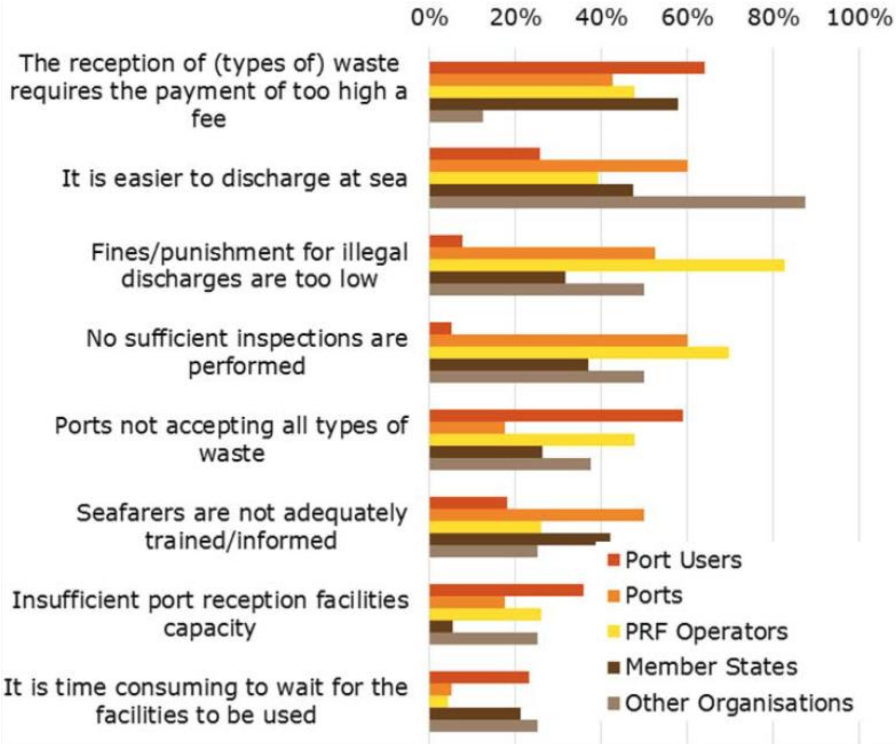
> *Sometimes facilities are not used because it's not common knowledge that the fee is mandatory.*[41]

A survey was conducted on behalf of the European Commission which elicited opinions from different stakeholder groups on the importance of different factors leading to the discharge of waste at sea, the results of which are presented in Figure 4**.** The survey did not separate the reasons for discharging garbage as opposed to any other waste stream, to which the different reasons given will apply to differing extents, as discussed above, so the results are must be considered with this in mind. The results show that more port users thought that illegal waste discharge was due to PRF costs being too high than any other reason.

[40] de Langen, P.W., and Nijdam, M.N. (2007) Charging systems for waste reception facilities in ports and the level playing field; a case from North-West Europe, *Coastal Management*, Vol.36, No.1, pp.109–124

[41] Panteia, and DG MOVE (2015) Evaluation of PRF Directive - Interim Report, Annex 3.

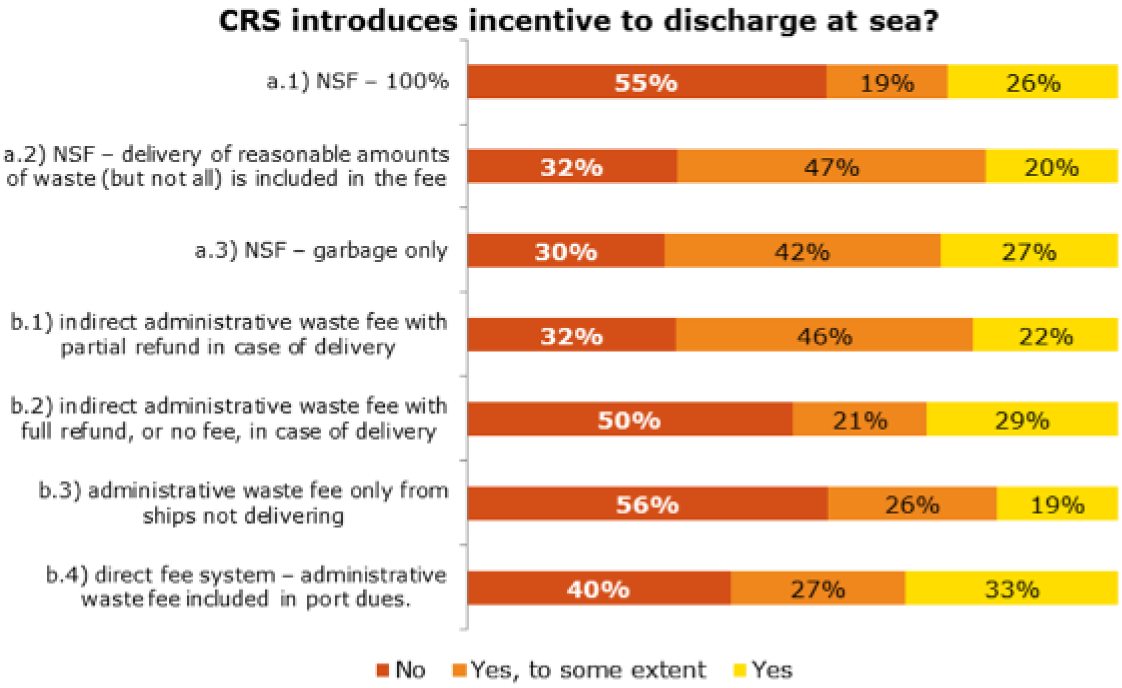
Figure 4. Stakeholder Consultation: Which Reason Contributes to the Decision to Discharge Waste Illegally at Sea?



Source: Panteia, and DG MOVE (2015) Ex-Post evaluation of Directive 2000/59/EC on port reception facilities for ship-generated waste and cargo residues, 2015

When asked specifically about different types of cost recovery systems, around half of stakeholders thought that penalty systems and full deposit refund systems did not result in incentives to discharge at sea, as shown in Figure 5. Where results differed between stakeholders, this was broken down. For penalty systems, the figure rose to 78% when port users alone were considered. Opinions about 100% indirect fee systems were similarly favourable amongst stakeholders as a whole, where again around 50% thought that it did not result in incentives to discharge at sea. However if the 100% indirect fee was applied to garbage alone, the proportion reduced to 30%. If port users alone were taken into account, this dropped further to 16%. For other systems (partial indirect, partial refund and 100% direct fees systems), 30-40% of stakeholders thought no incentives to discharge waste at sea were introduced.

Figure 5. Cost Recovery Systems and Incentive to Discharge Waste at Sea: Stakeholder Consultation Responses



Source: Panteia, and DG MOVE (2015) Ex-Post evaluation of Directive 2000/59/EC on port reception facilities for ship-generated waste and cargo residues, 2015

An important area to look into when attempting to determine the effect of cost recovery systems on marine litter is waste delivery data. It is assumed that there is an inverse relationship between the amount of waste delivered at ports and the amount of marine litter generated. The picture is of course, a little more complex. Such an assessment should also take into account the growth of the maritime sector, in terms of both gross tonnage and cargo handled, as well as seafarers employed, as we assume that the amount of waste generated is a function both of domestic type waste as well as waste generated by the maintenance and commercial operations of the ship.

One report assembling waste delivery data, based on delivery receipts, tentatively concluded that waste delivery has on the whole tended to increase over the last decade or so, both in absolute terms, and when taking into account general trends in gross tonnage. This has been taken as reflecting favourably upon the implementation of the

PRF directive.[42] Another study found that irrespective of the type of CRS in place, in most ports where an incentive to discharge waste in the port was introduced "as determined by expert observation", an increased level of waste delivery was observed when compared to the situation prior to the Directive's implementation.[43]

However, studies attempting to find correlations between CRS of particular types and delivery statistics have generally found it difficult to arrive at robust conclusions because:

1) there are so many potential configurations of CRS systems and a wide variety of these implemented in the EU;
2) delivery data is poor;
3) the point in time at which ports implemented their current systems varies and is generally not recorded; and
4) the ports implementing certain CRS may also have other features affecting the types of ships calling and thus waste delivery.

For example, in the Baltic region, some ports reported increased delivery of solid waste and sewage, after the "no special fee" was implemented,[44] while others felt it had no effect. Assessment of other waste types proved inconclusive.[45] Unless the sample size for each configuration could be increased considerably, variation within the subgroups will mask relationships. Nevertheless, the latest study testing the relationship between CRS systems and waste delivery (of MARPOL Annex I waste) concluded that a general increasing trend in waste delivery was observed only for ports with deposit systems; while since 2006 there has been a slow downward trend for ports with direct fee systems, partial indirect systems; and stable though low delivery trends for ports with penalty systems and 100% indirect fees (counterintuitively).[46] For Annex V waste, deposit CRS were associated with increasing volumes of waste delivered, penalties with stable but medium delivery over time; direct fees with low, stable delivery amounts over

---

[42] EMSA, and Ramboll (2012) *Study on the Delivery of Ship-Generated Waste and Cargo Residues to Port Reception Facilities in EU Ports*, August 2012, http://www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities/download/1972/1607/23.html,Panteia,

[43] EMSA (2005), Technical report evaluating the variety of cost recovery systems adopted in accordance with Article 8 of Directive 2000/59/EC on port reception facilities for ship-generated waste and cargo residues, cited in , Annex 2

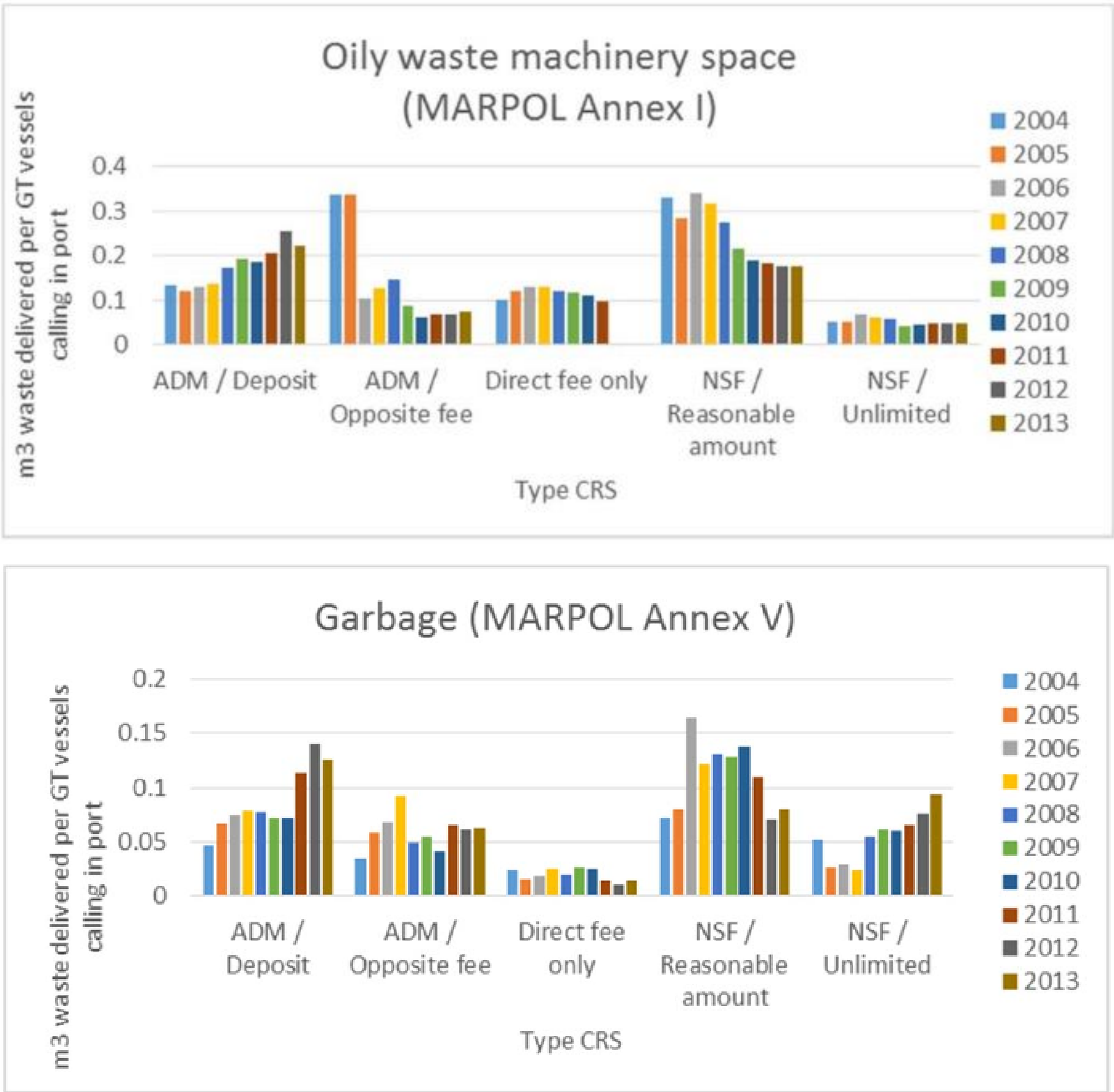
[44] Caveat: in some places actually a partial indirect free was in place rather than a 100% indirect fee as implied by the name "no special fee".

[45] Arcadis (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, http://ec.europa.eu/environment/enveco/water/pdf/report.pdf

[46] Panteia, and DG MOVE (2015) *Ex-Post Evaluation of Directive 2000/59/EC on Port Reception Facilities for Ship-Generated Waste and Cargo Residues*, 2015, http://ec.europa.eu/transport/modes/maritime/studies/doc/2015-ex-post-evaluation-of-dir-2000-59-ec.pdf

time, partial indirect systems with high delivery volumes peaking but then declining since 2010; and 100% indirect fees associated with increasing levels year on year since 2007. These results are shown in Figure 6. The study notes that volumes delivered in ports are also influenced by many external factors such as the traffic in the port, ship size, types of vessels, price level, efficiency on waste operations, and the type of port operations. It is important to note that these factors are not constant between or within the ports within in each CRS 'grouping' and will confound results to some extent. Because of these factors and because so many different variants of the principle CRS features are found in ports, there are limits to our knowledge from empirical data: the sample sizes of ports when all such factors are controlled for would be too small to make any valid correlation.

Figure 6. CRS and Delivery of Waste



Reproduced from Panteia, and DG MOVE (2015) Ex-Post Evaluation of Directive 2000/59/EC on Port Reception Facilities for Ship-Generated Waste and Cargo Residues*, 2015*

Real world examples of the different types of CRS are useful in understanding to what extent high fees of a CRS really do incentivise the discharge of waste at sea and therefore how a CRS may help remove some of the pressures that lead to the disposal of waste into the sea. In a 2008 study De Langen and Nijdam researched the competitiveness of three leading European seaports with different types of CRS:[47]

- **Partial Indirect Fee A**: The first port authority applies an indirect fee up to a maximum volume and disposal cost, which varies by ship size and is designed to cover enough garbage waste for at least one week at sea. If the vessel disposes of more waste than the maximum permitted by the indirect fee then they pay a direct fee on the excess quantity of waste.
- **Indirect Fee B**: This system is similar to the first but the indirect fee is higher as is the maximum disposal tonnage permitted. For the two types of vessel and garbage tonnage studied no direct fee was applied, therefore effectively we use the results to look at the performance of a 100% indirect fee system.
- **Direct Fee + Deposit Refund System:** Vessels pay a deposit which is refunded when they verify that all waste has been disposed of at the PRF or another European port. In this port vessels pay directly for waste disposal but receive a discount of around 30% to 40%. The discount is funded by the revenue from unclaimed deposits.

Figure 7 shows the fees charged to two vessels of different sizes and carrying different quantities of garbage (MARPOL Annex V) for two scenarios:

- When the waste is delivered to the PRF, and
- When the vessel chooses not to deliver any waste.

The difference in cost between the two scenarios represents the saving that a vessel could make by not disposing of the waste. For some vessels this saving could therefore be acting as an incentive to discharge the waste into the sea. It is important to understand the size of this incentive, and this will largely relate to how much this saving would reduce the profit margin and competitiveness of shipping operators. These values will vary for different operators and cargoes and so in order to gauge the scale of this incentive it is compared to the port dues paid by each vessel. This is also shown in Figure 7. Port dues are one of many costs that vessels incur in port, such as loading and unloading cargo and pilotage services. The costs for these other services depend on factors external to this analysis and so port dues alone are used for comparison.

---

[47] de Langen, P.W., and Nijdam, M.N. (2007) Charging systems for waste reception facilities in ports and the level playing field; a case from North-West Europe, *Coastal Management*, Vol.36, No.1, pp.109–124

Figure 7. Examples of PRF Fees for Garbage (MARPOL Annex V) circa 2008[48]

	5,000 GT 3,000 kW Cargo ship 1m³ Garbage (Annex V)			*35,000 GT 11,000 kW Cargo ship 3m³ Garbage (Annex V)*		
Port CRS	*Partial Indirect A*	*Indirect B*	*Direct Fee + Deposit System*	*Partial Indirect A*	*Partial Indirect B*	*Direct Fee + Deposit System*
Fee if not disposing waste	€ 70	€ 160	€ 500	€ 105	€ 230	€ 1,500
Fee if disposing waste	€ 90	€ 160	€ 40	€ 197	€ 230	€ 120
Incentive to dispose of waste into the sea[1]	€ 20	€ 0	€ -460	€ 92	€ 0	€ -1,380
Port dues[2]	€ 1,725	€ 2,640	€ 1,787	€ 11,943	€ 28,972	€ 24,883
Incentive to dispose into the sea as % of port dues[1]	1.2%	0.0%	-25.7%	0.8%	0.0%	-5.5%

GT = Gross Tonnage; kW = measure of engine power in kilowatts.
[1]Positive figures indicate sum gained from disposal into the sea; negative figures indicate sum lost from disposal into the sea.
[2]As stated above, port dues are used here simply to set the context of other costs incurred by vessels in port so that we may understand if the financial incentive to dispose of waste into the sea is a relatively large or small one for different vessel sizes.

The results show that smaller vessels carrying less garbage are most affected by the different incentives created by different CRS to discharge waste into the sea – whether they are positive or negative. However, even in the worst case scenario i.e. for the small

---

[48] de Langen, P.W., and Nijdam, M.N. (2007) Charging systems for waste reception facilities in ports and the level playing field; a case from North-West Europe, *Coastal Management*, Vol.36, No.1, pp.109–124. Note: the refundable deposit charged in the Direct Fee + Deposit Refund System is shown here in the 'fee if not disposing waste' although the deposit was not used in the paper's later analysis of CRS.

vessel at a port with a partial indirect CRS, there is relatively only a very small incentive created by the CRS to discharge the garbage into the sea illegally – a sum just 1.2% the size of the port dues that would have to be paid – amounting to 20 Euros. The deposit system used in the third port provides a negative incentive to discharge garbage into the sea (i.e. a positive incentive to deliver it to the PRF) and again this affects small vessels the most relative to the port dues – dumping would incur extra charges equivalent to more than a quarter of the port dues (25.7%).

Even though this example suggests that fees are not, in absolute terms, high, for small amounts of waste, stakeholder responses from the consultation suggest that more investigation may be needed into specific situations at particular ports to establish whether this is generally the case.[49]

> *Member State: In some countries the cost for delivering wastes, **especially domestic** is too high. Therefore, it is usually delivered in less expensive ports*
>
> *Port: There is still an economic advantage for vessels with a lot of waste (coming from or going to other parts of the world) to discharge annex V at sea*
>
> *Port: Particularly for the disposal of hazardous or other special waste, fees of a considerable amount may incur.*
>
> *Port User: More remote ports may be forced to charge higher fees, because there is simply no demand and competition for waste contracts in more remote locations.*

In future sections, we will rely on the assessment of environmental performance using mostly economic indicators regarding financial incentives or disincentives to deliver waste rather than direct environmental indicators, because uncertainties regarding the relationship between CRS and waste delivery mean that in turn, quantitative estimates of how much delivery could be improved by under different CRS are subject to too much uncertainty. However the waste delivery data and stakeholder opinion will be taken into account to 'sense check' the results.

2.4.2 Other Factors that Affect the Incentive to Discharge Waste at Sea

Removing a financial incentive to dump waste at sea from the CRS is an important step to reducing the amount of marine debris and will lead to some vessels making more use of PRFs. However, we have shown that under the most common CRS regime in Europe – the partial indirect fee – this financial incentive is small relative to other costs footed by vessels, at least for MARPOL Annex V garbage where typically waste volumes are small and disposal cost per tonne is low. The financial incentive is also not the only reason contributing to the decision to dispose of waste into the sea. The PRF Directive states

[49] Panteia, and DG MOVE (2015) Evaluation of PRF Directive - Interim Report, Annex 3.

that processes for receiving waste must be "simple and expeditious", and that this is to create an incentive to use facilities, which implies that these processes do affect incentivisation. Returning to the survey conducted on the importance of different factors leading to the discharge of waste at sea (Figure 4), three of the eight reasons listed in the survey relate to the adequacy of the port to receive all types of waste, with sufficient capacity, and without it being time consuming. These requirements are also set out in the PRF Directive (article 4):

> *Member States shall ensure the availability of port reception facilities adequate to meet the needs of the ships normally using the port without causing undue delay to ships.*

Ports must address these issues as necessary and this may lead to a reduction in dumping behaviour but they are not influenced by the type of CRS used, and in fact all ports surveyed do accept garbage. Assessments of "inadequacy" might be inflated because PRFs don't always accept segregated waste (out of scope of this project).[50]

'It is easier to discharge at sea' was seen to be an important factor by many of the survey respondents. The circumstances under which it is easier to discharge at sea and the pressures that apply in the decision making process of vessel operators and crew are not well understood. However, it may simply be that there has been a long established culture of disposing waste into the sea and despite ongoing education and training efforts this is hard to break

The port authorities contacted for this study report that their PRFs are easy to use and not time consuming (though this may not be the case for all ports and all waste streams, where waiting for berths to discharge of particular waste streams have been cited as a concern)[51] but other pressures may be leading to dumping behaviour. However, Figure 4 shows that around 20% of port users surveyed in the Panteia and DG MOVE (2015) study consider that time spent waiting for the facilities to be used is a disincentive.

---

[50] Caveat: Stakeholders and other previous reports have signalled that provision of hazardous waste particularly, is an issue; and there may be significant gaps in coverage for other Annex V wastes that are going under the radar because of the crudeness of categorisations when assessing availability of PRFs by waste streams. Panteia – Interim Report, Annex 3 (2015); IEEP (2013).

[51] EMSA (2012) *Addressing Illegal Discharges in the Marine Environment*, 2012 "An additional determinant element in the economic decision not to use port reception facilities is the additional time that a ship may have to stay in port to comply with waste disposal regulations. Interruption of commercial activities is costly for the ship operators. A vessel may have to wait a period of time before it is possible to discharge waste, depending on the availability of Port Reception Facilities, and the queuing system in place. In some ports, discharging at a port reception facility might also require a shift in berth, generating even more costs (use of tugs, linesmen, pilot, etc.). Shortage of staff available to undertake the task following proper procedures could also be an issue; the period in port is usually very busy, and there may not be staff available to undertake waste disposal operations unless the vessel stays longer in port for specifically this purpose."

A vessel operator may simply not want the hassle of co-ordinating a further task in port when dealing with other port activities which rank much higher in their personal and professional priorities. Crew members tasked with waste disposal may wish to spend the time recuperating, an important activity when under heavy workloads at sea, or engaging in personal activities available at ports such as contacting family members or shopping.. A stakeholder response from the study for DG Move supports this:

> Port user: *During port operations, the crew is often too busy with other tasks, hence, in some cases there is not sufficient staff to deliver all waste on shore.*[52]

In situations where PRFs are not as streamlined between waste types, as well as between ports, these pressures will be accentuated. Several studies have reported that a multiplicity of systems for different waste streams and between ports mean that the process of using port reception facilities is more complex, increasing the perceived level of inconvenience and also the level of training necessary for a high rate of compliance:

> *The wide range of different systems in place requires that the ship operator, master and/or crew are proactive in selecting appropriate port reception facilities. As a minimum, they need to determine what types of waste can be offloaded, what volume of waste will be accepted, and what arrangements need to be made (which, if different types of waste are involved, may also require different procedures). This administrative and logistical burden can also be a deterrent to effective waste disposal, making illegal disposal seem not only a cheaper, but also an 'easier' option.*[53]

The other inconvenience and time-costs in the process relate to the at-sea management of garbage. Vessels must provide containers for garbage, and most likely empty smaller containers distributed around the vessel into a central larger container to remove the garbage from sight of the crew and minimise the perceived smell that may be associated with it. The inconvenience and time-cost of these activities have not been quantified but may be considered low, especially where crew members are familiar with similar management of domestic waste on land. Conversely they may be considered high, if crew come from places with poor waste management. A stakeholder (a port) reported the following when asked about reasons for discharge of waste at sea:

> *The most common reason is laziness: it is easier to throw waste overboard at sea, than to handle it, store it, handle it again and deliver to a PRF. Most of the time ships are not (adequately) equipped with waste storage facilities*

Whether large or small, these barriers could be overcome by means of a positive incentive to dispose of garbage in a PRF.

---

[52] Panteia, and DG MOVE (2015) Evaluation of PRF Directive - Interim Report, Annex 3.
[53] EMSA (2012) *Addressing Illegal Discharges in the Marine Environment*, 2012

Whilst there may be a number of complex reasons why discharge at sea persists it is clear that further measures are required in order to create the behaviour change needed.

The largest difference between the responses of port users and those of the other stakeholder groups relates to efficacy of monitoring and enforcement. As shown in Figure 4, compared to other stakeholder groups far fewer port users thought that low fines and insufficient inspections contributed to the decision to discharging waste at sea. If some garbage is being dumped at sea then it must be assumed that, in these cases at least, the monitoring and enforcement regime is not able to prevent this illegal activity. It is not known whether improvements to the monitoring and enforcement regime would completely eradicate illegal dumping nor is it known whether it would be cost-effective to do so even if it were possible. It would be very costly to monitor and track all ship waste through inspections and undertake the subsequent enforcement activity, and so these activities are likely to remain a supporting measure where other measures fail to impact.

2.4.3 Cost Recovery Systems and Factors Influencing Relative Attractiveness

In this section, drawing upon evidence from the literature, and stakeholder input, some of the factors that affect the relative attractiveness of cost recovery systems are considered. Account is taken of the way in which perspectives may differ depending on the particular stakeholders concerned.

In Section 2.3.2 the meaning of the polluter pays principle in the context of the PRF Directive was discussed, and it was concluded that it was intended to denote that port users should foot the bill for waste management as opposed to any other stakeholder, rather than to denote that payments should be in proportion to the amount of waste disposed of.

That said, amongst ports and port users, the latter interpretation may still influence how attractive and/or acceptable stakeholders find different CRS elements, because the **systems that satisfy this latter interpretation are likely to be viewed as fairer.** However, intuitively, one might expect such a perception to be greater for types of waste such as cargo residue, which only some vessels produce, as opposed to forms of ship generated waste, which every vessel produces.

Systems adhering to the broader interpretation of the polluter pays principle may also be perceived as more attractive because they mean **lower fees for users with smaller amounts of waste**. This may be a particular concern with respect to Annex V (Solid CR). On the other hand, for Annex V (garbage), the savings involved are likely to be pretty small.

Banding of fees according to some vessel criteria that is related to waste volumes may help to alleviate some of these concerns. However, the volume of waste is likely to depend on various factors such as ship size, operations (fishing, shipping, cruise etc.), crew numbers, and fuel type, and this will vary for different waste streams. As there is no one criterion that is correlated with all waste streams, it introduces a moderate level of complexity to charging systems.

Lack of transparency about how port fees are calculated has been cited as a concern for port users. Where standard charges are included together with, and as an unknown proportion of, other dues, there has been concern that it could be a 'blank cheque' used as a means of profiteering, despite the fact that the PRF Directive states that fees should be set on the basis of *cost recovery*. [54] [55] However this lack of transparency, though some CRSs are more prone to it than others, is not necessarily an inherent aspect of any cost-recovery approach.

Some CRS may involve different levels of **upfront costs to users**, which may vary independently to overall costs. High upfront costs may be perceived negatively, even if they make little or no difference to overall costs.

Stakeholders, particularly port users, may find **positive incentives for 'good' behaviour more acceptable than negative incentives for 'bad' behaviour**. Negative incentives may be seen as failing to reward those who perform well e.g. undertake best practice in waste prevention, recycling and separation, which has not yet been the focus of PRF implementation. Additionally, industry is likely to have an aversion to schemes involving negative incentives because they will be regarded as punitive. However best practice schemes and applying negative incentives are not mutually exclusive. Incentivising *delivery* as well as best practice in waste management might be a necessary step to engage those that do not participate in proper waste management at all. Providing schemes that reward best practice – for example, a Green Ships scheme, could help to alleviate concerns around fairness and the polluter pays principle. In turn, this raises issues around administrative burden and whether the cost:benefit ratio is favourable.[56] However determining this is not the focus of the present study.

Additionally, there is the stipulation in the PRF Directive that the **facilities for receiving waste should lead to no undue delay for users**. While the particular CRS applied would not influence this in and of itself, **harmonising systems whether between waste streams or between ports may counterbalance user reservations regarding particular CRS**, because of the time savings owing to:

- Simpler and potentially more transparent charging systems;
- Standardised and streamlined implementation of communications regarding notification and delivery; and

[54] EMSA (2010) *Horizontal Assessment Report - Port Reception Facilities (Directive 2000/59/EC)*, 2010, http://ec.europa.eu/transport/modes/maritime/consultations/doc/prf/emsa-report.pdf
[55] Panteia, and DG MOVE (2015) Evaluation of PRF Directive - Interim Report. Annex 2.
[56] EMSA (2008), EMSA Paper on the identification of ships producing reduced quantities of ship-generated waste as provided by Article 8.2.c of Directive 2000/59/EC, cited in Panteia, and DG MOVE (2015) Evaluation of PRF Directive - Interim Report, Annex 2.

- Reduced training needs derived from the above.

On the other hand, Anna Bobo-Remijn, DG Move Policy Officer, suggested that different conclusions regarding the best CRS may apply to different waste streams, for example low volume versus high volume ones, although it is out of the scope of this report to explore CRS for all the different waste streams, so this has not been taken into account in our evaluation.[57]

An important question which will influence relative attractiveness is whether **administrative burdens for authorities** are similar between CRS regimes. One report state that: [58]

> *Implementation costs for authorities and…costs for ports… are not likely to vary significantly between one or another cost recovery system*

On the other hand, another study predicted that: [59]

> *The system of an administrative fee either charged ex post as penalty in case of non-delivery, or refunded upon delivery, require additional administrative procedures after waste delivery, and often require close cooperation between the port authority and the waste operators*

Again, **harmonising systems may help to counter this** because of time savings owing to:

- Sharing of best practice leading to reduced time needed for developing and updating waste management plans (harmonisation between ports); and
- Simpler waste management plans (harmonisation between waste streams).

Some CRS, if implemented in a restricted geographic area, have been reported to **distort the waste market at ports**. This can lead to inconvenience for ports for whom this results in disproportionate waste burdens; difficulties for ports whose PRFs may no longer be economical owing to the lack of waste throughput; and impact upon the likelihood of discharge at sea either because of poorer PRFs or because, as one stakeholder (a PRF operator) reported in one study: [60]

> *Ships can decide to keep up to the cheapest port with the risk to…fill the maximum capacity of storage and have no choice…but to discharge it at sea.*

---

[57] Stakeholder meeting held in order to provide feedback on this report.
[58] Arcadis (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, http://ec.europa.eu/environment/enveco/water/pdf/report.pdf
[59] EMSA (2005), Technical report evaluating the variety of cost recovery systems adopted in accordance with Article 8 of Directive 2000/59/EC on port reception facilities for ship-generated waste and cargo residues, page *26.* Cited in Panteia, and DG MOVE (2015) Evaluation of PRF Directive - Interim Report
[60] Panteia, and DG MOVE (2015) Evaluation of PRF Directive - Interim Report, Annex 3.

Harmonisation can also solve this problem for the CRS systems vulnerable to this issue; **by implementing across the board or at least, in a high percentage of ports in an area**, ports would not feel unfairly disadvantaged.

It was stated in EMSA (2012) that the current distribution and wide variety of different CRS systems across Europe was a result of ports generally choosing the implementation method that involved the least change to the status quo. This gives an important clue as to another driver for the relative attractiveness of different CRS systems; **how much change they will require by what proportion of ports.** Despite the many potential benefits to port users and authorities of harmonising systems, Antonis Michail, ESPO, reported that the diversity of ports in terms of size, user base and treatment systems, means that imposing harmonised systems would be unfair.[61]Environmental outcomes themselves may influence relative attractiveness, and the extent to which they do will be dependent on the particular stakeholder. For example, **some stakeholders may prioritize environmental over economic concerns.** For example, members of the public and environmental advocacy groups may be more likely to view marginal costs for overhauling the PRF system as being outweighed by the potential environmental benefits.

2.4.4 Assessment of Performance Indicators

We have reviewed how features of cost recovery systems and other factors can influence environmental performance; as well as the relative attractiveness of different charging structures and aspects of their implementation. The elements that can be equated to environmental performance and relative attractiveness are summarised in Table 2, and we will use these as a series of 'performance indicators' to evaluate specific cost recovery systems in more detail.

The performance indicators, and hence the rows of the table, are divided into 'net direct financial incentives' and 'other drivers'. As shown in Table 2, the net direct financial incentive to discharge at sea of a CRS can be one of following:

1) No incentive to discharge waste at sea (and no disincentive to discharge the waste at sea) – the vessel incurs the same costs either way.
2) Disincentive to discharge the waste at sea – the vessel will incur more costs by illegally discharging the waste at sea than it will if it discharges it at the PRF.
3) Incentive to discharge waste at sea – the vessel makes a cost saving by illegally discharging the waste at sea rather than at the PRF.

How 'net direct financial incentives' relate to environmental outcomes is clear; basically, a system that provides a disincentive to discharge waste at sea will perform better than a system that provides no incentive to discharge waste at sea (and no disincentive to discharge the waste at sea); which will in turn perform better than a system that

---

[61] Stakeholder meeting held in order to provide feedback on this report.

provides an incentive to discharge waste at sea. A large part of Section 2.4.1 was spent discussing what the net financial incentives of different cost recovery systems are.

On the other hand how ‘net direct financial incentives’ relate to relative attractiveness is more complicated; based on the environmental outcome of net direct financial drivers alone, a similar ranking arises. It should be borne in mind however that the environmental outcome created by the CRS will be relatively important for some stakeholders whereas others will be more concerned with other implications of the CRS. Overall attractiveness is dependent the assessment of these ‘other drivers’ too and this depends on the particular cost recovery system and implementation method.

‘Other drivers’, while primarily used to assess relative attractiveness, do influence environmental performance. For example, negative incentivisation, although it might be unattractive to some stakeholders (those who would prefer to be rewarded for their good management practice), may succeed in engaging a different group of hard to reach stakeholders (those that do not currently conform with existing legislation) and improve environmental performance.

And in turn, environmental performance influences relative attractiveness – for which reason, rather recursively, it itself has been included in the list of ‘other drivers’, at the end of the table.

Because of these interrelationships, a two dimensional table cannot fully represent what would be a complex flow chart of relationships, and it is intended as a simplified outline of the framework.

Table 2. Summary of Performance Indicators and their Impact on Environmental Performance and Relative Attractiveness

	Performance Indicator	Environmental Performance		Relative Attractiveness	
Net direct financial drivers	No incentive to discharge waste at sea (and no disincentive to discharge the waste at sea)	↑	*Only deals with direct financial cost of fees charged to users. Other costs and factors to incentivise dumping exist – so incentive not truly zero.* *Only minimal improvement for small volume waste streams such as Annex V (garbage).*	↑	*[Based on environmental outcome of net direct financial drivers alone; there will be different weighting by different stakeholders; overall attractiveness dependent on implementation method as evaluated by 'other drivers'.]*
	Disincentive to discharge waste at sea	↑	*More improvement relative to providing 'no incentive'. Overcomes other factors incentivising dumping.*	↑	*See above*
	Incentive to discharge waste at sea	↓	*For small volume waste streams such as Annex V (garbage) this effect is small*	↓	*See above*
Other Drivers	Satisfies polluter pays principle, in that vessels pay directly for all waste delivered (i.e. through a direct fee CRS)[1]	↓	*Associated with increased incentive to discharge waste at sea, but the effect is for small volume waste streams like Annex V (garbage)*	↑	*May be perceived as fairer by some stakeholders.* *Appeal of lower fees for those with smaller amounts of waste.*
	Change requirement	↑	*The more extensive, the greater impact*	↓	*Stakeholders likely to be change resistant*
	Administrative burden (for authorities)	-	*No effect*	↓	*Increased burden seen as less attractive*
	Upfront costs to users	-	*No effect*	↓	*High upfront costs perceived negatively, even if no difference made to overall costs*

	Performance Indicator	Environmental Performance		Relative Attractiveness	
	Transparency	↑	*Vessels may be more likely to participate if fees perceived as fair*	↑	*Stakeholders have expressed concern about transparency in the past so likely to be perceived positively*
	Positive incentivisation	↑	*May struggle to engage those with most transgressive behaviours*	↑	*Rewards those who do well*
	Negative incentivisation	↑	*More likely to influence those with the most transgressive behaviours*	↓	*Not rewarding those who do well* *Perception as punitive*
	Harmonisation: *leading to* *Time savings* *Transparency* *Level playing field*	↑	*Time savings help overcome 'hidden' incentives to discharge waste at sea*	↑	*Systems easier to use, to administer and more transparent* *Reduce distortion of market*
	Extent to which overall environmental outcome is positive	*n/a*	*n/a- This performance indicator* **is** *the 'Environmental Performance' so the assessment is not necessary*	↑	*Different weighting by different stakeholders*

[1] *According to the wider interpretation of the polluter pays principle than that of the PRF Directive*

In the following sections, the potential influence of the main features of CRS upon incentivisation of discharge at sea as well as relative attractiveness to stakeholders are evaluated according to this framework.

2.4.4.1 100% Direct Fee System

Under the direct fee system a vessel pays a fee relative to the quantity of waste delivered. This could be perceived by vessels as the fairest CRS *if there were no illegal dumping,* as each vessel only pays for the waste that it delivers to the PRF. Waste reduction is also positively incentivised via cost savings.

However, as shown in the practical example in Figure 7, it also creates the greatest financial incentive for a vessel to discharge into the sea. Under this system if a vessel chooses to deliver no waste to the PRF then it pays no fee and therefore avoids all costs of waste disposal. The direct fee system is therefore unfair as vessels that manage waste responsibly pay more than those that dump at sea. However, this incentive to dump at sea may be small when considered alongside port dues and the costs of other port activities. In addition, the incentive to dispose of waste into the sea is diminished if there are subsequent ports on a vessel's journey that operate a 100% or partial indirect fee CRS, as the waste can be stored on board until that port is reached and then discharged at potentially lower or no additional cost; although there is a risk that storage will be exceeded and that discharge at sea will still take place. The CRS creates no disincentive to dispose of waste at sea.

The 100% direct fee is non-compliant with the stipulation of the PRF Directive that an indirect fee must make a significant contribution towards the cost of the PRF. Relatively speaking, it will have comparatively poor environmental performance and this will make it less attractive to some stakeholders. This system is likely to be closest to what many ports that had reception facilities did before the PRF Directive, and require least change. It typically involves no involvement from Port Authorities and hence may be associated with a lighter administrative burden. Fees are always charged separately from other port dues and so it is clear to the user what is being paid and what service has been provided.

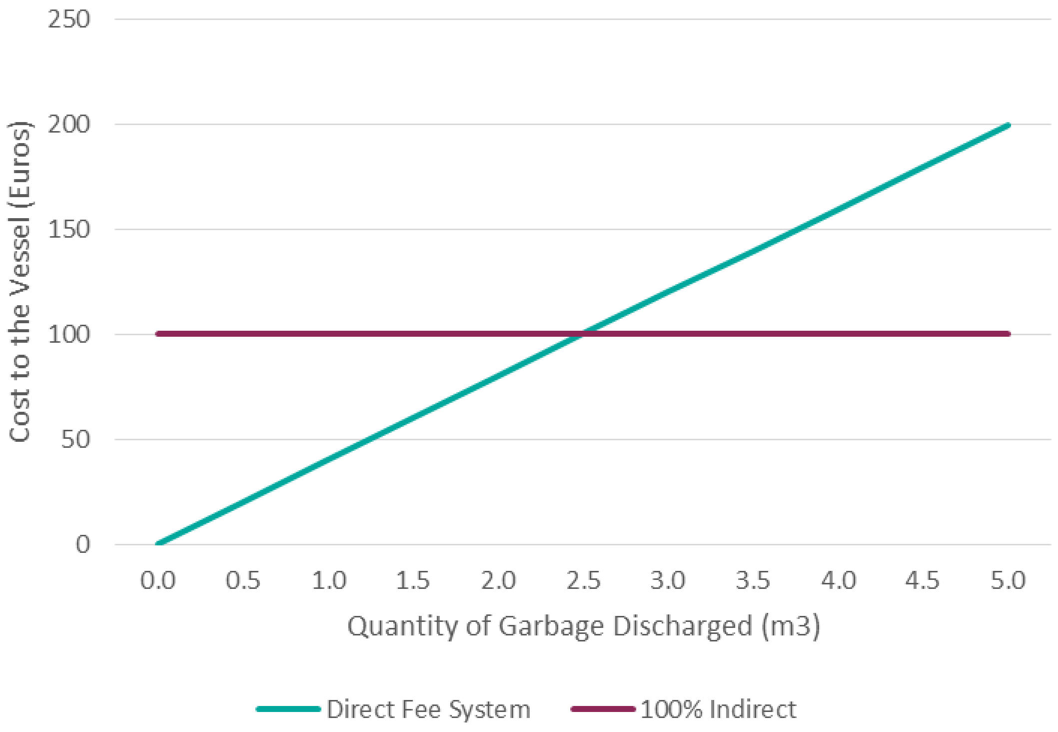
2.4.4.2 Indirect Fee Systems

Some port authorities employ an indirect fee that is completely decoupled from the quantity of waste delivered. Under this CRS a vessel will pay the same fee to deliver a large quantity of waste as they would pay to deliver no waste. Figure 8 compares the cost to a vessel delivering different quantities of waste for a 100% indirect fee compared to a 100% direct fee only CRS. In this example the indirect fee is set at €100 and the direct cost of garbage disposal is 40 € / m^3 based on the value reported by De Langen and Nijdam for the Direct Fee + Deposit Refund System port authority.[62] The volume of garbage (MARPOL Annex V) generated is related to the number of persons on board and the time since the vessel last disposed of the waste. Using a waste generation estimate of 2.5 kilos of waste per person per day (derived from data for a cruise ship)[63] and an average density of the waste of 1 tonne/m^3, the upper bound of 5 m^3 in Figure 8 relates to 2000 person-days of waste, or to put it another way a crew of 100 generating garbage for 20 days. The indirect fee, in this instance, covers the cost of up to 2.5m^3 of garbage (under a 100% direct fee approach).

[62] de Langen, P.W., and Nijdam, M.N. (2007) Charging systems for waste reception facilities in ports and the level playing field; a case from North-West Europe, *Coastal Management*, Vol.36, No.1, pp.109–124

[63] Policy Research Corporation (2009) *Tourist Facilities in Ports. The Environment Factor.*, Report for DG MARE, 2009, http://ec.europa.eu/maritimeaffairs/documentation/studies/documents/environment_factor_en.pdf

Figure 8. Cost to Vessel of Waste Disposal – 100% Indirect Fee vs. Direct Fee CRS



In contrast to the direct fee only CRS, the 100% indirect CRS does not create any financial incentive to dispose of any waste into the sea as waste disposal is provided at no additional cost to the vessel. However, the CRS provides no direct financial incentive to use the PRF, or financial *disincentive* to discharge waste at sea either (see Figure 11 for a comparison of all the fee systems in terms of their incentivisation to discharge waste at sea). A vessel that is content to discharge waste into the sea due to other pressures or influences, and is able to avoid enforcement of laws that prohibit this activity, may therefore still choose to discharge its waste at sea. The cost-saving of doing so is reduced under the 100% indirect fee compared with the 100% direct fee, as it will not avoid any waste disposal costs, but the scale of the cost-saving would be small relative to other costs in the first place, as shown in Figure 7; so this 'reduction in cost-saving' under the 100% indirect fee is also on a small scale. In essence the vessel has already paid the disposal cost through the indirect fee, and the notion of 'using something that has been paid for' may also influence the decision making process in deciding whether to discharge into the sea or to use the PRF. On the other hand, vessels may just regard it as a 'sunk cost' and disregard it. In the end, because the risk of detection is so low, discharge at sea is effectively free, save for a guilty conscience, and comes with indirect/non-financial benefits owing to time and convenience savings, so this may outweigh the aversion to losing the value of a service already paid for. Additionally, the system does not positively incentivise waste reduction and prevention.

An example regarding the harmonized no special fee system implemented by the Baltic countries for sewage initially seems to confirm that a 100% indirect fee, alone, may not be sufficient to incentivise the use of PRFs:

> *Sewage is covered by the no special fee system, but the system does not provide sufficient incentives in absence of legislation to make sewage discharges illegal and motivate delivery in ports.*[64]

Therefore the Baltic was designated a ‘special area’ where discharge was illegal. However, it is important to note that despite the intention to create a harmonized system, implementation in different countries in terms of granted exemptions, waste types and amounts under the system, was different. For example, in some ports no ships were covered by the indirect fee and in practice many ports were actually applying partial indirect fees. Therefore whether this was a true test of the potential success of the ‘no special fee’ system can be disputed. One could also take issue with the idea that prohibiting discharge provides sufficient incentive, when the likelihood of being caught, as things currently stand, is extremely limited.

To summarise, regardless of the limitations of the real world data available, the 100% indirect fee can completely remove the (sometimes only small) financial incentive to dispose of waste into the sea created by a 100% direct fee. However, for vessels that are willing to illegally dispose of waste into the sea, the indirect fee CRS provides no actual *financial incentive* to use the PRF. The system is thus likely to be associated with a moderately improved environmental outcome and therefore be supported by stakeholders for whom this is important.

The 100% indirect fee is likely to be perceived by vessels generating and delivering small quantities of waste as less fair than a 100% direct fee system, where a vessel only pays for the waste it delivers. The difference between the cost of the direct fee system and the 100% indirect system, see example in Figure 8, shows how vessels delivering different quantities of waste for disposal might be advantaged or disadvantaged under the 100% indirect fee. The 100% indirect fee disadvantages vessels delivering smaller quantities of waste as they pay a fee greater than the actual cost of their waste management. The 100% indirect fee benefits vessels that dispose of waste with a management cost greater than the indirect fee. Port authorities often set the indirect fee in bands based on factors such as the gross tonnage or power of the vessel, and the number of persons on board. This aims to adjust the indirect fee to the likely quantity of the waste that a vessel is carrying and therefore minimise issues of unfairness. If a vessel has sufficient storage capacity it could save costs by choosing not to deliver the waste at ports with a direct fee component and store the waste on board until it reaches a port

[64] Arcadis (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, http://ec.europa.eu/environment/enveco/water/pdf/report.pdf

en route with a 100% indirect fee CRS where it will be charged no additional cost to dispose of the waste. One port authority stakeholder suggested this behaviour takes place but it would be difficult to establish to what extent this is true without a comprehensive survey of port users. If it were commonplace then it would result in an increased quantity of waste received at these ports.

100% indirect fees may represent a significant departure for many ports from their current pricing structures, and especially for waste streams beyond garbage and sewage – e.g. Annex V cargo residue. 100% indirect fees are often included in port fees and both this, and the fact that they are not in proportion to waste delivered, have attracted concerns about transparency and inflated pricing. However, a lack of transparency is not an inherent characteristic of any specific cost recovery system and can be resolved. Increased involvement by the port authority is likely around price setting compared to 100% direct fee systems where prices are set solely by the external PRF operators. It is not essential but may be preferable, to facilitate change, to make sure that pricing is appropriately banded and not inflated, and information on pricing clearly disseminated to port users.

Partial Indirect Fee System

The extent to which partial indirect fee systems provide an incentive to discharge waste at sea is in direct relation to the relative proportion of the direct fee component; i.e. the larger the direct fee component, the more incentive there is to discharge waste at sea. At the same time, however, alignment with the polluter pays principle (according to its broadest interpretation), as well as the incentivisation of waste reduction and prevention, improves. If the indirect fee component confers delivery rights, these effects apply only to vessels producing more than the 'reasonable use thresholds' that may be set in accordance with the indirect fee component. If the indirect fee does not confer delivery rights, the effects are felt by all vessels, just to a slightly reduced degree in comparison to a 100% direct fee.

The PRF Directive (article 8) requires that all ships make a significant contribution to the costs of the PRF as an indirect fee, which the Commission later clarified to mean a minimum 30% indirect fee. This is low in that such a CRS is more similar to the 100% direct fee than the 100% indirect fee, for a larger proportion of ships with higher waste loads. Therefore incentivisation of discharge at sea will still be created.

In practice some vessels will choose not to discharge any waste in a port but will still be required to pay the indirect fee. The port authority will therefore have a revenue from the indirect fee but will not have to pay any PRF costs for that vessel (as no waste is delivered), and so can use this revenue to further support the system. Similarly, a vessel may discharge less waste than the value of the indirect fee. A port may therefore charge a relatively low indirect fee to all vessels and still cover the majority of the total PRF costs as it is supported by indirect fees from these vessels. Of course this effect would be diminished if more vessels choose to discharge their waste in the port. One example of this is seen in the Netherlands ports of Delfzijl and Eemshaven—operated by Groningen

Seaports— where a small mandatory indirect fee is charged based on the type and size of the vessel, and vessels are granted a 'right to discharge' up to a threshold value of waste for free (waste reception costs are refunded through the agent). Beyond that threshold value PRF costs are charged with a direct fee. The details of this cost system are shown in Figure 9. The right to discharge is financed through the revenue from the indirect fee of vessels which do not make use of the PRF or deposit less waste than the value of the indirect fee. In essence the waste reception facilities are largely funded by the vessels that do not deposit waste and so the small indirect fee paid by all vessels equates to roughly 100% of the collective waste reception costs of the vessels which choose to deposit waste.

Figure 9. CRS at Delfzijl and Eemshaven, Holland

GT-class	Indirect fee*	Right to discharge (value of waste)
Fishing vessels	€ 7.50	-
< 100	€ 7.50	-
101 - 2,000	€ 35	€ 300
2,001-3,000	€ 70	€ 400
3,001-6,000	€ 100	€ 500
6,001-10,000	€ 160	€ 600
> 10,000	€ 275	€ 1,000

** Exclusive of € 15 administration costs*

This shows that in specific circumstances, a partial indirect system for Annex V waste can easily cover most of the cost for the waste facility as a whole with a low fee to the individual vessel. In this particular case, the proportion of indirect fees that cover the cost of the whole facility will be much higher than 30% requirement associated with the PRF Directive. The pros and cons associated with direct fees are therefore diminished; i.e. the incentive to discharge waste at sea is reduced. In this instance, because of the banding system, the perception of unfairness should also be reduced. It must be noted however that as a port aims to increase participation in the PRF there will be more waste delivered and therefore increased waste management costs. Accordingly, as fewer vessels forego the deposit refund there will be less money available to subsidise these costs. The level of the indirect fee will therefore need to be raised to keep the system in equilibrium and maintain the same high proportion of indirect fee.

In the examples given in Figure 7 two port authorities operate partial indirect fee CRS. For the 'Partial Indirect A' port authority the right to discharge is lower and so a greater portion of waste may be subject to a direct fee. The Partial Indirect B port authority is similar to Delfzijl and Eemshaven in that vessels are granted the right to discharge a large quantity of garbage under the indirect fee and so the quantity of waste subject to a direct fee, and therefore the incentive created by the CRS to discharge waste into the sea, is minimised.

These discussions show that the environmental outcome associated with partial indirect fees will be subject to considerable variation depending on the exact configuration, of which there are many potential variations. Generally speaking, partial indirect fees will be associated with improved environmental outcomes the greater the indirect fee component. They can expect to attract support associated with better environmental outcomes in proportion with an increased indirect fee component.

An issue that may be experienced by ports with a high proportion of indirect fees may be the attraction of high volume waste producers because of favourable charges. This is problematic as ports then have to deal with far more than their fair share of the waste stream as a whole. On the other hand, it would provide more revenue for waste operators, and potentially port authorities. Ports are businesses which generally view increased custom as positive, although the advantage would be minimal if the advantageous conditions lead to more waste being discharged but no increase in port calls.

Additionally, diverting waste disposal away from other ports may make the provision of port reception facilities in such places uneconomical. Attempts have been made to limit the market distortion by imposing ‘reasonable use’ limitations, but this effectively means that a partial indirect fee is in place and an incentive to dump is then created. This incentive could be minimized by setting the proportion of indirect fee very high (which doesn’t necessarily equate to high standard fees, as shown by the previous examples). However it could also be tackled by harmonisation – as long as this covers a sufficiently large geographical area.

Where indirect fees, whether 100% or partial, are included in port dues, there are negative implications for transparency, as it becomes more difficult to assess what proportion of the port’s PRF costs are covered by indirect fees. This leads to an increased potential for, or at least risk of increased perception of, unfair pricing. Where the indirect fee component does not confer delivery rights, this may also increase perceptions of unfairness. That said, ports and waste operators operate in a competitive market and this should keep prices low. It has been suggested also that port authorities could be involved in monitoring whether pricing is reasonable or not, to improve confidence in the system, although this would increase the administrative burden of port authorities to some extent. Both mitigating factors would be facilitated by billing indirect fee components separately from other port charges.

For some ports, imposing indirect fees as an ‘administrative charge’ on top of a direct fee system, resulting in a partial indirect system, may represent a relatively easy way of introducing an element of indirect fee without overhauling the entire pricing structure and its administration.

2.4.4.3 Deposit Refund/ Penalty System

Some port authorities choose to charge vessels a deposit that is refunded when proof, such as a waste receipt, is provided to show that the vessel's waste has been disposed of at the PRF. If the vessel chooses not to dispose of its waste at the PRF then it does not receive the refund of the deposit. This provides what resembles a *positive* incentive for the vessel to use the PRF in order to receive the refund. The need for such an incentive is reflected in the PRF directive:[65]

> *the fee system should encourage the delivery of ship-generated waste to ports instead of discharge into the sea*

Instead of a deposit other ports choose to charge vessels a penalty if they do not provide proof that they have used the PRF, and the net effect is essentially the same in that the vessel will lose money if it does not make use of the PRF. As vessels may not wish to deliver waste to every port on their journey a port authority may accept a receipt from a port visited later as proof of waste delivery, giving this system extra flexibility.

In Maltese ports vessels are charged a penalty if they do not notify the authority with a waste receipt for waste handling within 15 days. The size of the penalty is based on the gross tonnage of the vessel and the number of persons on board, up to a maximum of €582.[66] This penalty is relatively low compared to the deposit charged in the Port of Antwerp in 2004 which varied between €500 and €3,000.[67] In Malta, vessels deal directly with PRF operators to organise the collection and disposal of the waste for which they usually pay a direct fee. Whilst the penalty provides positive incentive to use the PRF there is no incentive to dispose of all of the waste. A vessel seeking to minimise costs may choose to deliver only the minimum tonnage that will not rouse suspicion and discharge the remaining waste into the sea in order to avoid the majority of the direct fees for waste delivery whilst not losing the deposit or being charged a penalty for not delivering waste. However, as shown in Section 2.4.1 these direct fee costs can be relatively small and so such behaviour is unlikely.

As mentioned above the PRF operators in Malta charge a direct fee for waste discharged. They apply a minimum fee for this service whereby waste quantities below a certain threshold are all charged at the same rate, and so, similar to the partial indirect CRS, the disposal quantity up to this minimum value is associated with no incentive to

---

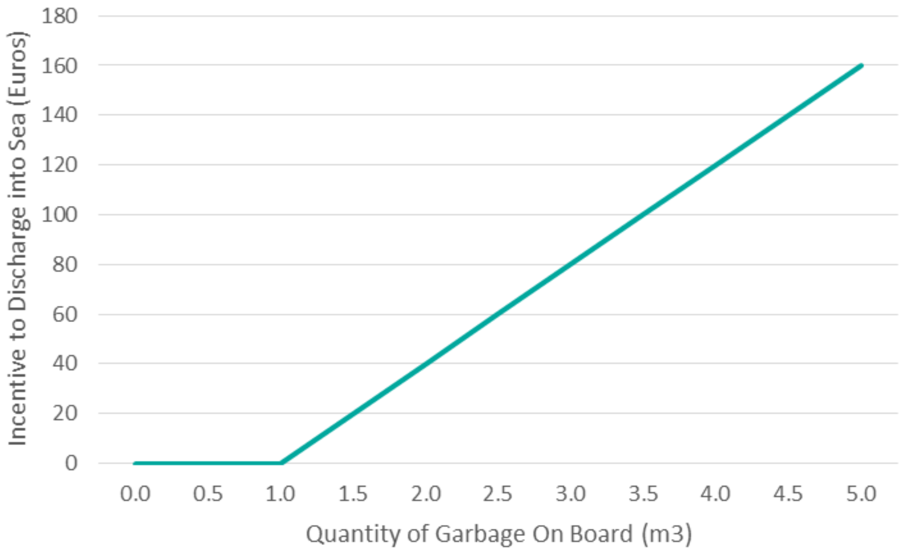
[65] The European Parliament and the Council of the European Union (2000) *DIRECTIVE 2000/59/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues*, November 2000, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02000L0059-20081211&from=EN

[66] Information provided by a Port Officer of the Ports and Yachting Directorate in Malta, which is responsible for inter alia prevention and control of pollution, including the control of ship-generated wastes, and the management of port facilities.

[67] de Langen, P.W., and Nijdam, M.N. (2007) Charging systems for waste reception facilities in ports and the level playing field; a case from North-West Europe, *Coastal Management*, Vol.36, No.1, pp.109–124

discharge at sea. An example of the incentive to discharge garbage into the sea under this partial indirect fee system (not including the effect of the deposit) is shown in Figure 10. We assume the minimum tonnage delivered equates to 1 m^3 of garbage and for the ease of comparison with previous examples the direct fee is set at 40 € / m^3. This illustrates the level of incentive to discharge at sea that the deposit must compensate for.

Figure 10. Level of Incentivisation of Discharge at Sea of Partial Indirect Fee (Minimum Fee)



A Eunomia study for CPRE reports deposit refund systems for drinks containers in Denmark, Norway, Finland, USA, Israel and Australia in which the return rate varies between 50% and 100%, and between roughly 88% and 100% for EU Member States.[68] These systems differ from the deposit / penalty CRS in that the deposit is added to the items at the point of sale rather than at the point of waste delivery but there is no reason to believe that similar results are not obtainable. It is shown that the return rate generally increases with the size of the deposit.

We note the following analysis:[69]

> *According to EMSA, both a deposit system (where – parts of – the administrative fee are refunded) or a penalty system (where an additional penalty is charged for*

---

[68] Eunomia Research & Consulting (2010) *Have We Got the Bottle? Implementing a Deposit Refund System in the UK*, Report for Campaign to Protect Rural England (CPRE), September 2010, http://www.cpre.org.uk/resources/energy-and-waste/litter-and-fly-tipping/item/1918-have-we-got-the-bottle

[69] Panteia, and DG MOVE (2015) Evaluation of PRF Directive - Interim Report. Annex 2.

non-delivery) create these incentives, required under the Directive[70]. For this to be true however, it is necessary that the charged penalty fee is high enough based on a pure economic calculation.[71]

It could be argued that the incentive to use PRFs created by penalties or deposits would be in proportion to the extent to which the size of penalty or deposit exceeds the amount that a user would stand to gain by not delivering the waste (under a 100% direct fee, this would be the entire cost of disposing of the waste). In the example provided in Figure 10, for a ship discharging 5m^3 this would be greater than €160. But ultimately if the system is to be successful then the deposit refund/penalty must affect those making the decision whether to dispose at sea or to use the PRF. This level of deposit refund/fee may not necessarily be that high and may effectively act as a 'nudge' towards responsible waste management. In a port with a well-run PRF the deposit / penalty may be enough to raise the priority of waste disposal and, if no other barriers apply, ensure disposal of all applicable waste. For example, in Malta the ease of use and speed of the PRF does not provide any disincentive to waste disposal:[72]

1) The vessel makes an official request to the agent to discharge garbage. The agent then contacts a service provider and applies for a waste consignment permit from the environment authority. This process is expected to take **not more than 1 hour**. The agent initiates this process 24 hours before the vessel arrives at port and so the waste carrier should be waiting at the quay on arrival.
2) The service provider receives the waste from the vessel. The time required depends on the waste stream and type of vessel but it is estimated that on average a vessel can **deliver 2 m^3 of garbage in 5 minutes**.
3) The Maltese port authority operates a penalty CRS whereby a fee is charged to vessels if they do not present a waste receipt to the authority within 15 days. To comply with this system the service provider provides the vessel with a waste disposal receipt and provides a copy to the agent. The agent then emails the receipt to the authority. Time-cost to the agent is therefore only **a couple of minutes**.

In such a system the time-cost of delivering garbage through the PRF is low, and therefore a small refundable deposit, such as that seen in the Malta CRS, should provide sufficient incentive for most vessels to engage with the PRF.

---

[70] EMSA (2005), Technical report evaluating the variety of cost recovery systems adopted in accordance with Article 8 of Directive 2000/59/EC on port reception facilities for ship-generated waste and cargo residues, page *25.*

[2]ibid. p *26.*

[72] Information provided by a Port Officer of the Ports and Yachting Directorate in Malta, which is responsible for *inter alia* prevention and control of pollution, including the control of ship-generated wastes, and the management of port facilities.

The level of the deposit refund/penalty can thus be set based on experience from ports that have already implemented the system. Alternatively ports that adopt this system may choose to start low and adjust the level based on observed results. Once those vessels are engaged in the PRF system the financial incentive to only deliver the minimum quantity of waste (i.e. carry out partial delivery in order to 'game' the system) is only small compared to port dues as well as the costs of other port activities and may not be an important factor.

However it must be borne in mind that stakeholders have reported that there are ports, such as Le Havre, where the penalty is set too low to be effective.[73]

Data on Oily Waste (Annex I) has revealed a potential discrepancy between deposit versus penalty systems with respect to waste delivery – in Malta, high delivery levels in 2004 and 2005 dropped considerably in subsequent years, and one study attributed this to minimum waste delivery strategies.[74] Ports employing deposit systems in contrast showed a consistent rising trend in delivery, which was theorised to be the result of the concept of "reward" encouraging the delivery of all wastes. For Annex V waste, the performance was less differentiated – although deposit systems were still associated with rising trends in delivery and penalty system associated waste delivery appeared to level out, delivery levels were closer between these two systems for Annex V waste than those seen for Annex I waste (see Figure 6 in Section 2.4.1). As the dataset does not detail the amount at which deposits or penalties are set, some variation may be caused by different levels of net financial incentivisation in between or within the CRS groups.

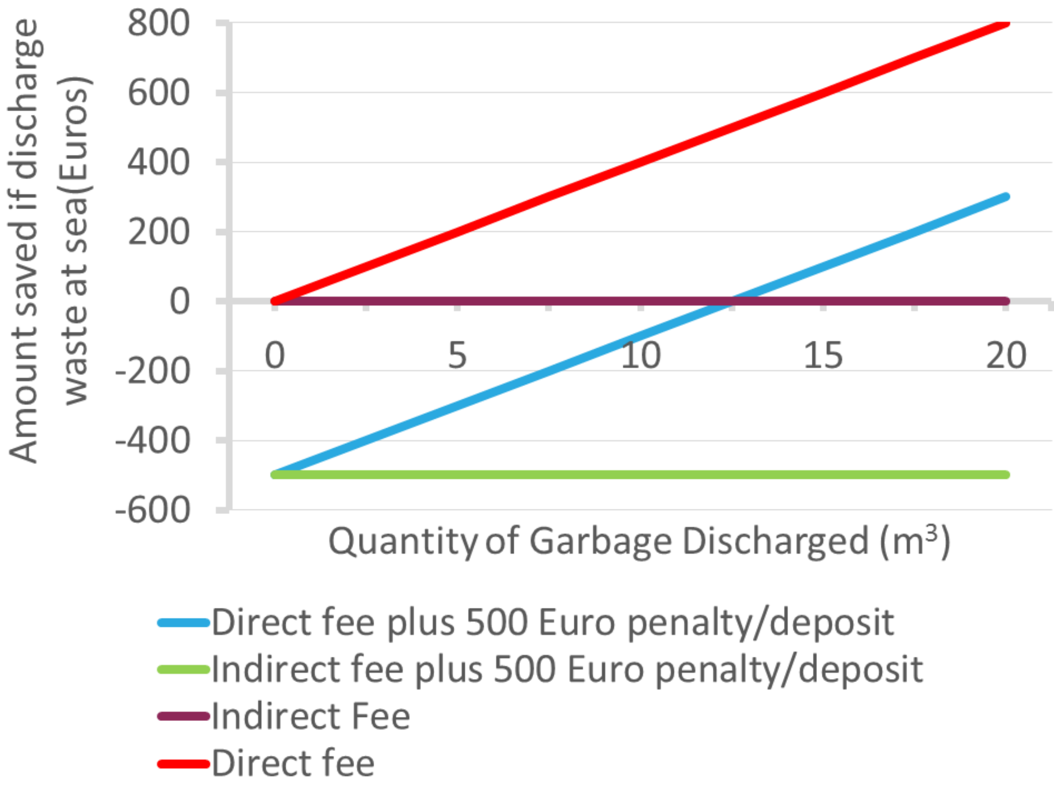
In the worst case scenario those vessels still 'gaming the system' by delivering the minimum tonnage are at least delivering some waste whereas previously they were delivering none. Where this is found to be a problem then the deposit/penalty system could be combined with the indirect fee system to remove the incentive to deliver only a minimum quantity of waste.

The key strength of the deposit refund/penalty system is that it can provide a disincentive to discharge waste at sea, and no other system is able to do this. This means that this system alone has the potential to counteract other hidden incentives to discharge at sea. Whether it fulfils this potential depends on the deposit/penalty at an appropriate level. The distinction is illustrated in Figure 11 which compares the financial incentivisation of the major cost recovery system elements. The limited data that is available also attests to the potential for this system to increase the amount of waste delivered. The environmental outcomes are therefore likely to be improved and can be expected to attract support from stakeholders for whom this is a priority.

---

[73] Coen Peelen, Netherlands Ministry of Infrastructure and the Environment, referenced this finding from Euroshore at the stakeholder meeting held in order to provide feedback on this report.
[74] Panteia, and DG MOVE (2015) Evaluation of PRF Directive - Interim Report

Figure 11. Comparison of Different Cost Recovery Systems According to Incentivisation of Discharge at Sea



Only negative values represent a net direct financial disincentive to discharge waste at sea, or conversely, an incentive to use PRFs. The magnitude of this is dependent on the level of at which the penalty or deposit is set Model: 40€ per m^3 of waste (direct fee); indirect fee set at €100; deposit/penalty set at €500

Deposit/refund systems can also be implemented alongside any combination of direct and indirect fee system. Therefore the alignment of the system with the polluter pays principle and perceptions of fairness will be dependent in part on the system alongside which it is implemented. However, the increased costs incurred by those delivering no waste means that a deposit/refund system will always improve this alignment.

For the other factors that influence relative attractiveness the impact of the deposit/penalty system must also be considered in context of the indirect/direct fee components with which it is combined. The deposit/penalty is likely increase the requirement for change and the administrative burden of the underlying fee system. It will have no further impact on transparency or the positive incentivisation of waste reduction and prevention.

On a final note regarding other drivers of relative attractiveness, a deposit, versus a penalty, may be regarded as a more palatable implementation by port users and industry alike because of the perception of this as 'positive' versus a 'negative' incentive. On the other hand, deposits versus penalties may differ in appeal because of the timing of the charges incurred and breadth of application. With a deposit, *all* users pay an *upfront* charge, even though compliant vessels are refunded at no net cost, with respect to this component of the CRS. With a penalty, only some, perhaps 'deserving', are out of pocket for any length of time. This distinction would become more important, the higher the level at which the deposit or penalty is set.

2.4.5 Potential for Change in the Incentivisation of the Discharge of Waste at Sea by CRS Regimes in the EU

EMSA reports that the majority of ports (in 16 Member States) have implemented some variation of the indirect fee.[75] Some of these ports are only recovering part of the cost of the PRF with an indirect fee and a direct fee is applied if a vessel deposits waste above a certain quantity; therefore they are effectively partial indirect fee systems.

Figure 3 shows that 26% of ports reviewed operate a 100% indirect fee CRS and 64% operate a partial indirect fee CRS for garbage (MARPOL Annex V).[76] It is not known how much waste is subject to direct fees at the ports with a partial indirect fee CRS but the examples in Sections 2.4.1 and 2.4.4.2 suggest this is likely to be small. The main potential for removing the incentive in the CRS to dispose of waste into the sea therefore lies with the 10% of ports that use a 100% direct fee CRS. These ports appear to be non-compliant with the clear requirement in the PRF directive for an indirect fee to make a significant contribution towards the cost of the PRF.

Whilst Member States will seek to make ports compliant with the PRF Directive over time, moving to a 30% indirect fee may not be enough to create significant behaviour change as there will be little difference between this and the level of incentivisation associated with the 100% direct fee, especially for ships delivering moderate to large quantities of waste. Any improvement over the 100% direct fee may be small, where the cost of disposal for garbage (MARPOL Annex V) is relatively small, as explained in Section 2.4.1.

The deposit refund/penalty system explored in Section 2.4.4.3 provides a financial incentive for vessels to engage with the PRF. If the vessel chooses not to use the PRF, or cannot do so having previously dumped its waste at sea, it will pay an additional cost in terms of the penalty or foregoing the deposit refund. A 2012 survey of European ports reports that 7 of the 40 ports (18%) surveyed employed some form of deposit / penalty system in their CRS, indicating that the large majority of ports are yet to adopt the system.[77] The potential for change is therefore large.

---

[75] EMSA (2010) *Horizontal Assessment Report - Port Reception Facilities (Directive 2000/59/EC)*, December 2010, http://ec.europa.eu/transport/modes/maritime/consultations/doc/prf/emsa-report.pdf

[76] See Section 2.3.4.2 for discussion of the limitations of this estimate.

[77] EMSA, and Ramboll (2012) *Study on the Delivery of Ship-Generated Waste and Cargo Residues to Port Reception Facilities in EU Ports*, August 2012, http://www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities/download/1972/1607/23.html

2.4.5.1 Fishing Vessels Delivering Fishing for Litter Waste

Fishing vessels are required under the PRF Directive to cover the cost of PRF for ship generated waste, but are exempt from mandatory i.e. indirect charges. They are therefore generally liable for direct fees for this waste stream. While excluding fishing vessels from the mandatory charge requirement of the PRF directive was certainly intended to be to their advantage, it may in fact mean that they are penalised for delivering passively fished marine debris to PRFs. Removing the disincentive for them to collect and deliver such waste will help the implementation of fishing for litter (FFL) schemes on a wider basis (see Section 4.9.2 for more discussion of the potential contribution of this to marine litter reduction goals).

There are two clear options to remove the disincentive to deliver FFL waste created by a direct fee CRS. The first option under the PRF Directive is to require the provision of reception facilities (where available) for this waste at no additional cost to the vessel. Indeed, the Helsinki Commission has already amended the Baltic 'no special fee' system to encompass this waste type. The PRF could be funded by adding a small fee onto other port costs, such as the CRS for other waste types. In doing so the system would still satisfy the PRF Directive requirement that the costs of PRF be covered through the collection of a fee from ships. However, it can be difficult to distinguish between FFL waste and end-of-life gear owned by the fishing vessels and so the system is potentially susceptible to exploitation for free disposal of end-of-life gear.

The second option under the PRF Directive is to bring all waste from fishing boats within mandatory fee structures. This would open up the possibility of applying cost structures other than a 100% direct fee. Applying a partial indirect fee where the proportion of indirect fee is low (e.g. 30%) will still mean that delivering 'extra' waste will incur greater fees and will not have the effect of removing disincentives to deliver recovered marine debris. Under a partial indirect fee system, the fact that participating in FFL may significantly increase waste volumes means that 'reasonable use' thresholds would have to be adapted or the system would end up disincentivising the delivery of extra waste.

Applying a 100% indirect fee would mean that there was no disincentive to retain 'fished' litter or retrieved items e.g. fishing nets and dispose of them legally. This would improve environmental outcomes with respect to marine litter. Importantly, such changes would also remove the disincentive created by the direct fee to deliver garbage to the PRF, as per other types of vessel. Under a penalty/deposit system one might envisage the maximum engagement of vessels with the PRFs, and this might be positive for participation in FFL schemes. Although if implemented in tandem with a direct fee, or un-adapted partial indirect system, there would still be a disincentive for fishing vessels to deliver additional tonnages of waste.

There is a direct conflict between cost recovery systems that positively incentivise waste reduction and prevention and the removal of disincentives for fishing vessels to deliver FFL waste; both cannot be achieved by the same CRS; additional options such as an independent Green Ships scheme, or separate cost structures for fishing vs other vessel types would be needed to achieve both at the same time.

Schemes currently in operation offer free waste disposal (KIMO Fishing for Litter – the cost of disposal is footed by the KIMO project, not the fishermen) or payment for delivery (South Korea – funded by the government). If provision were to be made for schemes like this under the PRF Directive, it would have to be for this waste stream only, or for fishing vessels alone, as strictly speaking, currently both are in contravention of the stipulation that vessels should pay for waste disposal rather than other stakeholders (the Directive's interpretation of the polluter pays principle). At a recent meeting on marine litter, it was stated that there was a lack of awareness of funds made available by European Institutions which can be used to support the collection of waste by fishermen, implying that this payment mechanism is feasible on a wider scale.[78]

2.5 Future Cost Recovery System Scenarios

In this section, four scenarios are constructed in order to analyse the potential impact of changes in the CRS used in EU ports and other steps to address factors thought to lead to dumping of garbage into the sea. As discussed in detail above, the type of CRS used in a port for the reception of waste may influence the behaviour of vessels, and potentially reduce the amount of waste dumped at sea, by:

- Removing any financial incentive to dump waste at sea created by waste reception fees by decoupling the fees from the quantity of waste received. This system is called the 100% indirect fee.
- Creating a disincentive to discharge waste at sea through the use of a deposit or penalty fee.

Other factors also influence the decision of whether to deliver waste to port or dump it at sea, as explored in section 2.4.2. A number of these factors relate to the adequacy of the facilities. Others relate to ease of use, need for training and information, and the time required to use the PRF. These issues could potentially be addressed through harmonisation between waste streams and across ports, i.e.:

- **Employing a 'one-stop shop' approach**: where
    - The facilities are provided at the vessel's berth rather than having to locate the facilities for each different waste stream and transport the waste to their location.
    - The vessel provides notification of the waste just once and the port authority then coordinates the PRF operators for different waste streams

[78] Waste Free Oceans (2015) Press Release – Guardians of the Sea Conference, October 14th 2015 "Ms. Elisa Roller of the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE) stressed the fact that there remains a lack of awareness of the funds made available by the European Institutions to support the collection of waste by fishermen."

and sends the waste receipts to port state control to check for a disparity between the amount of waste reported and that delivered.

- **Harmonisation across ports**: where all ports operate a similar PRF and CRS system so that it is easy for vessels to calculate fees in advance and they are familiar with the use of the system. This reduces the need for training, and administrative and organisational tasks.

We refer to such changes collectively as a 'streamlining of services'.

Four scenarios are considered and the potential impact of changes to the CRS and PRF at ports in the EU evaluated. The scenarios have been chosen to represent the fullest range of possible environmental outcomes. The scenarios consider:

- All ports moving to a 100% indirect fee CRS which provides no financial incentive to dump garbage at sea, with and without a streamlining of services;
- All ports moving to a 100% indirect fee CRS with a deposit refund/penalty to provide a positive incentive to deliver garbage when in port, with and without a streamlining of services.

Each of these scenarios takes as its basis a 100% indirect fee, and so with respect to how ports users and port administration view its relative attractiveness compared with the status quo, we can expect there to be concerns around the extent of change needed and the administrative burden in terms of involvement from the port authority. It would require most ports to change their charging structure, however, only a few ports will be changing from the 100% direct fee (for Annex V (garbage)) and for others that already have some sort of partial indirect fee and hence be more likely to have some involvement in charging for waste, this will be less of a shift. Some users may be concerned about its alignment with the polluter pays principle (in its wider interpretation), and the fact that smaller boats are charged more than the cost to dispose of their waste. Therefore we propose that *every* scenario should incorporate an element of banding for the indirect fee component.

No scenario caters for the incentivisation of *waste reduction and prevention* and intrinsically, none presented here are able to do so. This will raise concerns from some quarters, especially port users or their representatives. However the incentivisation of waste reduction and prevention *can* be addressed by the implementation of other approaches such as the Green Ships scheme independently of the CRS.

The argument can be made that in the marine context, the levels of environmental harm that can be addressed by focussing on preventing discharge at sea are greater than those caused by generation of marginally greater quantities of waste and imperfect application of the waste hierarchy, by vessels that are already discharging their waste at ports, and so should take precedence. 100% indirect fees are also likely to attract concern around transparency issues; therefore we propose that in all scenarios, waste charges are billed separately from other port dues.

More detailed evaluation of the aspects that differentiate the scenarios, rather than the characteristics which they have in common, follows:

Scenario 1: all EU ports move to a 100% indirect fee CRS with no streamlining. In this case the estimated 10% of ports with a direct fee only CRS change to indirect fee, and some ports with partial indirect fee CRS will alter their system to cover all costs through the indirect element of the CRS. This change, however, may not have a profound impact upon reducing dumping behaviour as the cost of garbage disposal can be relatively small and other factors may remain that lead vessels to dump garbage at sea.

Scenario 2: all EU ports move to a 100% indirect fee CRS and streamline services. Provision of adequate facilities for waste reception is essential and efforts to minimise time, inconvenience and training requirements may have an impact. However, the full reasons behind the decision to dump garbage at sea are unknown and are likely to vary for different ships and circumstances. Other factors may therefore still remain leading vessels to dump their garbage at sea. Streamlining of services is likely to lead to benefits for port users and may prove popular (as benefits accrue); while for port authorities and PRF operators, the widespread change necessary is likely to meet with some resistance.

Scenario 3: all EU ports move to a 100% indirect fee with a deposit refund/penalty system and no streamlining. The level of the deposit/penalty should be set to overcome any factors that currently lead to dumping behaviour. It is not necessary to understand the individual factors as the deposit refund/penalty addresses them collectively. If this mechanism maximises participation as intended then vessels which previously dumped garbage into the sea now deliver waste to port. Ships will not be disincentivised to deliver all the garbage on board as the indirect fee ensures that all waste can be delivered at no additional cost and the time-cost of delivering garbage is thought to be small. The administration of the deposit refund/penalty scheme would require more involvement from Port Authorities and so may increase their administrative burden.

Scenario 4: all EU ports move to a 100% indirect fee with a deposit refund/penalty system and streamlined services. The level of the deposit/penalty in the CRS is set at a level which overcomes the factors which lead vessels to dump garbage at sea. Streamlining services also addresses some of the factors thought to lead to dumping waste at sea. In this scenario the level of the deposit refund/penalty in the CRS may be reduced whilst maintaining the same level of participation. The lower deposit level will make the system more attractive to port users and improve ease of implementation and acceptance by port users. Streamlining itself is likely to lead to benefits for port users and may prove attractive to them; while for port authorities and PRF operators, the widespread change necessary is likely to meet with some resistance. The administration of the deposit refund/penalty scheme would require more involvement from port authorities and so may increase their administrative burden. Additionally because of the great variation between ports in terms of their existing facilities and systems, some ports will feel unfairly disadvantaged compared to others if moving towards harmonisation means more change for them than for other ports.

With respect to Scenarios 3 and 4, we have not presented separate analysis of the deposit refund vs penalty scenario. This is because in terms of net direct financial incentive, they are the same, and so in theory, should have the same effect. There is some suggestion however from both the limited data available as well as from indicators of ‘relative attractiveness’ that there may be something to choose between them. Waste delivery data suggests that perhaps deposits have been performing better than penalties (Figure 5, Section 2.4.1). It is not known, however, whether the real life schemes represented by the two categories are truly comparable, for example in the level at which the deposit/penalties were set, whether the deposits were full or partial refund schemes, and whether they were equally likely to be implemented alongside direct or indirect fee systems in the deposit versus penalty categories. In terms of relative attractiveness, as discussed in Section 2.4.4.3,deposit schemes may be more attractive because they psychologically resemble ‘positive’ incentivisation rather than the punitive term ‘penalty’ and this was the reason suggested that they were more successful in terms of the waste delivery data. On the other hand deposits involve upfront costs more widely applied, which may be viewed negatively by stakeholders. More research would be needed to make the correct choice between them.

The scenarios are summarised in Table 3, rated in terms of their potential for impact and ranked first to last on this basis.

Table 3. Scenarios of Changes to CRS and Streamlining of Services

	Indirect Fee CRS	**Indirect Fee CRS with Deposit refund/penalty System**
No Streamlining	**Scenario 1.** Environmental impact limited as costs may not be a dominant factor in dumping behaviour for garbage. **Potentially limited impact.** **Rank: #4**	**Scenario 3.** Vessels incentivised to deliver garbage waste at PRF. No disincentive to disposing all waste held on board. **Potentially high impact.** **Rank: #2**
With Streamlining	**Scenario 2.** As above, plus streamlining may help address some, but not all, of the additional factors leading to dumping. **Potentially moderate impact.** **Rank: #3**	**Scenario 4.** As above, plus the level of deposit refund/penalty may be reduced leading to greater acceptability amongst port users. **Potentially high impact, plus increased relative attractiveness to users.** **Rank: #1**

2.5.1 Summary of Cost Recovery System Scenarios

All EU ports should comply with the PRF Directive requirement that a CRS should provide no incentive for ships to dump waste at sea, and this can be achieved through a 100% indirect fee system where the fee is decoupled from the amount of waste delivered. However, the cost of delivering garbage may in many cases be relatively small for shipping operators and so this may not be a dominant factor in the decision of some vessels to dump garbage into the sea.

The PRF Directive also states that a CRS should encourage the delivery of ship-generated waste to ports. This can be achieved through a deposit which is only refunded upon delivery of waste or a penalty applied to vessels that choose not to deliver waste. Such a system can be effective at increasing the number of vessels using the PRF and the amount of waste delivered. A key advantage of this system is that it is not necessary to understand and address all of the factors which lead vessels to dump waste into the sea (which vary for different vessels and circumstances) as the deposit refund/penalty aims to overcome all of the factors collectively. The level of the deposit or penalty is set so as to outweigh these factors for the persons making the decision of how to manage the garbage. Ports which also address some of these factors directly will be able to achieve the intended levels of participation with a lower level of deposit or penalty, as there will then be fewer factors, such as perceived inconvenience, to overcome.

2.6 Assessment of Marine Litter Reduction Potential of Future Scenarios

In order to understand the extent of the impact on marine litter from improving the incentivisation of waste delivery at ports, it is necessary to undertake a synthesis of the information available on the amount of litter already in the marine environment, and the flows of litter to the marine environment from land and sea-based sources.

2.6.1 Annual Input of Marine Debris

There is little empirical data on the quantity of marine debris entering the marine environment either overall, or from different sources. Material flow analysis has been used to estimate input, and this covers various different approaches to estimating waste generated and released from different sources. A recent source of empirical data is riverine sampling, which covers a portion of land-sourced litter.

Early estimates from the National Academy of Sciences (NAS) in 1975 put the influx at approximately 6.4 million tons annually on a global level.[79] This estimate was derived from the estimated amount of waste generated from ocean vessels (i.e. maritime

---

[79] National Academy of Sciences (1975) *Assessing Potential Ocean Pollutants: A Report of the Study Panel on Assessing Potential Ocean Pollutants to the Ocean Affairs Board, Commission on Natural Resources, National Research Council.*, 1975

sources alone), and the tonnage was adjusted, based on waste composition data, to include only materials which were thought to pose a marine litter risk – i.e. excluding food and vegetable wastes. The estimate was made prior to MARPOL Annex V, prohibiting and restricting the dumping of garbage at sea, coming into force in 1988.[80] It was assumed therefore that nearly all the waste generated was thrown overboard.

Therefore this may now be an overestimate of maritime sources of waste, although this might be counterbalanced by an increase in maritime traffic in the intervening period (we estimate this to have more than doubled in terms of persons at sea)[81] plus an increase in post-consumer waste of materials which pose a high marine debris risk, such as plastic (which in 1975 was assessed to make up only 1.5% of at-sea waste and 2.5% of on-shore waste generated – whereas now, by way of comparison, it is 10.4% of UK household waste).[82] [83]On the other hand, a significant proportion of the waste estimated to be generated (85%) was cargo-associated waste (packaging, strapping, dunnage, pallets, tarps, wires and even harbour materials such as shoring were included in this category) which may reasonably be expected to have reduced in recent years, owing to the containerisation of cargo.

This early estimate does not, however, take into account debris generated from land-based sources. A recent attempt to quantify the input of marine litter from land-based sources was published in 2015. This took data regarding waste generation, coastal populations, the proportion of waste which is plastic, and the proportion of waste which is badly managed, to estimate the input of plastic from land-based sources. Note that the authors restricted the scope to plastic alone. They estimated that out of 275m tonnes of plastic waste generated in 192 coastal countries in 2010, 4.8-12.7 m tonnes entered the ocean (based on low, medium and high rates at which mismanaged waste was reaching the water of 15%, 25% and 40%).[84] Total plastics production in 2013 was estimated at 299m tonnes, giving a sense of the sheer scale of turnover in plastic

---

[80] http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-%28MARPOL%29.aspx

[81] The NAS 1975 takes into account the activities of approx. 2,492,945 person years at sea. For 2013, we estimate, using the modelling undertaken for Section 2.6.5.1, a comparable estimate of activity at sea to be 4,936,560 person years, although this does not included passenger ferries, which the original study excluded and now account for almost a million extra person years at sea globally.

[82] 1.8% of the 71% of on-shore waste that was non organic and 0.7% of the 46% of at-sea waste that was non-organic. The actual kg per capita used (2.2 kg/person/day = 803kg/person/yr for on-shore waste and 1.75 kg/person/day = 634 kg/person/yr) are comparable with waste generation figures we have derived from more recent data.

[83] Sum of categories: plastic film (3.8%) and dense plastic (6.6%). DEFRA (2015) *Digest of Waste and Resource Statistics - 2015 Edition*, 2015, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/422618/Digest_of_waste_England_-_finalv2.pdf

[84] Jambeck, J.R., Geyer, R., Wilcox, C., et al. (2015) Plastic waste inputs from land into the ocean, *Science*, Vol.347, No.6223, pp.768–771

products – a similar amount of plastic waste is being produced as plastic products generated, on an annual basis. Making an extract of the data to look at the estimates for EU countries alone gives figures of 54,000 to 145,000 tonnes of plastic per year entering the marine environment from land-based sources.[85] As well as being restricted to plastic, this model does not take into account riverine transport from inland areas, focussing only on populations within 50km of coastal areas.

This leads us to another method for estimating input of marine litter from land-based sources, which is to use riverine sampling to capture floating litter in the cross section of a river. If this is done using absolute quantitative methods and combined with data on flows in rivers, inputs can be estimated. This has only been done for a very few rivers and scaling up results is highly tentative, because the litter load of rivers will depend a great deal on characteristics of the surrounding catchment. Net based sampling also tends to lead to restrictions in size ranges, so very small particles and macrolitter are likely to be underrepresented; as well as leading to underrepresentation of denser materials (because most sampling is performed at or near the surface), so plastic is generally the focus. The most prominent study of recent years is that by Lechner *et al* (2014) who estimated an annual input from the Danube of 1,533 tonnes;[86] with a flow rate of 202 km^3/yr,[87] which equates to 7.5 tonnes per km^3. However the method only sampled plastics within 0.5-50mm. A study sampling litter floating in the open sea calculated that items >200mm accounted for 75% of the total weight of items. If a similar size distribution applies to riverine litter, the litter load would be at least 30 tonnes per km^3. Given a world river discharge of 37,288 km^3/yr,[88] the input could be in the order of 1.1 million tonnes per year. Given a European river discharge of 2,100 km^3/yr,[89] this would equate to 63,000 tonnes input per year. As riverine studies vary widely in terms of estimates of input, it is sensible to look at another study to provide some sort of range.

A study published in 2015 looked at four European rivers (the Rhine, Dalålven, Po and Danube), with the average litter load calculated to be 1.95 tonnes per km^3.[90] This

[85] For those requiring further detail on this calculation please see Work Package 2, Section 6.3.2.6.

[86] Lechner, A., Keckeis, H., Lumesberger-Loisl, F., et al. (2014) The Danube so colourful: A potpourri of plastic litter outnumbers fish larvae in Europe's second largest river, *Environmental Pollution*, Vol.188, pp.177–181

[87] Aiguo Dai, and Kevin E. Trenberth (2002) Estimates of Freshwater Discharge from Continents: Latitudinal and Seasonal Variations, *Journal of Hydrometrology*, Vol.3, pp.660–687

[88] Aiguo Dai, and Kevin E. Trenberth (2002) Estimates of Freshwater Discharge from Continents: Latitudinal and Seasonal Variations, *Journal of Hydrometrology*, Vol.3, pp.660–687

[89] Milliman, J.D., and Farnsworth, K.L.(2011) *River Discharge to the Coastal Ocean: A Global Synthesis*, Cambridge University Press

[90] Tweehuysen, G., Peterlin, M., Van der Meulen, M., Van der Wal, M., and Sherrington, C. (2014) *Identification and Assessment of Riverine Input of (Marine) Litter. Second Progress Report for the European Commission DG Environment under Framework Contract No ENV.D.2/FRA/2012/0025*, 2014. For those requiring further detail on this calculation please see Work Package 2, Section 6.3.2.6.

equates to a global input of around 75,000 tonnes per year and a European input of 4,000 tonnes per year. Results are very preliminary at present.

It is worth keeping in mind that single events can cause dramatic point-source increases of a magnitude comparable to estimates we have of marine debris input from other sources, such as the 2011 Japanese tsunami which created an estimated 1.5 million tons of floating debris.[91]

Although these figures start to give us a picture of the orders of magnitude of different inputs to the ocean, other types of data are needed to provide more up to date estimates of input derived from at-sea sources particularly, and we will reprise the discussion of these in Sections 2.6.4 and 2.6.6.

2.6.2 Stock of Marine Debris

There is some empirical data on the quantity of marine debris in the marine environment. This comes from sampling material from different marine compartments, such as the sea surface, the sea floor, or the sea sediment.

At this point it is worth mentioning that as the distribution of marine debris is so variable, sampling from all possible marine compartments is in theory desirable. However, data from each compartment comes with its own set of limitations which must be borne in mind when comparing and integrating this data. For example, coastline monitoring, such as beach counts, have not been generally used to estimate stocks of marine litter. In part this is because there is an unknown relationship between the total stock of marine litter and beach litter, which is a dynamic system in itself; as well as the fact that historically, beach counts have not been standardised to a geographical unit. Where they have, to beach length, this does not take into account width of beaches, width of strandlines, or curves of beaches - all characteristics which may cause deviation from a linear relationship between amount of litter and beach length, which would be a necessary assumption for accurate *pro rata* calculations, or comparisons between beaches.

Also, calculating regional totals for geographical units to gross up to are not always trivial tasks. Similar limitations apply to other marine compartments such as under sand and in biota (for example, there is very limited population data for most species of animals). Sampling from different marine compartments also has certain biases regarding particular material and item types. Sea surface trawls focus exclusively on plastic, as a rule, as they float, while sea floor surveys will account for heavier items and different materials such as metal also.

Another important issue that needs to be mentioned at this point is that different sampling techniques affect the representativeness of the sample, especially with respect

---

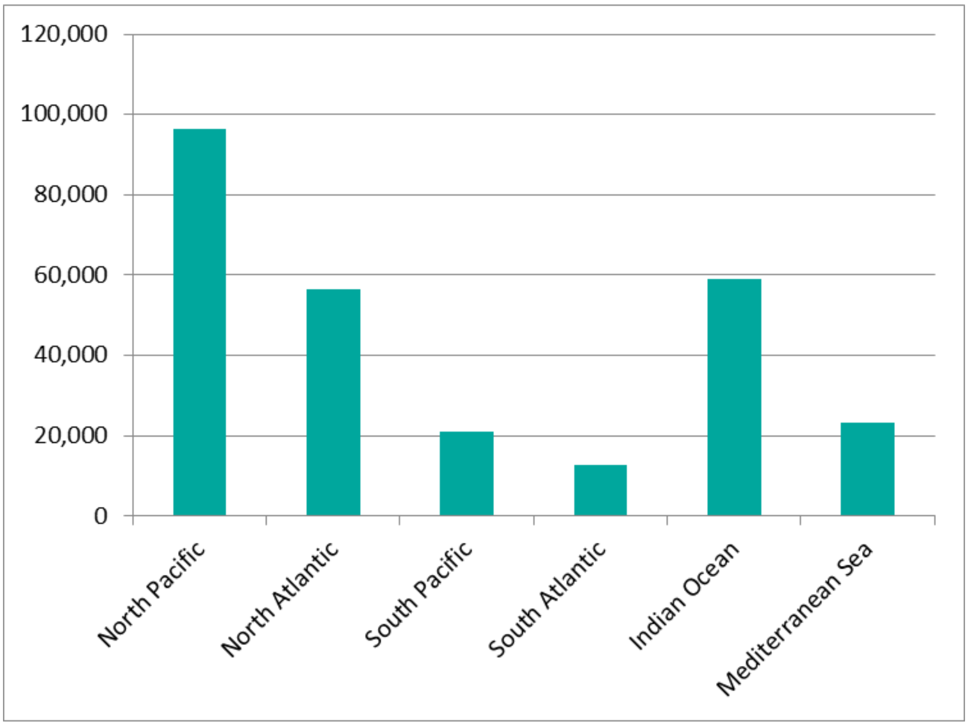
[91] NOAA (2013) *Japan Tsunami Debris FAQs*, accessed 5 November 2013, http://marinedebris.noaa.gov/tsunamidebris/faqs.html

to size of debris item. It is challenging to include microplastics and macroplastics in the same sampling technique in an unbiased way and adequately represent both, and it must always be borne in mind that studies may not take missing parts of a size distribution into account when estimating amounts or prevalence; or will do so by making assumptions that are not tested.

With these issues in mind, an overview of the information available via prominent studies, and a broad-brush synthesis, is provided below.

One recent study, headed up by the Five Gyres Institute, estimated, on the basis of surface trawls and visual surveys that the mass of plastics floating at or near the sea surface was 268,000 tonnes (~233,500 tonnes of macro/mesoplastic and ~35,500 tonnes of microplastic). As their net opening size and trawl times meant that large items were underrepresented, they accounted for this by including data from visual surveys. They also accounted for dispersal of marine litter by oceanic currents and wind driven vertical mixing in their model. [92] Figure 12 shows that in their model, the North Atlantic and Mediterranean regions, being the two EU relevant regions, had the third and fourth highest concentrations of marine litter, accounting for 21% and 9% of the total respectively.

Figure 12. Distribution of Marine Litter (Floating) Between Marine Regions (Tonnes)



[92] Eriksen, M., Lebreton, L.C.M., Carson, H.S., et al. (2014) Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea, *PLoS ONE*, Vol.9, No.12, p.e111913

Adapted from Eriksen et al. (Five Gyres)

Another study, again based on surface trawl data, estimated a global total of 10,000-40,000 tonnes of plastic.[93] This figure was smaller in part because the authors did not account for macrolitter, vertical mixing, or oceanic currents and how they are predicted to distribute items on the sea surface. Because the size distribution of particles was not as expected, smaller particles being underrepresented, (this was a shared finding of both papers), the paper discussed various potential sinks for the material, including estimates of the stock of particles in mesopelagic fish (the most abundant group of zooplanktivorous animals in the open ocean), based on data regarding fish ingestion of plastics and fish stocks. The authors concluded that it would be a similar order of magnitude to their estimates for floating litter.[94]

It must also be borne in mind that only 50% of plastics produced are buoyant in salt water (see Appendix A.4.0), and this would lead to a reduction in the amount of plastic likely to be found floating on the ocean surface compared with the total amount in the ocean.

An interesting comparison to make is with beach clean-up tonnages estimated from the International Coastal Clean-up (ICC) data. In 2012, for example, their volunteers collected approximately 4,513 tons of beach litter from 26,700km of coast.[95] This is a large amount, compared with the global estimates of floating litter, considering that the clean-ups covered only 1.9% of a world coastline of 1.4 million km.[96] Grossing up gives an estimate of 236,331 tonnes of beach litter globally, just to give a sense of scale (all these figures are approximate). The surface of the oceans, which should in theory be represented in its entirety in the floating litter studies, is 361 million km^2.[97] Furthermore, beach litter estimates are likely to be underestimates. Although beaches will represent an accumulation of litter to some extent, because beach cleans often do not happen more than four times a year (e.g. the OSPAR beach litter monitoring cycle), as the ICC is undertaken on an annual basis, many beaches do get cleaned in the interim.

[93] Cozar, A., Echevarria, F., Gonzalez-Gordillo, J.I., et al. (2014) Plastic debris in the open ocean, *Proceedings of the National Academy of Sciences*

[94] 12,000-24,000 tons per year ingested by mesopelagic fish in the North Pacific Subtropical Gyre; there are 5 gyres in total, where there is a concentration of floating plastic. Cited from Davison, P., and Asch, R.G. (2011) Plastic ingestion by mesopelagic fishes in the North Pacific Subtropical Gyre, *Marine Ecology Progress Series*, Vol.432, pp.173–180

[95] Ocean Conservancy (2012) *The Ocean Trash Index - Results of the International Coastal Cleanup (ICC)*, 2012, http://www.oceanconservancy.org/our-work/marine-debris/2012-icc-data-pdf.pdf

[96] CIA World Factbook: ~1.2 million km; World Resources Institute: ~1.6 million km; cited in https://en.wikipedia.org/wiki/List_of_countries_by_length_of_coastline

[97] CIA World Factbook https://www.cia.gov/library/publications/resources/the-world-factbook/geos/xx.html

Additionally, papers looking at the effect of sampling interval on estimates of accumulation rate of litter on beaches found that collecting litter daily increased the accumulation rate compared with estimates based on a similar overall time period where monitoring was carried out weekly or monthly. One study comparing daily to weekly monitoring intervals found the estimate was increased by a factor of 1.7 by weight and 2.5 by count on average, and this was much higher for lighter items.[98] A study comparing daily with monthly monitoring periods found accumulation rate by count increased by a factor of 10.[99] The 'turnover' rate of litter would vary widely depending on not only the item characteristics but also the characteristics of the beach. These studies indicate that quarterly or yearly monitoring will underestimate the amount of stranded beach litter by a potentially large margin.

The exact significance of the comparison between beached litter and floating litter depends on the relationship between beach litter and oceanic stock, which represents a significant unknown. One figure for the recovery rate (beaching, finding and returning to a research centre by a member of the public) of experimental floats dispersed at sea is 2%. As much coast is inaccessible to people, this is probably an underestimate of beaching. A mathematical model proposed in 2012 predicted that 28% of at-sea sourced marine litter would become beached over time and 40% of land-based litter would be beached.[100] An additional complicating factor is that some studies attribute the major share of beach debris to direct deposition on the beach, and though this will become marine debris if not cleaned up, further distorts the relationship between marine stock and beach litter.[101]

The conclusion is that, the amount of beach litter captured in a 'snapshot' of beach litter, accumulated over periods of a year at the most, is unlikely to be equal to the total quantity of marine litter accumulated over decades. Therefore, it is likely that the stock of floating litter is being underestimated and/or a large proportion of litter is found in a different ocean compartment.

A few papers have undertaken samples of litter under sand. The ratio of buried to exposed litter was 0.65:1 for a sample of beaches on the Sea of Japan.[102] Sandy beaches

---

[98] Ryan, P.G., Lamprecht, A., Swanepoel, D., and Moloney, C.L. (2014) The effect of fine-scale sampling frequency on estimates of beach litter accumulation, *Marine Pollution Bulletin*, Vol.88, No.1-2, pp.249–254

[99] Smith, S.D.A., and Markic, A. (2013) Estimates of Marine Debris Accumulation on Beaches Are Strongly Affected by the Temporal Scale of Sampling, *PLoS ONE*, Vol.8, No.12, p.e83694

[100] Lebreton, L.C.-M., Greer, S.D., and Borrero, J.C. (2012) Numerical modelling of floating debris in the world's oceans, *Marine Pollution Bulletin*, Vol.64, No.3, pp.653–661

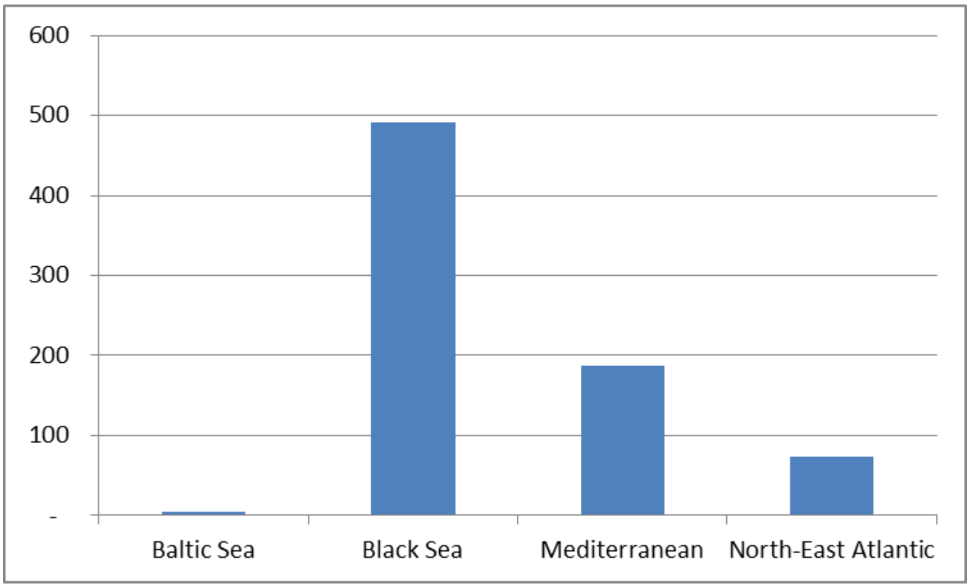
[101] Browne, M.A., Chapman, M.G., Thompson, R.C., Amaral Zettler, L.A., Jambeck, J., and Mallos, N.J. (2015) Spatial and Temporal Patterns of Stranded Intertidal Marine Debris: Is There a Picture of Global Change?, *Environmental Science & Technology*, Vol.49, No.12, pp.7082–7094

[102] Kusui, T., and Noda, M. (2003) International survey on the distribution of stranded and buried litter on beaches along the Sea of Japan, *Marine Pollution Bulletin*, Vol.47, No.1–6, pp.175–179

make up 34-40% of the world's coastline.[103] This suggests that a significant amount of marine litter resides in this location.

Figure 13 shows what we can tell about the prevalence of beach litter from the ICC data in different regions. In contrast to the floating litter data, litter on beaches appears to be more concentrated in the Mediterranean than the North-East Atlantic. Table 4 suggests that when looking at EU compared to global totals, floating litter is more severe – or rather, more evenly distributed – compared to beach litter. However we must bear in mind how tentative these comparisons are (they do not have identical geographical scope), and again, that local authority beach cleaning is likely to be better in the EU than globally.

Figure 13. Distribution of Marine Litter (Beaches) Between Marine Regions (kg/km)



Based on data from: Ocean Conservancy (2012) The Ocean Trash Index - Results of the International Coastal Cleanup (ICC)*, 2012*

[103] Schwartz, M.(2006) *Encyclopedia of Coastal Science*, Springer Science & Business Media. p147

Table 4. Marine Litter: Floating and Beach; Europe vs Global Estimates

Data source	Region	Marine Litter (kg)	Length Coastline Cleaned (km)	Marine Litter (kg/km)	Total Coastline (km)	Total (tonnes)
Beach litter (ICC)	World	4,513,449	26,709	169	1,398,504	236,331
Beach litter (ICC)	EU	67,653	2,052	33	70,000	2,308
Floating litter (Eriksen *et al*)	World	-	-	-	-	268,940
Floating litter (Eriksen *et al*)	EU[1]	-	-	-	-	79,620

[1]*North Atlantic plus Mediterranean area*

Very recent research suggests that deep sea sediment could be a significant sink for marine litter. Even plastics which would normally be buoyant in sea water can sink if they are biofouled by microbial communities.[104] Sediment sampling tends to concentrate on microplastics; their concentration in sediment has been found to be up to 30,000-130,000 times the level of concentration by particle count found in surface waters. However this was taking into account fibres of a size far below that considered in typical floating litter surveys.[105]

This brings us on to the fact that sediment sampling technique does not look at macrolitter, for which visual surveys and trawls of the sea floor are the most relevant source of data, in this marine compartment. In the EU, densities range from 0-6,600 items per km^2 with the highest concentrations in coastal areas and coastal canyons.[106] By count, the highest densities are found in the western Mediterranean and off the west coast of France; the Black Sea, and the wider North East Atlantic are the next worst affected and appear to have similar item counts per square kilometre.[107] In the Baltic,

[104] Lobelle, D., and Cunliffe, M. (2011) Early microbial biofilm formation on marine plastic debris, *Marine Pollution Bulletin*, Vol.62, No.1, pp.197–200,Van Cauwenberghe, L., Vanreusel, A., Mees, J., and Janssen, C.R. (2013) Microplastic pollution in deep-sea sediments, *Environmental Pollution*, Vol.182, pp.495–499
[105] For those requiring further detail on this calculation please see Work Package 2, Section 6.3.2.6.
[106] Pham, C.K., Ramirez-Llodra, E., Alt, C.H.S., et al. (2014) Marine Litter Distribution and Density in European Seas, from the Shelves to Deep Basins, *PLoS ONE*, Vol.9, No.4, p.e95839
[107] Pham, C.K., Ramirez-Llodra, E., Alt, C.H.S., et al. (2014) Marine Litter Distribution and Density in European Seas, from the Shelves to Deep Basins, *PLoS ONE*, Vol.9, No.4, p.e95839,Ioakeimidis, C., Zeri, C.,

sea-floor debris was found to be twice as great as in the North Sea, according to one linear trawl study in 2011, indicating that the Baltic could also be particularly vulnerable to accumulation of marine litter on the sea floor.[108]

By weight, data is only available where trawling was used as the sampling method, which was only implemented on a comparable "by-unit-area" basis in the Mediterranean. The densities were 70-180kg per km^2 generally with a maximum of 400+/-180kg per km^2 in the worst affected area.[109] To put these statistics in context with results from other marine compartments, the concentration of litter items on the sea-floor is higher than floating on the surface; one review has this at a range of 0-600 items per km^2. Therefore we expect the weight of macro debris in this compartment to exceed estimates for floating litter, which, to recap, were estimates of approximately 270,000 tonnes globally. Making the assumption that the area on the sea-floor is roughly equivalent to the area on the sea surface, using the low range for debris of 70-180kg per km^2 gives figures of 25.3-65m tonnes of debris globally and 0.79-2.0m tonnes for the EU (Table 5); while using the higher density of 400kg per km^2 gives a global estimate of 144.4m tonnes and an EU estimate of 4.5m tonnes. The amount of sea floor debris is highly dependent on physiography of the area sampled; therefore these estimates are extremely crude.

Table 5. Estimates of Sea-floor Litter

Litter Density	EU Sea-floor Litter (tonnes). Sea area = 11,313,402km^2	Global Sea-floor Litter (tonnes). Sea area = 361,000,000km^2
70kg/km^2	791,938	25,270,000
180kg/km^2	2,036,412	64,980,000
400kg/km^2	4,525,361	144,400,000

Sea area for EU defined as areas of Black Sea, Baltic Sea, plus OSPAR Regions II (Greater North Sea), III (west coast of UK, Ireland and France), IV (west coast of Spain and Portugal) and V (wider North East Atlantic). OSPAR region I (Arctic) excluded. Data from Wikipedia and OSPAR.com.

Kaberi, H., et al. (2014) A comparative study of marine litter on the seafloor of coastal areas in the Eastern Mediterranean and Black Seas, *Marine Pollution Bulletin*, Vol.89, No.1–2, pp.296–304

[108] MARLIN (2014) *Final Report of Baltic Marine Litter Project Marlin. Litter Monitoring and Raising Awareness. 2011-2013.*, 2014, http://www.hsr.se/sites/default/files/marlin-baltic-marine-litter-report.pdf

[109] Pham, C.K., Ramirez-Llodra, E., Alt, C.H.S., et al. (2014) Marine Litter Distribution and Density in European Seas, from the Shelves to Deep Basins, *PLoS ONE*, Vol.9, No.4, p.e95839

By integrating predicted inputs of marine debris over time, we can arrive at rough estimates of the stock of marine debris. For instance, using the figures from Jambeck *et al* (4.8-12.7 million tonnes plastic input from coastal areas per annum) and modelling their evolution over time between 1980 and 2013 as a constant proportion of plastics production figures,[110] gives a cumulative total of 100-265 million tonnes.[111] This is three orders of magnitude more than the largest estimates derived from sampling floating plastics alone.

If the same method is used just for the EU region, where the proportion of plastics estimated to be released to the marine environment is lower because of better waste management, the cumulative total between 1980-2013 is between 1.4 and 3.7 million tonnes; two orders of magnitude apart from estimates derived from floating litter alone. If we integrate 33 years of riverine plastic input estimates globally and for the EU (again, taking into account plastic production over time), an additional 1.86-28.6 million tonnes and 0.1-1.6 million tonnes are predicted.

It is interesting at this point to note how the cumulative totals derived from Jambeck *et al* are of a similar order of magnitude to sea-floor density data.

In conclusion, floating litter probably represents only a small share of the stock of marine litter, with the sea floor harbouring large quantities. In terms of absolute quantities, in the EU region, the stock of marine litter may be in the order of a few million tonnes. Other types of data are needed to assess how much of this stock is derived from marine sources, and we will discuss these in the following sections.

2.6.3 Source Attribution

Determining from where marine litter originates is one of the great challenges of marine litter research. Data from litter surveys yields information on prevalence according to item type, which can then be mapped onto source categories. The data is always assessed on an item count basis, which may lead to an underestimate in prevalence for items like fishing nets.

As the methods are usually visual and conducted *in situ*, it is hard to include microplastic and macrolitter in the same survey method and same categorisation schema so microplastics are generally excluded. Also it is not possible to attribute microplastics as specifically to item types and therefore sources.[112] This technique has been applied to sea floor data and beach data; but most widely to beach data, which may present quite different prevalences. It is also not common for prevalence to be linked with absolute

---

[110]This may lead to an underestimation, as waste mismanagement probably increases as we go back in time, rather than remaining constant, as per this method.

[111] For those requiring further detail on this calculation please see Work Package 2, Section 6.3.2.6.

[112] Some source attribution by plastic type is possible but needs laboratory analysis and the source categories that can be mapped onto are even broader and more ambiguous than that made possible using item type approaches.

quantities and geographical units; which means that it can be hard to compare data between regions. Knowing the prevalence alone does not allow a conclusion to be made regarding whether a particular item type is present in greater quantities in one region or another.

The most sophisticated form of source attribution by item-type analysis uses a technique called the 'matrix scoring technique' to take into account the fact that one item type may have multiple sources.[113] This assigns a proportion of items of a certain item type to each possible source. In one application, the proportion was calculated by a probability score determined by the assessment of local circumstantial information and consultation with stakeholders.[114]

2.6.4 At-Sea versus Land-Based Sources of Debris, and Sources of At-Sea Debris

A widely quoted figure derived from the cover of a conference proceedings in 1994 stated that 80% of marine debris came from land. No source for the statistic was given.[115] Another potential source of this statistic is the 1991 report by the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) into marine pollution, in which it was stated that 22% of marine pollution is accounted for by shipping operations.[116] However, this referred to all types of marine pollution, and other source categories include, for example, the atmosphere (33%). Therefore the corollary of the '22% of marine pollution deriving from shipping' statistic is not that 78% of marine debris comes from land-based sources; and in fact the report stated that it was not easy to assess the amount of debris originating from land versus that arising from fishing and shipping.

A rudimentary summing of land based source categories from the International Coastal Clean-up data gives figures of 80-98% of marine debris originating from land-based sources.[117] As not all item types are counted (only 43), bias may be caused by more prevalent items within source categories being chosen as indicator items. Additionally, as the mapping of item type to source category is one-to-one, only items unequivocally

---

[113] Tudor, D.T., Williams, A., and Paskoff, R. (2004) Development of a 'Matrix Scoring Technique' to determine litter sources at a Bristol Channel beach, *Journal of Coastal Conservation*, Vol.10, No.1, pp.119–127

[114] Arcadis (2012) *Case studies on the plastic cycle and its loopholes in the four European regional seas areas*, Report for DG Environment, 2012, http://ec.europa.eu/environment/marine/pdf/Arcadis/Arcadis.zip

[115] Faris, J., and Hart, K. (1994) Seas of Debris: A Summary of the Third International Conference on Marine Debris: A Summary of the Third International Conference on Marine Debris

[116] GESAMP(1991) *The State of the Marine Environment*, Oxford: Blackwell Scientific Publications

[117] Equating the classes "Shoreline & recreational activities", "Smoking related litter", "Dumping" and "Medical/Hygiene" summed together to land-based sources. Ocean Conservancy 2012 Data Release,CSV files http://www.oceanconservancy.org/our-work/international-coastal-cleanup/2012-ocean-trash-index.html

derived from ocean/waterway activities are included in that category and so will be underestimated. The overall percentages, though calculated from raw data on item counts, are not weighted according to geographical distances, and so is not necessarily an accurate picture of the prevalence Europe-wide.

Table 6. Prevalence by Source, ICC Data 2012, European Sea Regions

Row Labels	*Baltic Sea*	*Black Sea*	*Mediterranean*	*North-East Atlantic*	*EU-wide*
Shoreline & Recreational Activities	*57%*	*16%*	*31%*	*55%*	*41%*
Ocean/Waterway Activities	*3%*	*2%*	*5%*	*20%*	*12%*
Smoking-Related Activities	*38%*	*80%*	*62%*	*23%*	*45%*
Dumping Activities	*3%*	*0%*	*2%*	*2%*	*1%*
Medical/Personal Hygiene	*0%*	*1%*	*1%*	*1%*	*1%*
Land-based	*97%*	*98%*	*95%*	*80%*	*88%*
Sea-based	*3%*	*2%*	*5%*	*20%*	*12%*

Land-based total obtained by summing Shoreline & Recreational Activities, Smoking-Related Activities, Dumping Activities and Medical/Personal Hygiene categories[118]*Data from Ocean Conservancy (2012)* The Ocean Trash Index - Results of the International Coastal Cleanup (ICC)*, 2012, http://www.oceanconservancy.org/our-work/marine-debris/2012-icc-data-pdf.pdf. Country data assigned to their Regional Seas areas.*

In WP2, further information provided with this dataset – estimates of pounds of material collected per mile per person -was used to counter the effects of differing effort allocated to clean-up in different countries and distance covered (presented here in Table 7 – denoted by '(weighted)'). The raw item type count data was also combined with weight factors to try and correct for the fact that some heavier item types would be under-represented by the count data (Table 7 – denoted by 'by Mass'). The effect is to increase the proportion of debris derived from at-sea sources from 12% to 32%.[119]

---

[118] Ocean Conservancy (2012) *The Ocean Trash Index - Results of the International Coastal Cleanup (ICC)*, 2012, http://www.oceanconservancy.org/our-work/marine-debris/2012-icc-data-pdf.pdf
[119] For those requiring further detail on this calculation please see Work Package 2, Section 6.3.2.6.

Table 7. Estimates for Marine Litter Sources from ICC Beach Cleanups

Source	Global			EU
	Proportion by Item	Proportion by Item (weighted)	Proportion by Mass (weighted)	Proportion by Mass (weighted)
Shoreline & Recreational Activities	65%	73%	59%	47%
Ocean/Waterway Activities	**9%**	**10.6%**	**23%**	**32%**
Smoking-Related Activities	22%	12%	2%	7%
Dumping Activities	2%	3%	14%	13%
Medical/Personal Hygiene	2%	1%	1%	1%
Total	100%	100%	100%	100%

Source data: Ocean Conservancy (2012) The Ocean Trash Index - Results of the International Coastal Cleanup (ICC), 2012, http://www.oceanconservancy.org/our-work/marine-debris/2012-icc-data-pdf.pdf

An analysis categorising all items using a one-to-many relationship matrix (matrix scoring technique) gives the following results. The study benefits not only from a more nuanced technique for attributing item types to sources but also estimates proportions for many more sectors than the ICC data. It is important to note that the average is not weighted according to absolute quantities/densities of marine debris found in each region, and so is not necessarily indicative of the prevalence Europe-wide.

Table 8. Prevalence by Source, Arcadis 2012, European Sea Regions

Sector	Riga (Baltic Sea)	Costanta (Black Sea)	Barcelona (Medite-rranean)	Oostende (North East Atlantic)	Average
Agriculture[1]	1%	0%	1%	1%	1%
Aquaculture[2]	0%	0%	0%	3%	1%
Construction & Demolition[1]	4%	4%	4%	6%	4%
Coastal/Beach Tourism[1]	25%	3%	32%	26%	21%
Dump sites/landfills[1]	0%	5%	0%	1%	2%

Sector	Riga (Baltic Sea)	Costanta (Black Sea)	Barcelona (Medite-rranean)	Oostende (North East Atlantic)	Average
Fishing[2]	3%	2%	3%	12%	5%
General Household[1]	12%	20%	11%	5%	12%
Other industrial activities[1]	1%	1%	1%	2%	1%
Other maritime industries[2]	0%	3%	0%	8%	3%
Ports[2]	5%	2%	4%	8%	5%
Recreational Boating[2]	6%	10%	6%	10%	8%
Recreational Fishing[2]	3%	46%	3%	3%	14%
Sewage[1]	29%	0%	26%	1%	14%
Shipping[2]	4%	2%	4%	10%	5%
Waste collection/treatment[1]	7%	3%	6%	4%	5%
[1]**Land-based sources**	82%	52%	84%	50%	66%
[2]**At-Sea sources**	18%	48%	16%	50%	34%
⇨ ***% fishing sector (% as proportion of at-sea sources)***	*9% (51%)*	*42% (88%)*	*9% (58%)*	*24%(48%)*	*22% (65%)*
⇨ ***% shipping sector(% as proportion of at-sea sources)***	*9% (49%)*	*7% (12%)*	*8% (42%)*	*26% (52%)*	*13% (35%)*

'Fishing sector' aggregated from Fishing, Aquaculture, 72% of Recreational Boating, 72% of Recreational Fishing categories. 'Shipping sector' aggregated from Shipping, Ports and Other maritime industries categories. Sums to equal "Sea" category percentage.

Immediately it can be seen that results vary widely between studies; for example, in the Arcadis (2012) report, the sewage sector for the Mediterranean and Baltic (26 and 29% respectively) have a much greater relative proportion than the comparable ICC results (1 and 0% respectively). In another example, for the North-East Atlantic, at-sea sources are much more prevalent (54%) than perhaps suggested by the ICC data (20%). These differences are likely to be caused by the limited scoring categories and one-to-one item-source relationships defined in the ICC data. Moreover as access to the raw data is not available it is not possible to make any correction for count-based data, geographical distance covered, or for differing levels of activity per unit area, as we have done for the ICC data.

Both studies, however, show that there are significant differences in sources in different EU regions. For example, in the ICC data, at-sea sources range from 2%-20% in the raw data (i.e. uncorrected for weight or clean-up effort), while for the Arcadis data the comparable proportions are 16%-50%.

There are also individual studies that report even higher prevalence from North Sea beach data from at-sea sources – up to 90% of beach litter deriving from shipping and fishing, for example in Texel.[120].[121] However we will assume a general split of 20% to 40% of marine litter deriving from at-sea sources by weight where necessary for the EU and 10%-30% globally.

It is important to compare beach litter data to perhaps the most significant sink for marine litter: the sea floor, as they are likely to accumulate different item types differentially. Standardized trawls with item type count data have only just started to be published in recent years and here we will consider some European data.

Ioakeinidis *et al*, working in the Black Sea, identified a range of 28-69% of items from land-based sources and 15-39% for items from at-sea sources. Items which they could not confidently attribute to one or other category were recorded as an 'unknown' source, 15-28% (Table 9).[122]

[120] Van Franeker, J.A., Meijboom, A., De Jong, M., and Verdaat, H. (2010) Fulmar litter EcoQO monitoring in the Netherlands 1979-2008 in relation to EU directive 2000/59/EC on port reception facilities, *Wageningen IMARES Report*, No.C027/10

[121] Van Franeker, J.A., Meijboom, A., De Jong, M., and Verdaat, H. (2010) Fulmar litter EcoQO monitoring in the Netherlands 1979-2008 in relation to EU directive 2000/59/EC on port reception facilities, *Wageningen IMARES Report*, No.C027/10

[122] Ioakeimidis, C., Zeri, C., Kaberi, H., et al. (2014) A comparative study of marine litter on the seafloor of coastal areas in the Eastern Mediterranean and Black Seas, *Marine Pollution Bulletin*, Vol.89, No.1–2, pp.296–304

Table 9. Estimates for Marine Litter Sources from Sea-floor Trawls in the Black Sea (Ioakeinidis *et al* 2014)

Area	Land	Fishing	Vessels	Unknown
Saronikos Gulf	68%	15%	3%	15%
Gulf of Patras	43%	9%	28%	20%
Echinades Gulf	41%	8%	24%	27%
Limassol Gulf	57%	2%	13%	28%
Constanta Bay	28%	13%	26%	33%
Range	28-68%	2-15%	3-28%	15-28%

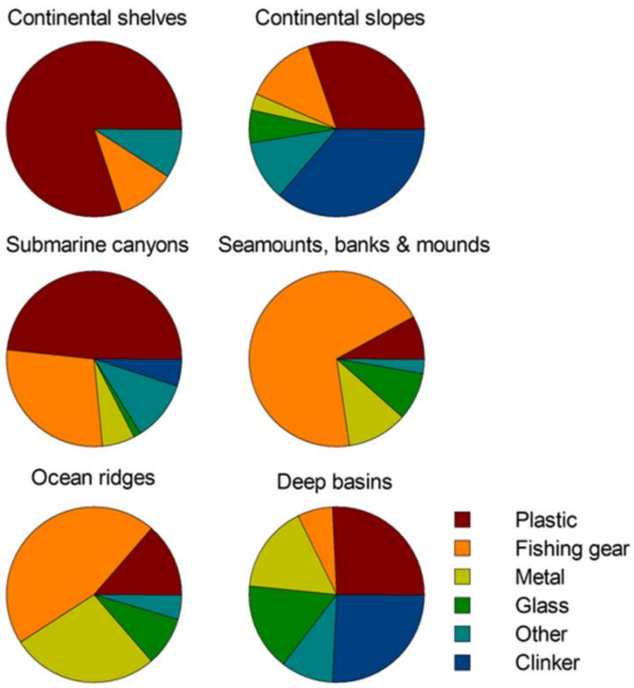
In the North Sea and Celtic Sea, Cefas estimated that between 1992-2012 around 30% of the total benthic items were fishing gear and equipment. They did not categorise by any other sectoral category, so shipping was not disaggregated as a category.[123]

Pham *et al.*'s study, covering the Mediterranean and North-East Atlantic, also looked at fishing gear vs other items, and depending on the type of physiography of the subsea area – e.g. ridge, shelf, canyon – found ranges of around 6-66% overall (Figure 14).[124] Ranges were from 0-100% in the Atlantic and 0-21.6% in the Mediterranean taking all sites into consideration.

[123] Unpublished data.

[124] Pham, C.K., Ramirez-Llodra, E., Alt, C.H.S., et al. (2014) Marine Litter Distribution and Density in European Seas, from the Shelves to Deep Basins, *PLoS ONE*, Vol.9, No.4, p.e95839

Figure 14. Benthic Litter by Item Type; Sites in the North-East Atlantic and Mediterranean Categorized by Physiography



Reproduced from Pham, C.K., Ramirez-Llodra, E., Alt, C.H.S., et al. (2014) Marine Litter Distribution and Density in European Seas, from the Shelves to Deep Basins

Each of these sea floor studies have categorised by item count, and as such are likely to underestimate provenance from the fishing sector; this gives at-sea sources tentatively a greater contribution on the sea-floor compared with beach litter studies. Therefore taking both sources of data into account, perhaps prevalence of 40:60 in EU waters for at-sea:land-based sources is more realistic. However as there is not data for other categories of at-sea sources, nor adequate geographic data to hand for making EU-wide averages that are grossed up appropriately, it is necessary to be cautious in such estimates.

2.6.5 Estimation of Input of At-Sea Sources of Waste

To compliment this data review, we have made our own estimation of the input of at-sea sources of waste into the marine environment. The general steps that we have followed to understand this is to estimate the total amount of waste generated at sea in EU waters with relevance to marine litter and compare it to statistics on delivery of waste at ports.

The generation side of the equation is built up by estimating the number of persons at sea, in EU waters over a year, and applying estimates of waste generated per capita per year. Where the annual waste generation estimates per capita do not take into account that persons may only be at sea for a fraction of a year, the person estimates are adjusted to 'person-years' or 'vessel-years' so that generation is not overestimated. In addition to this approach, for some waste streams EU-wide estimates were made directly on a sector by sector basis, if this was the most direct way of doing so (namely, solid cargo residue, and Annex V operational waste). Where possible, i.e. data permitting, the evolution of the amounts both of per capita generation of waste components, as well as persons at sea, has been factored into the model.

Additionally the proportion of waste generated that is food waste (and so which may legitimately be disposed of at sea in some circumstances), and the proportion of waste that is incinerated (and so 'disappears' from the generation and delivery balance sheets), is also estimated and taken into account, so as to avoid overestimating the generation/delivery gap.

This approach has precedent in the form of the National Academy of Sciences paper from 1975, which sought to estimate inputs of many sources of marine pollution, including marine litter, using a similar approach. At that time, international legislation prohibiting discharge at sea was not in force, and it was common practice to dispose of waste at sea; therefore it was assumed that all the waste generated became marine litter. Today we know that much waste is delivered to ports, which is why delivery statistics are taken into account.

A more recent study was undertaken in 2006 by TRT Srl. on behalf of the European Parliament. This estimated waste generated at sea by the merchant shipping fleet, (including the passenger and cruise sectors) as well as the proportion disposed of at ports, versus being incinerated/discharged at sea.[125] This data has also been used to arrive at our final estimates.

2.6.5.1 Quantifying Persons and Vessels at Sea in the EU

Here we look at the number of persons at sea in the EU over time. Vessel numbers have also been estimated, because firstly, this was used to estimate persons at sea for the naval sector, and also this is useful to assess the scope of legislation, its various requirements, and their exceptions. This information has also been used in both Section 2.6.5.4 on total waste delivered and also Section 3.0 on legislative gaps. The following maritime sectors have been defined:

- Shipping
- Fishing
- Cruise
- Passenger
- Recreational
- Naval

It must been borne in mind that statistics from different sources may not have exactly the same country scope, and for the EU, sometimes the number of countries included

[125] TRT Srl., Maffii, S., Molocchi, A., and Chiffi, C. (2007) External Costs of Maritime Transport

changes over time, producing some comparability issues and irregularities. However, these are considered generally to be a minor percentage of the total values. As a general rule we have attempted to obtain data for the period 2006-2013, and used mainly linear extrapolation to fill in missing data.

Shipping

Employment data for 2011, and the number of EU owned vessels (whether registered in the EU or elsewhere) was taken from a DG Move report on seafarer employment in the EU.[126] This was combined with data on the year on year development of the world fleet from Equasis (produced for EMSA) to produce estimates of persons and ships in EU waters between 2006 and 2013.[127]

The employment data was built up from EU supplied staff operating on EU owned vessels. Countries for whom data was available suggest that 33% of staff on board national vessels were non-EU nationals, and so this was also factored in. Each person was assumed to be a full time equivalent, spending only the equivalent of standard workdays per year at sea (253 days a year, or 69%).[128] Data on non-EU seafarers on non-EU owned vessels are not available, however we assume the underestimation thus caused this to be counterbalanced by the overestimation owing to the time EU-owned vessels spend operating outside EU waters.

The number of vessels was restricted to those over 100 GT in both sources. Shipping vessels were taken to spend 300 days per year at sea.[129]

For 2013, the number of seafarers was in this way estimated to be 384,289, or 266,370 in full person-years. The crew of passenger vessels (Ro-ro, ro-pax and ferries) are included in this figure, and as we account for these in a separate section (14% of the total – see below for the derivation), they are subtracted from the shipping sector to give 329,323 seafarers; or 228,271 in person years. The corresponding number of vessels was estimated to be 18,000, or 14,795 in vessel-years (again, passenger vessels have been subtracted from this estimate – see below).

Fishing

Data on fishing employment and vessel numbers were obtained from the FAO yearbook of fisheries statistics[130] and the EC's fishing fleet register[131] respectively. Only vessels

---

[126] DG MOVE, and Sulpice, G. (2011) *Study on EU Seafarers Employment - Final Report. MOVE/C1/2010/148/SI2.588190*, 2011, http://ec.europa.eu/transport/modes/maritime/studies/doc/2011-05-20-seafarers-employment.pdf

[127] Equasis (2015) The World Merchant Fleet 2006 -2013, http://www.emsa.europa.eu/implementation-tasks/equasis-a-statistics/item/472.html

[128] http://www.work-day.co.uk/

[129] TRT Srl., Maffii, S., Molocchi, A., and Chiffi, C. (2007) External Costs of Maritime Transport

[130] FAO (2012) *FAO yearbook. Fishery and Aquaculture Statistics 2012*, 2012, http://www.fao.org/3/a-i3740t/index.html

[131] http://ec.europa.eu/fisheries/fleet/index.cfm?method=Search.ListSearchSimple

fishing commercially need be registered. The vessel data was a complete record from 2006-2013 while the employment data was limited to 2007-2011. A linear trend was used to extrapolate to the remaining years required. In the EU, FTEs in the fishing sector are 79% of the number of jobs.[132] In 2013 we estimate the number of fishermen in FTEs as 136,077. Again the time spent at sea over the year was factored to constitute 69% of the year, giving 94,322 person-years. The number of vessels was 80,529 in 2013, and taking into account an assumption of vessels spending 2/3rds of the year at sea, is equal to 53,149 vessel-years.

Cruise

In the cruise sector, both passengers and crew in the EU were accounted for, as well as vessel numbers, with data from two different sources.[133] [134] From 2012 onwards, the passenger numbers were projections only while 2007-2011 constituted real data. We assumed an average cruise length of 7 days.[135] Employment in FTEs, as well as vessel numbers, was available for 2011 to 2014. Any other year's data needed was extrapolated from these figures on a linear trend. Time at sea was not taken into account for vessels as they were assumed to be more or less constantly inhabited; with much time spent in port with a full complement of crew and passengers. Therefore only taking into account 'cruise time' would be misleading. For 2013, the passenger numbers were projected to be 5,660,000 in Europe, but with only 1.9% of the year spend on board, this constitutes only 151,823 person-years. Employment was 62,432 FTEs and there were 198 vessels operating in EU waters.

Passenger

Data on all passengers embarked and disembarked in the EU were obtained from Eurostat, and covered all forms of transport where passengers are involved such as cruises, ferries, Ro-ro and Ro-pax vessels as well as all ports in the EU.[136] As figures are very similar for embarkments and disembarkments, inwards travel was chosen as a basis for the statistics, so as not to double count persons, and our figures on cruise passengers were subtracted from them (as we account for these in a separate section). Data was available for the whole period of 2006 to 2013. In 2013, the number of passengers transported is estimated to be 194.6 million. We contacted the operator of a website which provides information to passengers on ferry routes to obtain the average length of a ferry journey in the EU, as 6.16 hours. Although this may seem long, the number and

---

[132] Calculated excluding Bulgaria. Joint Research Centre, Paulrud, A., Carvalho, N., Borrello, A., European Commission, and Institute for the Protection and the Security of the Citizen(2014) *The 2014 annual economic report on the EU fishing fleet (STECF-14-16)*, Luxembourg: Publications Office

[133] CLIA (2013-2015) *Contribution of Cruise Tourism to the Economies of Europe* http://www.cliaeurope.eu/media-room/clia-europe-economic-contribution-report

[134] http://www.statista.com/statistics/270605/cruise-passengers-worldwide/

[135] FCCA (2010) Cruise Industry Overview, http://www.f-cca.com/downloads/2010-overview-book_Cruise-Industry-Overview-and-Statistics.pdf

[136] http://ec.europa.eu/eurostat/product?code=mar_mp_aa_pphd&language=en&mode=view

length of longer routes push up this average. Factoring this figure in leads to an estimate of 136,815 person-years.

Data on the crew staffing passenger vessels was not obtainable as a separate statistic however these staff are included in the shipping crew estimates derived from DG Move (2011).[137] The report does, however, include the number of vessels, 2,755, operating in this sector in 2008.[138] We have used the evolution in the world fleet to estimate a time series for this data to give a total of 3,004 vessels in 2013. We have used this to apportion a proportion of the shipping crew estimated to the passenger sector (14%). In 2013 this gives 54,965 persons. Taking into account a standard working year, this is equivalent to 38,099 person years at sea for passenger vessel crew.

Recreational

There are few publicly available sources of information on the recreational boating sector, however, we have found estimates of the number of recreational boats owned in the EU for 2003 and 2010; these numbers were used to estimate a trend over time. [139] The number of people in the EU who engage in marine boating activity over the year was also found for 2010.[140] The vessels numbers apply to both inland and coastal waters; we have made an apportionment based on the length of inland waterways (27,000km) and the length of coastline (70,000km) in Europe, making the assumption therefore that 72% of the boats are for maritime use.[141] We assumed a conservative 2 days' worth of excursions per year per vessel. In this way we estimated, in 2013, there to be 4,453,608 recreational maritime vessels, equating to 24,403 vessel years; and 37,028,571 recreational maritime boaters equating to 202,896 person years.

Naval

We used figures on the different types of naval vessels in the EU plus estimates of staffing in different types of vessels to build up an estimate of staffing of naval vessels.[142]

---

[137] DG MOVE, and Sulpice, G. (2011) *Study on EU Seafarers Employment - Final Report. MOVE/C1/2010/148/SI2.588190*, 2011, http://ec.europa.eu/transport/modes/maritime/studies/doc/2011-05-20-seafarers-employment.pdf

[138] Does not include cruise ships

[139] British Waterways Scotland (2003) *Waterways for growth*, European Boating Industry (2010) *Facts & Figures*, accessed 18 August 2015, http://www.europeanboatingindustry.eu/facts-and-figures

[140] European Boating Industry (2010) *Facts & Figures*, accessed 18 August 2015, http://www.europeanboatingindustry.eu/facts-and-figures

[141] European Boating Industry (2010) *Facts & Figures*, accessed 18 August 2015, http://www.europeanboatingindustry.eu/facts-and-figures

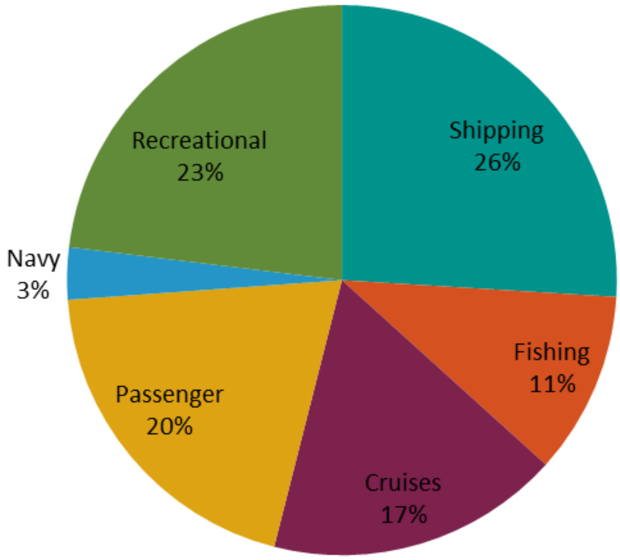
[142] https://en.wikipedia.org/wiki/Military_of_the_European_Union#Naval_forces, https://en.wikipedia.org/wiki/Invincible-class_aircraft_carrier, https://en.wikipedia.org/wiki/Wasp-class_amphibious_assault_ship, https://en.wikipedia.org/wiki/USS_Whidbey_Island_%28LSD-41%29, http://www.navy.mil/navydata/fact_display.asp?cid=4200&tid=900&ct=4,https://en.wikipedia.org/wiki/Sa%27ar_5-class_corvette, https://en.wikipedia.org/wiki/Vedette_c%C3%B4ti%C3%A8re_de_surveillance_maritime, https://en.wikipedia.org/wiki/HMS_Chiddingfold_%28M37%29,

A figure of 44% of ships deployed or underway for training or local operations was used to convert these numbers into person years and vessel years.[143] Data on military spending in the EU in million Euro was used to estimate a rough time series for this data.[144] The result was that in 2013, we estimated 61,113 staff would be needed to man the EU fleet of 549 vessels, and that this would equate to 26,890 person years and 241 vessel years.

Summary

Because of the wide disparity between amount of time spent at sea (e.g. contrast a ferry passenger that spends a few hours at sea with a shipping crew member, or a recreational boat spending a few days at sea per year with a cruise ship that may spend near all year in use), in order to provide an overview of the relative sizes of these sectors, the fairest comparisons between sectors in terms of both vessels and passengers, are made in person years and vessel years. These are illustrated for 2013 in Figure 15 and Figure 16.

Figure 15. Persons by Sector in the EU in 'Person Years', 2013



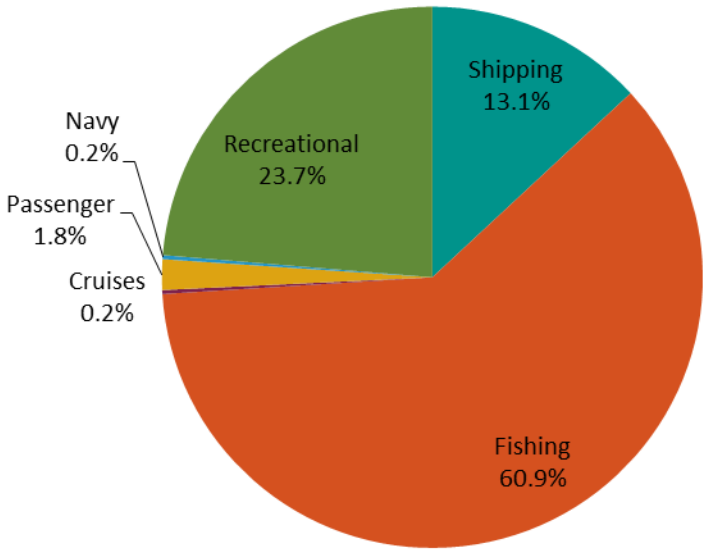
---

https://en.wikipedia.org/wiki/USS_George_Washington_%28SSBN-598%29,
https://en.wikipedia.org/wiki/USS_Annapolis_%28SSN-760%29,
http://www.navy.mil/navydata/fact_display.asp?cid=4200&tid=1300&ct=4
NB EU countries often class 'destroyers' as 'frigates'

[143] US proportion assumed to equal EU equivalent. http://www.navy.mil/navydata/nav_legacy.asp?id=146

[144] "Defence" COFOG99 category; NA_ITEM "Total general government expenditure", unit "million euro" http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=gov_10a_exp&lang=en

Figure 16. Vessels by Sector in the EU in ‘Vessel Years’, 2013



In terms of waste generation, it is the person years that affects our estimates most. The smallest sector in this regard is the navy at 3%; the largest is the shipping sector, at 26%. Of particular interest is that fishing vessels and recreational vessels make up around 85% of the vessels and 34% of the persons. Their general exemptions from many aspects of the PRF directive represents potentially a large proportion of waste under less stringent regulation than the remainder.

2.6.5.2 Quantifying Waste Streams of Relevance to Marine Litter Generated at Sea

Waste generation was quantified per capita on a stream by stream basis. The following waste categories were defined, to reflect different sources of data we were able to obtain, and were considered to give full coverage of the total relevant waste:

- Annex V – Domestic Type Waste
- Annex V – Operational Type Waste
- Annex V – Cargo Residue
- Annex IV – Sewage and SRD

Where possible we obtained data for the period 2006-2013. Where this was not possible, waste streams were assumed to follow similar trends to the most appropriate type of waste. More detail on this is provided in the following sections.

Annex V - Domestic Type Waste

We have drawn upon land-based municipal waste generation statistics per capita for Europe as a starting point for estimating at-sea generation of this waste stream per capita. In 2013, waste generation was 481kg per capita.[145] We have applied this to the shipping, fishing and navy sectors. Data available on waste generation on cruise ships suggests higher amounts of waste are generated: a 2008 figure was found of 913kg per capita, taking into account both passengers and crew.[146] If this were to evolve in the same way as land-based municipal waste generation (which has reduced between 2008 and 2013), in 2013 the equivalent figure would be 842kg per capita. As this is an overall figure, we assume that this also covers Annex V operational wastes also. We have applied this per capita estimate to the cruise passengers and crew, passenger ferry passengers and recreational boating, as patrons of these sectors are considered mainly to be consumers in leisure time or on-the-go, times when consumption tends to be high.

Accounting for food waste

Food waste, a subcategory of Annex V domestic type wastes, presents a particular problem when accounting for waste generated at sea as well as waste delivered. It may be disposed of legitimately at sea in certain locations and circumstances. It also may be incinerated. In this way an unknown proportion of it disappears from generation and delivery accounting. Failing to account for this would lead to an overestimation of the gap between generation and delivery. Land-based composition data suggests that food waste accounted for 17% of local authority collected waste in England in 2010/11.[147] We know that it is accepted by some port waste operators for disposal, suggesting that not all of it is disposed of at sea.[148] Short sea shipping that does not spend much time far (>3-12nm) from the coast will not be able to dispose of its food waste at sea. Also, ships that spend significant amounts of time in port will not be able to dispose of their food waste in the harbour waters and this may exceed their storage capacity for the waste. This probably applies to cruise vessels.[149]

---

[145] http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tsdpc240&plugin=1

[146] Policy Research Corporation (2009) *Tourist Facilities in Ports. The Environment Factor.*, Report for DG MARE, 2009, http://ec.europa.eu/maritimeaffairs/documentation/studies/documents/environment_factor_en.pdf.

[147] DEFRA (2015) *Digest of Waste and Resource Statistics - 2015 Edition*, 2015, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/422618/Digest_of_waste_England_-_finalv2.pdf

[148] Butt, N. (2007) The impact of cruise ship generated waste on home ports and ports of call: A study of Southampton, *Marine Policy*, Vol.31, pp.591–598

[149] Butt, N. (2007) The impact of cruise ship generated waste on home ports and ports of call: A study of Southampton, *Marine Policy*, Vol.31, pp.591–598

Additionally, most fishing vessels fish inshore fisheries (<12nm from the coast – three quarters of the fishing fleet in the UK by way of example).[150] We also surmise that fishing vessels, passenger ferries and recreational vessels are unlikely to have incinerators, but that shipping, cruise and navy vessels may. Therefore we assume that food waste is mostly disposed of or treated at sea by shipping, cruise vessels, navy vessels, some fishing vessels (a proportion of a quarter has been applied) and some passenger ferries (again, a quarter has been assumed - to cover those that have longer routes and spend time reasonably far from the coast). Corresponding amounts have therefore been subtracted from the per capita estimates of Annex V domestic waste for these vessels.

It must also be borne in mind that food waste will not in of itself cause marine debris if disposed of at sea as it will degrade.

Annex V - Operational Type Waste

General Operational Waste

Aside from waste generated by regular day to day living activities, we know that generally speaking, commercial operations lead to the generation of extra waste. For example, in the UK, commercial and industrial waste was around double (200% of) the amount of local authority collected waste, in 2010/2011.[151] However it would not be correct to apply this as a general proportion to at-sea sectors. Therefore we have taken the proportion of cargo associated waste estimated for the shipping sector (9%) cited in the TRT Srl. study and applied it to waste generation estimates for the shipping sector, the fishing sector and the navy sector.[152] The equivalent figure for the passenger vessel sector given in the TRT study is 2% and this has been applied to that sector. This modest increase is considered to take into account cargo-associated waste in the shipping sector, any kind of waste beyond fishing gear in the fishing industry (fish boxes, bait bags, strapping bands, PPE), any waste resulting from extra logistical needs of the navy, as well as any waste produced by administrative functions on board (we conceive this to be 'office-type' waste). This was not applied for the cruise and passenger sector as their per capita waste estimates were derived from whole-vessel approaches that should already take into account Annex V operational wastes. This waste stream was considered not to apply to the recreational boating sector.

Fishing equipment

The fishing sector produces a unique waste stream in the form of fishing equipment. There is very scarce data on this, however in Norway, a fishing gear recycling project estimated in 2014 that the annual tonnage of plastic equipment discarded from the

---

[150] http://www.seafish.org/industry-support/fishing/project-inshore

[151] DEFRA (2015) *Digest of Waste and Resource Statistics - 2015 Edition*, 2015, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/422618/Digest_of_waste_England_-_finalv2.pdf

[152] TRT Srl., Maffii, S., Molocchi, A., and Chiffi, C. (2007) External Costs of Maritime Transport

fishing and fish farming industry in Norway to be 15,000 tonnes.[153] In 2014, we estimate the number of people in Norway involved in fishing, from FAO data, to be 11,735; [154] and the number of people in aquaculture to be 5,900.[155] Accounting for part time work, using the same conversion factor as in the section on persons in the fishing sector EU-wide, this equals 14,015 FTEs. Therefore, we estimate the per capita generation of plastic waste of this type to be 1,070kg per year. However, aside from the plastic waste produced by the industry, they also lose a large proportion of nets. Brown et al (2007), from stakeholder information, put a rough estimate of this as 33% of a vessel's nets in a year (1 fleet of nets where a vessel may possess 3 fleets).[156] They also provide a rough estimate of the lifespan of a net being 1 year. Therefore we assume that the remaining 66% of nets become waste over the year.[157] To account for this in our figure for waste generation per capita, we assume that the 1,071kg represents fishing gear that has reached the end of its lifecycle, i.e. the 66% of total gear, while another 33% should be added on to account for lost gear. This equals 1,605kg per capita per year. It was not possible to find an appropriate way of accounting for the evolution of waste generation per capita over time, so it has been applied across each year.

Fishing discards

Fishing discards are legitimately disposed of at sea. The quantities are significant – 22% of the UK catch by tonnage is estimated to be discards or waste generated from processing at sea;[158] applied to an EU catch of around 7.4m tonnes in 2012[159] gives a generation statistic of 1.7m tonnes per year. This dwarfs the amount of any other waste stream we have included in our scope. However as it is entirely disposed of at sea and is not included within any other waste stream estimate it has been ruled out of scope and not taken into account.

Annex V - Cargo Residue

For the category of Annex V Cargo Residue i.e. solid cargo residues whether dry or whether contained within wash water, it is rather difficult to estimate tonnages. There are very few estimates of either tonnages of, or proportion of ship wastes, that are cargo

---

[153] http://nofir.no/#/about

[154] FAO (2012) *FAO yearbook. Fishery and Aquaculture Statistics 2012*, 2012, http://www.fao.org/3/a-i3740t/index.html

[155] http://www.fisheries.no/aquaculture/Aquaculture/#.VdeinpchFFs

[156] Loss statistics are usually reported and number of nets lost per net *deployment*, rather than nets *owned* by the vessel. As a net may be deployed hundreds of times in a year, these percentages are much lower than the figure we have used.

[157] Brown, J., and MacFadyen, G. (2007) Ghost fishing in European waters: Impacts and management responses, *Marine Policy*, Vol.31, No.4, pp.488–504

[158] Seafish (2001) *Fish Waste Production in the United Kingdom*, 2001, http://www.seafish.org/media/Publications/SR537.pdf

[159] FAO (2012) *FAO yearbook. Fishery and Aquaculture Statistics 2012*, 2012, http://www.fao.org/3/a-i3740t/index.html

residues. We know that the amount of solid cargo residue likely to be relevant to marine litter is small; in 2013 only 23% of cargo tonnage handled was dry as opposed to liquid bulk cargo[160] - applying this to the 2,229 million tonnes of cargo unloaded in all ports in the EU in that year[161] gives an estimated 513 million tonnes of dry bulk cargo unloaded. Of this, most are likely to be ores, aggregates, metal, coal or agricultural/forestry products.

In 1975, NAS estimated these 'non marine litter relevant' categories to be 96% of the dry bulk cargo transported as a whole. We might expect the remainder, which will include plastic granules, pellets, fibres or powders, to have increased in prevalence since then; but it has been difficult to obtain further breakdowns of the types of dry bulk cargoes. An extract from the EU international trade database, COMEXT, shows that in 2013, the import into EU-28 countries, from outside the EU, of all kinds of plastics in primary forms, synthetic ion exchange resins, non-spun synthetic fibres, and plastic and synthetic fibre waste, was 8.97 million tonnes. If these were transported exclusively by maritime transport, it would equal 1.75% of the total quantity of dry bulk cargo unloaded at ports.[162] Cargo residues may be a few tonnes of material if the hold is prepared by a "shovel clean" as opposed to a "sweep clean".[163] The cheaper the commodity value, the more likely that cleaning will be carried out to a minimal standard to facilitate a fast vessel turnaround and the cargo residue might amount to a few hundred tonnes.[164,165] The crew must then sweep up, bag and dispose of the cargo residue.[166] Given the weighted mean dwt (deadweight tonnage)[167] of a dry bulk carrier of about 46,500 tonnes, assuming that 90% of this capacity is for cargo, and that 10 tonnes might be left as cargo residue, this is 0.024% of the total load. Applied to the plastics we estimate to

---

[160] http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Gross_weight_of_seaborne_goods_handled_%28inward_and_outward%29_in_main_ports%281%29_in_2013_by_type_of_cargo%282%29.png

[161] 3,716 million tonnes handled (i.e. loaded and unloaded) in all ports; general split of 60% cargo unloaded and 40% cargo loaded applied; Eurostat: Country level - Gross weight of goods handled in all ports http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=mar_mg_aa_cwh&lang=en; unloaded/loaded split from http://ec.europa.eu/eurostat/statistics-explained/index.php/Maritime_ports_freight_and_passenger_statistics

[162] Assumptions: all extra-EU trade in these synthetic materials conducted via marine transport; a further 43.7 million tonnes of intra-EU trade not conducted via maritime modes and hence excluded.

[163] Standard Cargo (2011) Bulk Cargoes - Hold Preparation and Cleaning http://standard-club.com/media/23964/15056CargoJan2011Bulletinv06.pdf

[164] Wilhelmsen Ships Service (2015) Proper Cargo Hold Cleaning Procedures Mean Good Risk Management http://www.wilhelmsen.com/services/maritime/companies/buss/new_offers/Documents/Cargo%20Hold%20Cleaning%20white%20paper.pdf

[165] As long as it doesn't interfere with future cargoes like grain, for which a 'grain clean' is always necessary, or materials that always require a 'hospital clean' were carried;

[166] Standard Cargo (2011) Bulk Cargoes - Hold Preparation and Cleaning http://standard-club.com/media/23964/15056CargoJan2011Bulletinv06.pdf

[167] Capacity of ship in terms of cargo, fuel, ballast, passengers – in short, everything it carries fully loaded in addition to the cargo itself

be imported as dry bulk, this equals 2,142 tonnes. Applied to the 513 million tonnes of dry bulk cargo unloaded in the EU in total, this equals around 123,000 tonnes which could be destined for disposal at ports.

An uncertainty around the quantification of this amount of waste is that cargo residues which are not harmful to the marine environment can be legitimately disposed of at sea in certain locations. However, Regulation 4.1.3 of MARPOL Annex V states that this applies to "*cargo residues that cannot be recovered using commonly available methods for unloading"* and hence, there is a requirement to minimize quantities for disposal at sea. Therefore, we have not estimated a proportion of cargo residues that is disposed of at sea, assuming it to be minimal.

If we wished to take an alternative approach to the above and derive estimates of solid cargo residue tonnages generated by using delivery statistics to understand the relationship between quantities of ship generated waste delivered and solid cargo residue delivered, the following complication arises. Statistics on delivery split this waste stream into two. One category is for dry solid cargo residue, which gets reported within the Annex V solid waste category. There is therefore no way of disaggregating the quantities according to solid cargo residue versus other types of solid waste. A separate category is reported for solid cargo residue contained in wash water.

It is clear that the latter category includes a volume of wash water which will be many times the volume of solid waste itself, and an unknown proportion at that. Furthermore, the data on delivery volumes of solid cargo residue in washwater is very scarce (known for only 8 ports for a 2012 study on waste delivery and 15 in the 2015 study)[168] and previous studies have therefore not used it to compare to other amounts of waste generated or to estimate EU totals for the delivery of this waste stream.[169] For these reasons, it's not possible to use the relationship between quantities of ship generated waste delivered and solid cargo residue delivered, to estimate cargo residue generation quantities. Because of these difficulties, as Annex V CR in washwater is reported separately in delivery statistics we have decided to exclude it from consideration in the waste delivery estimate and therefore correspondingly, have not attempted to estimate its generation.

[168] EMSA, and Ramboll (2012) *Study on the Delivery of Ship-Generated Waste and Cargo Residues to Port Reception Facilities in EU Ports*, August 2012, http://www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities/download/1972/1607/23.html

[169] Panteia, and DG MOVE (2015) *Ex-Post Evaluation of Directive 2000/59/EC on Port Reception Facilities for Ship-Generated Waste and Cargo Residues*, 2015, http://ec.europa.eu/transport/modes/maritime/studies/doc/2015-ex-post-evaluation-of-dir-2000-59-ec.pdf,EMSA, and Ramboll (2012) *Study on the Delivery of Ship-Generated Waste and Cargo Residues to Port Reception Facilities in EU Ports*, August 2012, http://www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities/download/1972/1607/23.html

Annex IV – Sewage and Sewage Related Debris (SRD)

There are several estimates of cubic metres of sewage waste produced per capita at sea; if we take 30 litres a day of black water per capita as a midpoint of the figures cited in Butt (2007) (20 to 40 litres per person per day) this equates to $11m^3$ per person per year. However this does not tell us anything about how much sewage related debris there might be. Water UK estimates that 2 billion sanitary items are flushed down UK toilets each year;[170] with a current population of around 63 million this equals about 32 items per person per year. Sewage related debris may be anything from nappies to a cotton bud – widely ranging in weight per item. We have assumed an illustrative value of ~30 grams per item giving a total of 1kg sewage related debris per capita per year.

As these are estimates derived from behaviour on land, we have utilized only a quarter of the per capita amount for the shipping, fishing, and navy sectors, which will have fewer items deriving from e.g. infant care and cosmetics. The full amount has been attributed to the cruise, ferry and recreational sectors. It was not possible to find an appropriate way of accounting for the evolution of waste generation per capita over time, so it has been applied across each year. It is important to note that even if we assume that the great proportion of this material finds its way to sea (few water treatment methods can remove them completely, aside from expensive membrane based technologies and perhaps incineration which is practiced in some sectors) it will represent a very small proportion of the total amount of material generated at sea.

Accounting for incineration at sea

The fact that waste can be incinerated at sea means that a proportion of the waste that would otherwise be delivered is not. There is little direct information about the proportion of total generated waste that might be incinerated at sea. If we do not take it into account however, we risk overestimating the gap between generation and delivery.

The first thing to consider when estimating how much waste generated is incinerated is to consider what types of waste may or may not be incinerated.

Of the Annex V wastes, on cruise ships for example, recyclable materials are not generally incinerated. Additionally, most plastics and all hazardous wastes are not allowed to be incinerated.[171] If ships performed to the same standard as UK households, they might be left with about 56% residual waste to deal with after recyclables are

[170] http://water.wuk1.emsystem.co.uk/home/resources-and-links/bagandbin/what--s-the-problem-?textonly=

[171] Butt, N. (2007) The impact of cruise ship generated waste on home ports and ports of call: A study of Southampton, *Marine Policy*, Vol.31, pp.591–598

removed, from domestic type wastes and some kind of operational type wastes similar in composition.[172]

It is unlikely that most types of cargo residue would be incinerated as most of it would not reduce in volume or mass (the general aim of incineration), being inert materials. [173] Therefore we exclude these from our calculations.

We have also already taken into account food waste and its incineration as described in the above relevant section; if waste composition is similar to the UK, this is about 55% of the residual waste, and so we exclude that fraction from our accounting for incineration.[174]

Butt et al (2007) cite that on cruise ships, 75%-85% of *residual waste* is incinerated and so we use this to guide our estimated of incinerated waste, taking a midpoint of 80%.

Therefore we estimate that approximately 20% of the Annex V domestic type waste may be incinerated.[175] In terms of the reduction of mass, very combustible materials will reduce by 95%, while non-combustible material will reduce very little (<10%).[176] We assume an overall reduction of mass of 80%, and the remaining ash must be delivered to port, according to Marpol Annex V. This leaves us with a reduction of 16% owing to incineration to account for in the waste generation estimate.

In terms of types of vessels that incinerate, we will apply the assumption used when considering the fate of food waste; namely, that fishing vessels, passenger ferries and recreational vessels are unlikely to have incinerators, but that shipping, cruise and navy vessels may.

Garbage record books should state the tonnage of material incinerated, as well as the tonnage of ash generated. However as there is no database of garbage record book entries, this cannot be used to obtain a general overview of the amount of waste incinerated on ships that possess such equipment.

---

[172] DEFRA (2015) *Digest of Waste and Resource Statistics - 2015 Edition*, 2015, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/422618/Digest_of_waste_England_-_finalv2.pdf

[173] ABS (2012) *MARPOL Annex V Garbage Management Manual*, accessed 10 October 2013, http://www.eagle.org/eagleExternalPortalWEB/ShowProperty/BEA%20Repository/MyEagle/ClassificationForms/GarbageManagementManual

[174] DEFRA (2015) *Digest of Waste and Resource Statistics - 2015 Edition*, 2015, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/422618/Digest_of_waste_England_-_finalv2.pdf

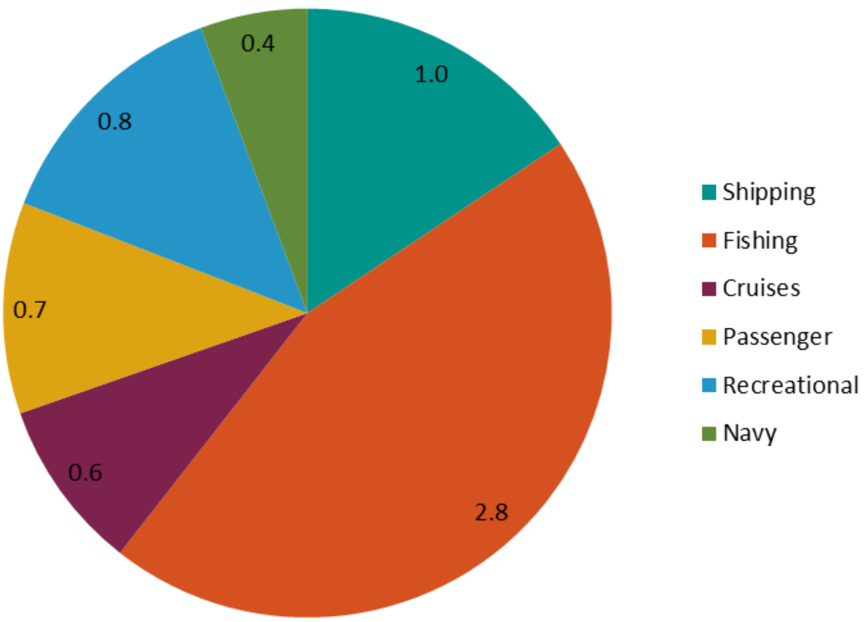
[175] 56% residual waste of which 55% is food waste and 45% is non food waste; of which 80% may generally be incinerated.

[176] ABS (2012) *MARPOL Annex V Garbage Management Manual*, accessed 10 October 2013, http://www.eagle.org/eagleExternalPortalWEB/ShowProperty/BEA%20Repository/MyEagle/ClassificationForms/GarbageManagementManual

Aggregated estimates of waste generated

The aggregated estimates of waste per capita for each sector are displayed in Figure 17. To recap, food waste estimated to be discharged at sea and waste estimated to be incinerated are not included in these figures, to make the results comparable with delivery estimates.

Figure 17. Comparison of Annual Waste Generated Per Capita in Different Sectors (tonnes per year, 2013)



It is notable how, according to our present model, that the waste generation per capita for the fishing sector is significantly larger than any other sector. However differing allocation of levels of activity at sea between sectors will be affecting the waste generation totals for each sector.

An interesting source of data is the per-vessel estimates of waste generation featuring in the 2006 study by TRT Srl, "External Costs of Maritime Transport".[177] These figures were obtained from the EMAS-ship project from 2006.[178] Separate estimates apply to the

---

[177] TRT Srl., Maffii, S., Molocchi, A., and Chiffi, C. (2007) External Costs of Maritime Transport

[178] EMAS-Ship (2006) Shipping with EMAS - Methodological Guidelines for the Implementation of EMAS in Shipping Companies LIFE03 ENV/IT/393

shipping, cruise and passenger sectors. The data is categorized according to the reporting categories for the unrevised MARPOL Annex V, namely:

- Cat. 1 Plastics
- Cat. 2 Floating dunnage, packaging and covering materials
- Cat. 3 Paper, rags, glass, metals, bottles, and other similar residues
- Cat. 4 Triturated paper, rags, glass, metals, bottles, etc. (* - comminution = <2.5 mm)
- Cat. 5 Food waste
- Cat. 6 Other waste (ashes, etc.)

Consultation of another source confirms that Category 2 generally is intended to include cargo associated waste and Category 3, solid cargo residue.[179]

We used data provided in this paper on vessel numbers, persons per ship-trip, and cruise time (days per year), as well as a volume:weight conversion factor of 2m^3 to 1 tonne[180] to calculate comparable figures for waste generation per capita to our own (and having also taken in to account food waste and incineration). Generally, we find that, in the comparable year (2006) the figures are almost double ours for the shipping sector, just under four times as great for the cruise sector and just under three times as great for the passenger sector (Table 10).

Table 10. Annual Per Capita Waste Generation Estimates by Sector (2006)

Sector	Shipping	Fishing	Cruises	Passenger	Recreational	Navy
Total per capita waste generation (our initial estimate) (tonnes per year)	1.0	2.9	0.6	0.8	0.9	0.4
Total per capita waste generation (TRT) (tonnes per year)	2.1		1.9	2.5		
Proportion (TRT)/(our initial estimate)	2.0		3.1	3.2		

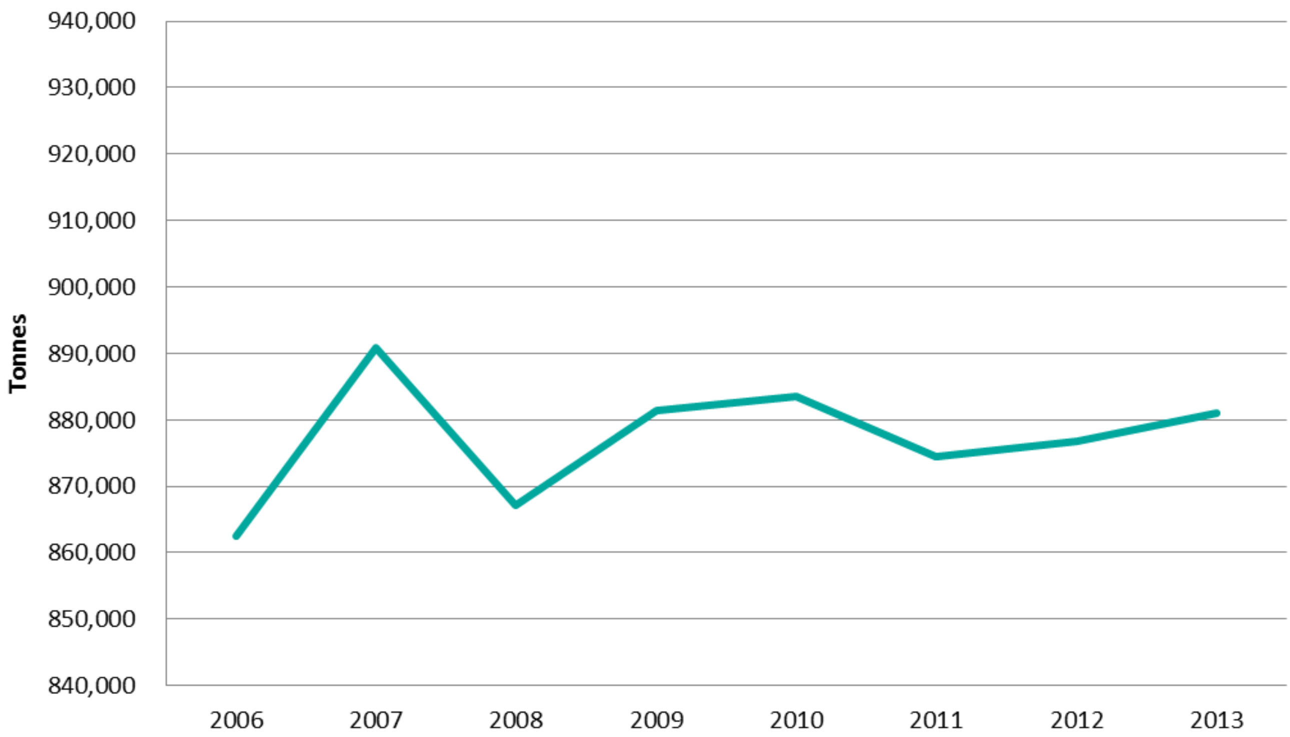
[179] www.marpoltraining.com *Annex V - Appendix - Form of Garbage Record Book*, accessed 24 August 2015, http://www.marpoltraining.com/MMSKOREAN/MARPOL/Annex_V/app1.htm
[180] As per EMSA/Ramboll (2012) and DG Move/Panteia (2015)

It is not known why there is such a discrepancy and we do not have access to the original dataset or information about how it was compiled. However we used some of the waste category data to estimate waste composition to account for 'missing' waste streams (cargo-associated waste and other operational waste – explained above).

2.6.5.3 Total Waste Generated by Vessels at Sea, EU

In Figure 18 the total amount of waste estimated to be generated from vessels in European waters is presented from 2006 onwards.

Figure 18. Total Waste Generated at Sea, 2006-2013



From Figure 19, Figure 20 and Table 11, insight into how much waste is covered by or excluded from different elements of the PRF directive can be gained. It also is a crude indication of the potential contribution of different sectors to marine litter. However, of course, the propensity to discard or lose their waste at sea is unlikely to be equal across the different sectors.

Figure 19. Total Waste Generated by Sector, 2013

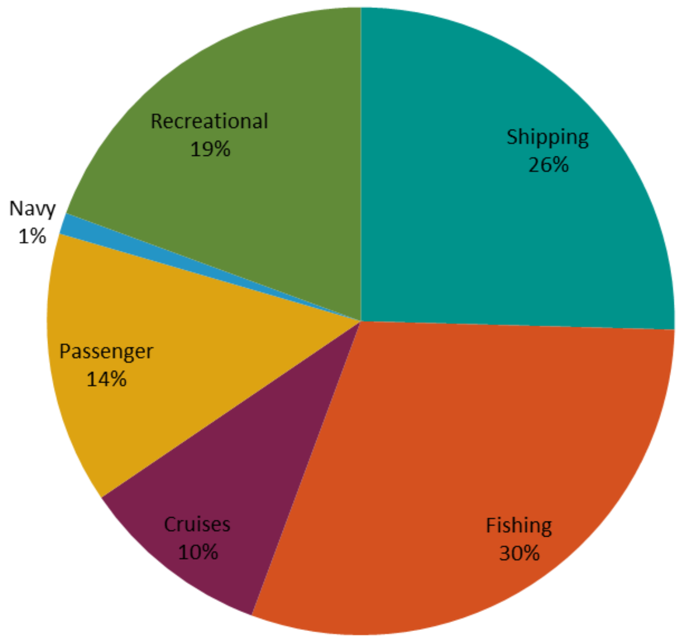


Figure 20. Total Waste Generated by Waste Stream, 2013

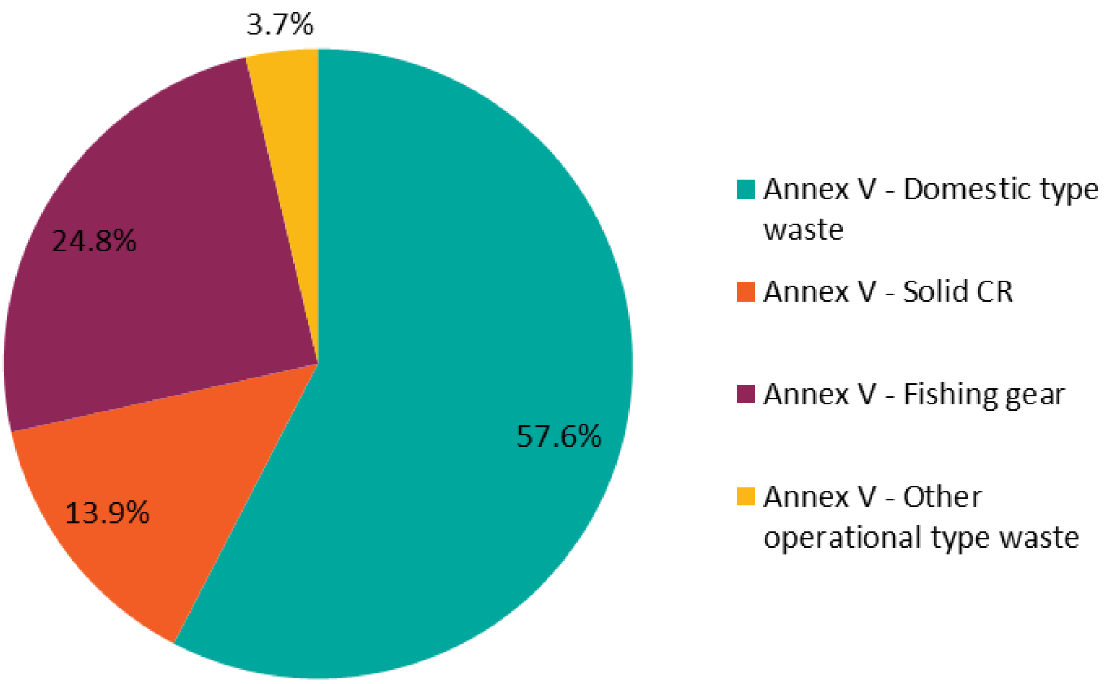


Table 11. Total Waste Generated by Sector and Waste Stream, 2013

Sector/Waste Stream	Shipping	Fishing	Cruises	Passenger	Recreational	Navy	Total	%
Annex V - Domestic type waste	74,443	43,531	86,717	123,016	170,928	8,769	507,406	58%
Annex V - Solid CR	122,521	/	/	/	/	/	122,521	14%
Annex V - Fishing gear	/	218,467	/	/	/	/	218,467	25%
Annex V - Other operational type waste	27,074	4,305	/	360	/	867	32,606	4%
Total	224,038	266,303	86,717	123,376	170,928	9,636	881,000	
%	25%	30%	10%	14%	19%	1%		

It is worth noting that the fishing and recreational sectors account for roughly half of the total waste generation at sea, and that there are exemptions for small recreational vessels and fishing vessels under the requirements of the PRF Directive. Whilst the waste generation figures do not necessarily mean the same sectors are responsible for half of the marine debris, it does suggest that a significant quantity of waste is not subject to the regulations designed to minimise debris contained in the PRF Directive. The legislative framework relating to different types of vessel is summarised under Task 1.2 in Section 3.10.2.

2.6.5.4 Total Waste Delivered

We have explored some of the scope of the delivery statistics in the course of the estimation of waste generation. Here our assumptions regarding Annex V waste reporting are restated and remaining assumptions are presented.

- Waste from fishing vessels is included[181]

[181] Fishing vessels although are exempt from mandatory reporting are not exempt from mandatory delivery; and the waste delivery statistics are based on *delivery receipts*, not pre-delivery notification forms. Fishing vessels should be paying for their waste delivery as per the PRF directive even though they are exempt from 'mandatory charges' (i.e. indirect fees) therefore receipts should be issued.

- Waste from recreational vessels is included[182]
- Waste from naval vessels is included
- Waste from the both cruise ships and ferries are included
- Solid cargo residue is included
- Operational type waste such as cargo-associated waste and fishing nets are included

Port Scope – Gross Tonnage vs Port Calls

The waste delivery statistics are based on data from waste delivery receipts for 50 ports, grossed up to EU level on the basis of gross tonnage of vessels. The report from which they are obtained also presents the data grossed up on the basis of passengers transported (not passenger years, however, which means that the EU total will be overestimated, so we exclude this from our discussion). If the data had been grossed up on the basis of port calls, reflecting the number of vessels, we think that this would have been rather more accurate, as although charging structures are indeed based around gross tonnage, we are still of the opinion that waste generated is more closely related to the number of persons per vessel, which varies less, generally speaking, in magnitude than the gross tonnage, per vessel. The DG Move/Panteia (2015) report uses the fact that charging structures are often based around gross tonnage to support the decision to use gross tonnage to gross up the delivery statistics. However the charging structure may be more closely related to ability to pay rather than waste generated, and also often covers many more elements than just waste disposal.

It is noted that the original 2012 dataset of 40 ports was held to account for 30% of the port calls, while the 2015 dataset of 50 ports accounted for 26-30% of the gross tonnage. This suggests that grossing up by port calls may result in lower delivery estimates compared with grossing up by gross tonnage. However it is difficult to be sure because the Panteia dataset removed any interpolation used by the Ramboll dataset and this meant that the number of ports for which data is available for each year may be somewhat less than 50. In order to compare the different approaches properly, we would have to obtain the Panteia dataset of waste delivered by port over the 2004-2013 time series. Data on port calls for each port would also be needed, as well as the total port calls in the EU.

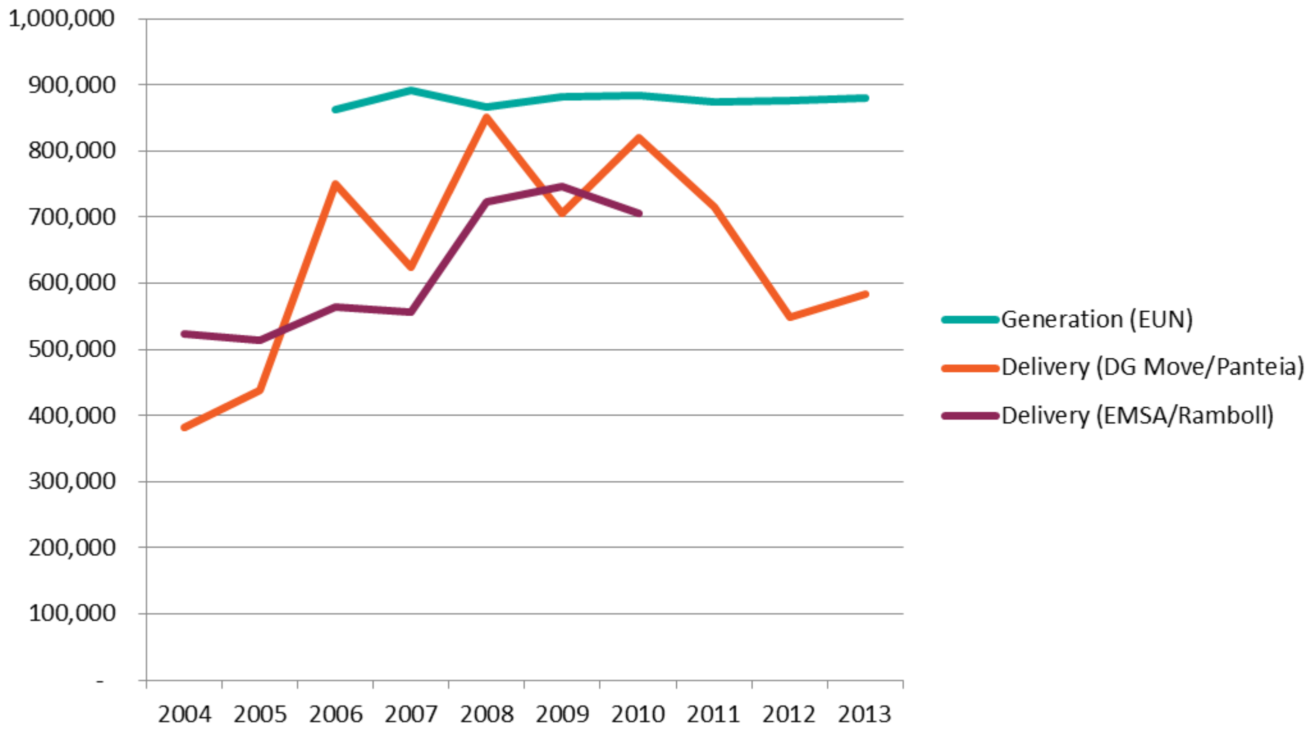
By way of comparison, albeit with the caveats introduced above, we have grossed up the 2012 dataset on the basis of port calls, (the data representing 30% of port calls save for the 2010 data point which was an estimated 29.5% of port calls)[183] to EU level and present both delivery estimates together with the generation estimate, in Figure 21.

---

[182] For considerations as per fishing vessels

[183] Marseille and Trieste missing – together, 0.5% of port calls on average 2006-2008 http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=mar_tf_qm&lang=en

Figure 21. Delivery estimates based on EMSA/Ramboll (2012) and DG Move/Panteia (2015); Generation estimate (this present study) - tonnes



Port Scope – All Ports vs Main Ports

We note that Eurostat's data on port calls as well as gross tonnage appears to apply only to the main ports (handling more than 1 million tonnes of goods or more than 200 000 passengers annually), not all ports; therefore including the remainder of ports will inflate the delivery statistics a little. The EU has over 1,500 ports[184] and thousands more marinas.[185] There are about 720 ports in the 'main ports' dataset.[186] This probably covers the vast majority of the shipping sector (for 2013, the 'main ports' dataset covered 3,643m tonnes of cargo while the 'all ports' dataset covered 3,718m tonnes, so the 'main ports' dataset covered 98% of the cargo handled);[187] but may be missing disproportionally more calls by fishing vessels and recreational vessels, so that the difference when grossing up on the basis of port calls may be rather greater. An analysis

[184] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:306:0066:0097:EN:PDF

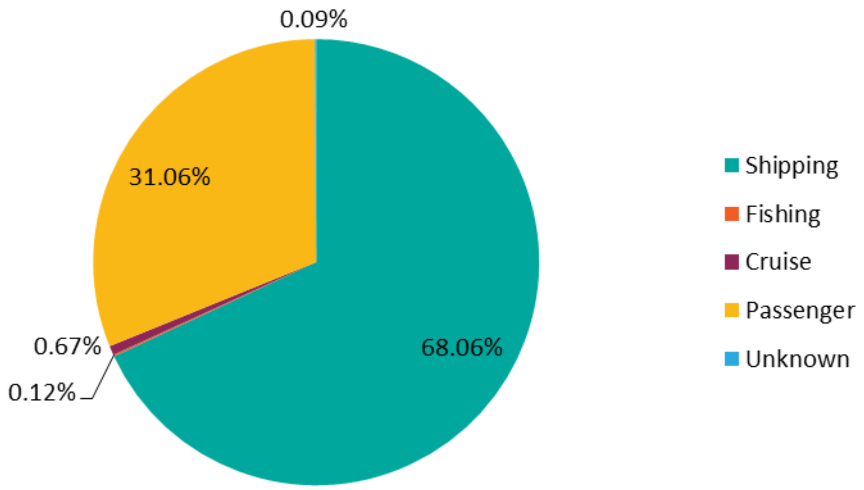
[185] 4,500 inland and coastal marinas; usinglength of coastline as proportion of waterways (27,000km) and coastline (70,000km) in EU (72%) this might be around 3250 coastal marinas http://www.europeanboatingindustry.eu/facts-and-figures

[186] http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=mar_tf_qm&lang=en

[187] http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Gross_weight_of_seaborne_goods_handled_%28inward_and_outward%29_in_main_ports%281%29_in_2013_by_type_of_cargo%282%29.png

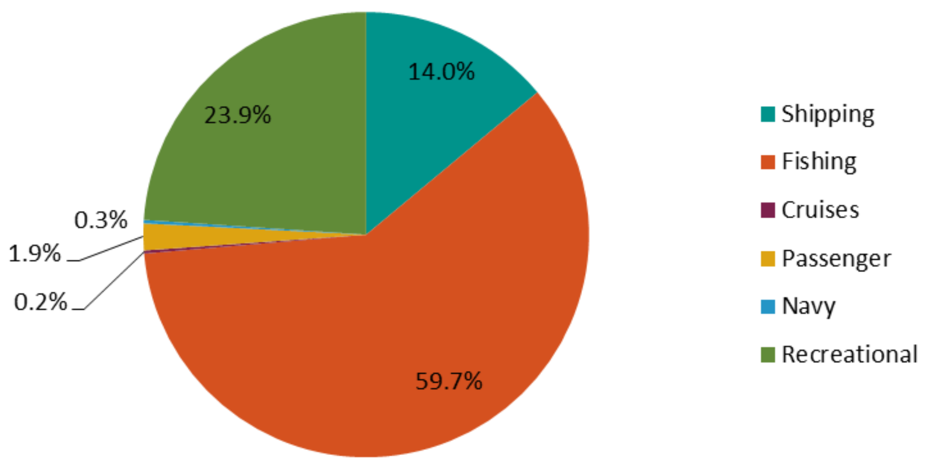
of port calls by vessel type in the 'main ports' dataset, compared with our own estimates of sector size in terms of vessel years, confirms this (Figure 22 and Figure 23). It shows us that fishing and recreational vessels, are likely to be massively underrepresented in the 'main ports' dataset.

Figure 22. Port Calls, Main Ports of the EU, by Vessel Type (2008)



Source: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=mar_mt_am_csvi&lang=en

Figure 23. Vessel Numbers by Sector, in Vessel-Years (2008)



When attempting to estimate the size of a waste stream at the margins, as we are doing here, even if the difference between the 'main ports' and the 'all ports' data sets is minor in terms of port calls or gross tonnage, it could significantly affect results. The data presented suggest it could actually be relatively important.

Delivery Rate

Another potential factor influencing the delivery statistics are the question of whether smaller ports have the same delivery 'rate' per port call as the larger ports. Smaller ports are likely to have poorer reception facilities than large ports where there has been significant investment over the years. Indeed it may be the case that many smaller ports do not receive any waste at all; although the PRF Directive requires that facilities be adequate, if there is no request for them, the ports can argue there is no need for them (even though it can in turn be argued that in view of the mandatory delivery requirement, every port needs reception facilities; nevertheless, this may not be happening everywhere). Grossing up on any basis that does not take this into account will tend to inflate the delivery statistics. On the other hand, because around half of ports in the EU and a few thousand marinas are not included in the 'main ports' dataset, these are effectively attributed a delivery rate of zero. We would need to use the Eurostat dataset on size of main ports by port calls, as well as the exact ports in the DG Move/Panteia study, to start to be able to account for this in our model.

Reporting Efficiency

A further factor that may influence the estimate of delivery is the efficiency of delivery receipt provision. We may reasonably assume that in some cases, less than 100% of the delivery receipts of a port are provided; this will lead to an underestimation of delivery. Grossing up by gross tonnage or port calls assumes that all ports have a similar reporting rate; yet it might be that smaller ports have either better (more centralised) or worse (less well developed) mechanisms for collating this documentation. This leads to further uncertainty in the delivery estimate.

Offshore Platforms

One uncertainty is whether solid waste from offshore platforms gets discharged at ports and appears in delivery receipts in the same way as vessel generated waste. Alternatively it could simply be transferred to a private operator almost as some form of cargo, at the port or at onshore bases for the offshore industry. Large amounts of solid waste, liquids, sludges and slurries are produced during the drilling process, and a proportion is transported to land for onshore disposal.[188] At least the liquid component,

[188] The wastes most commonly associated with offshore E&P activities include: Drilling fluids, drill cuttings, produced water, treatment, workover, and completion fluids, deck drainage, produced sand, naturally occurring radioactive materials (NORM), hydrostatic test water, and other assorted wastes, including human-derived wastes and general industrial wastes. "Although many types of offshore wastes can legally be discharged to the sea, companies bring some types of wastes back to shore for disposal. Some types of E&P wastes, such as oil-based drilling fluids and cuttings, produced sand, or NORM sludge and scale, areprohibited from discharge by the permits. Other wastes, such as some types of water-based drilling

which is very large (likely to be hundreds of millions of m^3),[189] will not be reported within Annex V solid wastes, and we do not need to be concerned with that. However, we do not know via what route solid wastes are reported and offshore platforms have not been accounted for in the waste generated statistics.

In the EU there are 232 offshore platforms in the fleet as of 2015[190] and a platform may be staffed by 100-200 people.[191] Taking a midpoint of 150 persons this is equivalent to 34,800 person years at sea. If the trend over time in the number of rigs is similar to the global trend of utilised rigs,[192] the numbers for 2013 would be 217 rigs and 32,496 person years, which in magnitude is 3.7% of the person years currently accounted for in our generation model for 2013; and so is a significant proportion of sources of at sea waste. It is larger than the naval sector, for example.

If it therefore is included in delivery statistics and our generation statistics are not comparable in this regard, we may be underestimating the generation-delivery gap. Applying similar waste generation per capita values for Annex V domestic type and operational type wastes, and assuming that incineration and discharge of food waste occurs to a similar extent, we estimate this to be 10,603 tonnes. However if any other kinds of solid waste are reported in the delivery statistics such as sand or drill cuttings, this number would inflate a great deal – in the order of hundreds of thousands of tonnes.[193]

2.6.5.5 Delivery Gap

Our analysis leads us to believe that between a few tens and a few hundreds of thousands of tonnes of waste are discarded at sea each year (Figure 24).The fluctuations

---

fluids and cuttings and some treatment, workover, and completion fluids, may not meet the permit's effluent limits and, therefore, cannot be discharged."
Veil, J.A. (2001) *Offshore Waste Management - Discharge, Inject, or Haul to Shore?*, 2001, http://ipec.utulsa.edu/Conf2001/veil_2.pdf

[189] OGP (2011) *Environmental Performance in the E&P Industry, 2010 data. Report No. 466*, 2011, http://www.ogp.org.uk/pubs/466.pdf, ICF Consulting (1995) *Overview of Exploration and Production Waste Volumes and Waste Management Practices in the United States*, Report for American Petroleum Institute, 1995, http://www.api.org/~/media/files/ehs/environmental_performance/icf-waste-survey-of-eandp-wastes-2000.pdf?la=en

[190] North Sea (184); Mediterranean (26), Black Sea (17),Eastern Europe (5); http://www.statista.com/statistics/279100/number-of-offshore-rigs-worldwide-by-region/, http://www.rigzone.com/data

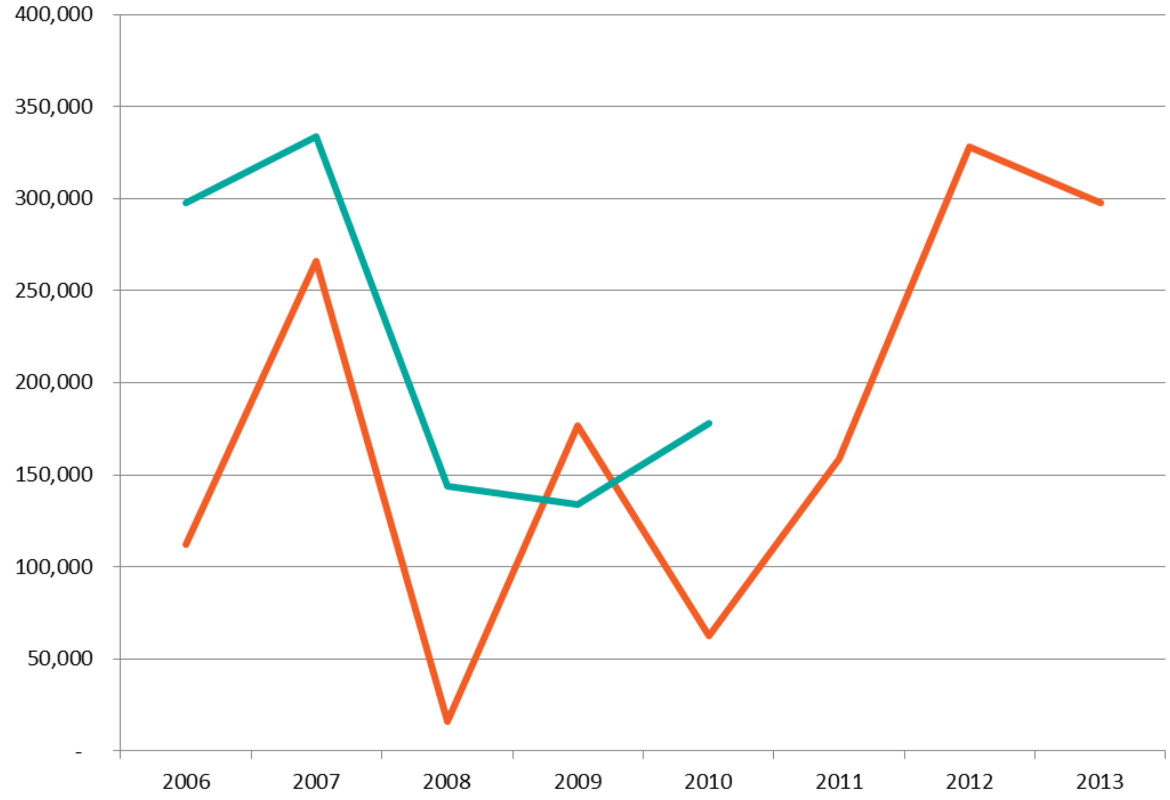
[191] http://science.howstuffworks.com/environmental/energy/offshore-drilling8.htm, http://theweek.com/articles/494480/oil-rigs-cities-sea, http://petrowiki.org/Offshore_rig_crews

[192] http://www.statista.com/statistics/307146/number-of-offshore-rigs-worldwide/

[193] OGP (2011) *Environmental Performance in the E&P Industry, 2010 data. Report No. 466*, 2011, http://www.ogp.org.uk/pubs/466.pdf, ICF Consulting (1995) *Overview of Exploration and Production Waste Volumes and Waste Management Practices in the United States*, Report for American Petroleum Institute, 1995, http://www.api.org/~/media/files/ehs/environmental_performance/icf-waste-survey-of-eandp-wastes-2000.pdf?la=en

year on year may be quite significant, however they are a function of variation in the delivery statistics, which may be owing to reporting issues as well as variations in delivery year on year.

Figure 24. Delivery Gap



Blue line: Gap, Waste generation and EMSA/Ramboll (2012) delivery figures; Orange line: Gap, Waste generation and DG Move/Panteia (2015) delivery figures. All quantities in tonnes.

One important question that we must address is, how much of this waste is likely to be the kind of waste that poses a marine debris risk. Only a small proportion of cargo residue constitutes a risk. Food waste and ash do not, broadly speaking - however these have already been accounted for and are not included in the delivery 'gap'. However all other types of waste do. Given that 13.9% of the waste is likely to be CR; and we established that 1.75% of this could be plastic, we subtract the non-plastic CR percentage to give an estimate of an overall percentage of 86.3% of the delivery gap tonnage to be marine debris causing waste. This assumes that there is an equal risk of dumping for each waste stream.

2.6.6 Revisiting Input of Marine Litter with Respect to At-Sea Sources

At this point we have assembled a wide range of data types available to us. Therefore we will summarise and compare them to create an overall synthesis of input and source (Table 12). The number of assumptions that have been made to arrive at this synthesis means that the conclusions are highly tentative. Microplastics are not specifically the focus of this exercise, for which, see results in WP2. Additionally, most of the figures on input and estimates of stock derived from input are based on plastic alone. The purpose of making such comparisons, notwithstanding the large number of approximations, is to get an idea of orders of magnitude of stock and input according to different sources and to sense check estimates made via different methods.

Table 12. Inputs and Source of Marine Litter – Including a Comparison of At-Sea Source Estimates Derived via Different Methods

Plastic Source	Approach	Study Basis	Global Estimate (tonnes per yr)	EU Estimate (tonnes per yr)
Land-based (Coastal)	Global mismanaged plastic waste (coastal).	Jambeck *et al* (2015)	4.8 – 12.7 million	54,000 – 145,000
Land-based (Inland)	Riverine plastic sampling data scaled up by using global river discharge.	Lechner *et al* (2014)	75,000-1.1 million	4,000-63,000
At-sea	Beach Survey (ICC) data used to derive the proportions of marine litter sources.	Ocean Conservancy (2012)	0.54 – 5.91 million[1]	14,500 – 138,670[2]
	Gap between at-sea waste generation and delivery	*This report*	*1.3-1.8 million*	*153,000-188,000*[3]
of which ***Fishing***[4]	Land input and Arcadis data	**As above; plus Arcadis (2012)**	0.3-3.8 million	9,000-89,000
	Delivery gap and Arcadis data	***This report; plus Arcadis (2012)***	*0.8-1.2 million*	*99,000-121,000*
of which ***Shipping***[5]	*Land input and Arcadis data*	*As above; plus Arcadis (2012)*	*0.1-1.4 million*	*3,500-33,500*
	Delivery gap and Arcadis data	*This report; plus Arcadis (2012)*	*0.5-0.6 million*	*54,000-67,000*
Total	*Based on land input and ICC data for at-sea sources*		**5.4 – 19.7 million**	**72,500 – 347,000**
Total	*Based on land input and delivery gap for at-sea sources*		**6.2-15.6 million**	**211,000-396,000**

[1] Global marine sources are estimated to account for 10–30% of total input; this is therefore proportional to the sum of the coastal and inland figures.
[2] European marine sources are estimated to account for 20–40% of total input; this is therefore proportional to the sum of the coastal and inland figures.
[3] Average 2006-2013. Only marine litter portion i.e. 86.3% of total gap.
[4] 'Fishing' 65% of at-sea sources and [5] 'Shipping' 35% of at sea-sources – see Table 8 for derivation and definition; applied to both the global and EU estimates as no separate estimate available

Table 12 shows that annual input from at-sea sources is likely to be a significant contributor to marine litter and we see that annual input estimated according to the 'delivery gap' is slightly higher at 153,000-188,000 tonnes vs 14,500 – 138,670 tonnes for estimates derived from land input and beach clean prevalence data (ICC). This is not inconsistent with the often cited figure of 20,000 tonnes of waste being discarded in the North Sea each year.[194] As a proportion of the total the input from at-sea sources tonnages derived from the 'delivery gap' versus the 'land input' data equate to 47-73% vs 20-40% of the total, showing how 'broad brush' estimates are when based on currently available data, and their sensitivity to revised assumptions. However this exercise has provided a framework that may be a useful starting point for directing future evidence gathering, so that more robust and precise estimates can be made as soon as possible.

2.7 Assessment of CRS Scenarios with respect to Marine Litter Reduction

The two highest ranked scenarios, 3 and 4, should be able to achieve similar increases in delivery of waste to port reception facilities. In theory they have the capacity to deal with or overcome all financial and non-financial incentives to discharge waste at sea. There are some situations that they still cannot influence; for example vessels travelling to countries outside the EU will no longer be reached by the system of incentivisation, but their discharges may still affect EU waters; casual littering by individuals on board; accidental loss of fishing gear; debris from aquaculture;[195] and accidental/catastrophic loss of cargo and waste and wrecks. Therefore there will still be a proportion of at-sea sources that they cannot impact. However we conclude that generally speaking the majority of input from at-sea sources can be reduced by them; and this is likely to approach a fair share of a 30% reduction target.

[194] MEPC (2000) Guidelines for Ensuring the Adequacy of Port Waste Reception Facilities. Resolution MEPC.83(44/20). Annex 2. Statistic attributed to a submission by Sweden to OSPAR Environmental Assessment and Monitoring Committee,
[195] As waste from aquaculture would not normally be delivered to port reception facilities.

3.0 Task 1.2: Legal Provisions for Waste from Ships

The objectives of Task 1.2 are as follows:

- Undertake a scoping exercise of relevant legal provisions applicable to waste generated from ships and offshore platforms;
- Map the existing EU legal framework and international commitments; and
- Identify gaps where further regulatory action could result in significant reductions of marine litter.

To the extent possible and appropriate, the issue of containers going overboard (i.e. plastic lost at sea during maritime transport) has also been considered.

We have based this analysis both upon the legislative instruments themselves, and a number of recent reports and working documents which provide an overview of the legislation and comment upon particular themes. These documents include, notably:

- The IEEP (2013) reports commissioned by Seas at Risk:
    - '*How to Improve EU Legislation to Tackle Marine Litter*' and
    - '*Reducing Ship Generated Marine Litter – recommendations to improve the PRF Directive*';
- The MARLISCO project D1.3 report (2013) '*Review of existing policies that may be applied to mitigate the impact of marine litter*';
- EC Commission Staff Working Document SWD (2012)365 '*Overview of policies, legislation and initiatives relevant to Marine Litter*';
- EMSA (2012) '*Addressing Illegal Discharges in the Marine Environment*'
- DG MOVE (2015) *Ex-Post Evaluation of Directive 2000/59/EC on Port Reception Facilities for Ship-Generated Waste and Cargo Residues* (study conducted by Panteia/PwC); and
- Regional Seas Commissions reports and working documents.

The distinctive stance taken by this report is to provide a comprehensive view, from waste reduction through to enforcement, of how legislation supports the range of activities to combat sea-based sources of marine litter. Our assessment of beach count data (see Section 2.6.4), shows that in the EU between 20-40% of marine litter could be derived from at-sea sources.

Sea-based sources of litter are derived from sea-going vessels and maritime industries, including offshore platforms. As well as domestic wastes, marine litter relevant waste generated at sea includes operational wastes such as solid cargo-associated waste (e.g. packaging materials used for cargo), discarded equipment such as fishing gear, and solid cargo residues left over from the unloading of cargo. Marine litter may also derive from:

- Sewage, as personal hygiene products may be discarded along with sewage waste;

- Disposal of unpackaged hazardous items (e.g. WEEE – as opposed to packaged hazardous goods which are dealt with by MARPOL Annex III);
- Dumping of wastes at sea; and
- Containers lost at sea.

Since the activities of ships themselves can contribute to a reduction in marine litter, not just in avoided discharge but in the active recovery of wastes from the marine environment, there is an additional category of waste to consider within scope of this exercise:

- Waste gathered at sea by ships.

Each of these potential sources of marine litter falls within the scope of different legislation at an international and EU level. Section 3.1 briefly introduces the main legal instruments on a European scale which play a role in reducing litter from ships and offshore platforms entering the marine environment, and Table 13 itemises this legislation by waste type and scale (International, European, and Regional).Sections 3.2 to 3.9 look at each waste type in turn.

Legislation can support the reduction in marine litter in different ways. For each waste type, when relevant, this review comments on how comprehensively the legislation:

- Prohibits the generation of marine litter;
- Provides for legal discharge at ports;
- Mandates good waste management; and particularly,
    - Supports waste minimisation/reduction within the industries concerned;
- Provides for or mandates the collection of waste *information* to support efforts to detect and enforce legislation; and
- Allows and supports the detection and enforcement of infringements.

Though we do not evaluate the implementation of legislation *per se*, evidence regarding barriers to achieving effective implementation is relevant, as they may indicate a problem which can be partly addressed by amending existing legislation or introducing new legislation.

This review also stops before it reaches Member States – no assessment is conducted beyond the most basic level of how well Member States have transposed international legislation into domestic law.

Section 3.10 summarises the gaps that have been identified, where further regulatory action could result in significant reductions of marine litter from ships and offshore platforms.

Actions and policies specifically designed to deal with marine litter reduction may be associated with legally binding mechanisms, implemented under international, regional, EU or national legislation; or they may be carried out through a series of non-legally binding mechanisms, under a range of formal or informal agreements. Deficiencies in existing legislation may be overcome by applying non-legally binding mechanisms of this kind, to provide a bridge between a lack of commitment and legally binding instruments, either at state level, for instance through collective commitment to Action Plans at a Regional Seas level, at company or ship level such as ISO codes, or market interventions such as ratings for environmental performance of ships.[196] Some of these voluntary agreements are referred to below, and further information can be found in the Appendices.

3.1 The Legislative Framework

The first item of global legislation relating to marine litter is the **United Nations Law of the Seas (UNCLOS)**.It both gives states jurisdiction to enforce legislation in relevant sea areas, and mandates states to adopt laws and regulations and take measures to address pollution of the marine environment, including through the development of international laws and standards.

UNCLOS has two main articles relating to marine litter: one on ‘Pollution by dumping’ (Article 210) and one on ‘Pollution from Vessels’ (Article 211).

These separate provisions are reflected in two main strands of global legislation: one in relation to the control of dumping - through The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (the **London Convention)** and its subsequent Protocol (the **London Protocol**), and one in relation to the control of ‘ship-generated’ wastes (SGW) and cargo residues (CR), through the International Convention for the Prevention of Pollution from Ships (**MARPOL 73/78**).

MARPOL Annexes cover different categories of wastes. Oil pollution (**Annex I**) was the initial focus of international efforts to address pollution, particularly in response to major accidents and large incidents of pollution. The main contributors to marine litter are addressed in **MARPOL Annex V, which covers ‘garbage’, using its widest definition.** At a European level, the **Directive on Ship-source Pollution (SSP Directive 2005/35/EC)** is to ensure common application of MARPOL Annex I and II (and to ensure that offences are prosecutable in criminal law), and **Directive 2008/99/EC (on the Protection of the Environment through Criminal Law)** partially reinforces MARPOL by mandating states to ensure that environmental offences which cause damage to water quality or to animals and plants (which may include the discharge of garbage) are prosecutable in criminal law. D**irective 2004/35/EC (on environmental liability)** mandates the operator to take both preventative and remedial action with regard to environmental harm, and places the cost burden for these remedial measures on the operator (the ‘polluter pays’ principle).

Conventions, agreements and legislation relating to ‘Port State Control’ have been established within Europe to address the issue of enforcement relating to suspected

[196] MARLISCO (2013) *D1.3 Review of existing policies that may be applied to mitigate the impact of marine litter*, 2013, http://www.marlisco.eu/review-of-existing-policies-that-may-be-applied-to-mitigate-the-impact-of-marine-litter.en.html?pdf=266

offences by foreign-flagged ships – the **Paris Memorandum of Understanding (Paris MoU)**, for example, reflected within the **Port State Control Directive (PSC Directive 2009/16/EC)** at a community level. See Appendix A.2.2.5 for background information on MoUs.

Since, if waste is not to be discharged into the seas, it must be delivered to ports, there is additional European legislation - the **Port Reception Facilities Directive (PRF Directive 2000/59/EC)** - to reinforce the requirements (introduced in MARPOL) to discharge waste at ports and to ensure availability of port reception facilities with an appropriate fee structure.

Additionally, there are supporting international standards and agreements at the global level relevant to ship-board procedures which have relevance, including Safety/Environmental Management Legislation, for instance through the **Convention on the Safety of Life at Sea (SOLAS)**, and the **International Management Code for the Safe Operation of Ships and for Pollution Prevention (the ISM Code).**

More recently, international legislation, declarations and agreements have established targets and actions relating to tackling marine litter – notably, the **Marine Strategy Framework Directive (MSFD) at the European level**, and, at a global level, the **Honolulu Strategy** and **Global Partnership on Marine Litter.** In addition, the **2016 Reporting Guidance for the Water Framework Directive (WFD)** allows for Member States to the identify measures taken to address the pressure of litter from land-based sources (and ships in WFD waters). These are declarations and statements likely to give additional impetus to efforts to tackle marine litter and strengthen the legislative instruments above, whilst not themselves providing additional legislation directly applicable to preventing marine litter from sea-based sources.

Regional Seas Commissions have been established under the IMO to foster co-operation at a regional level in tackling pollution, each with their own Conventions and voluntary **Regional Seas Action Plans**. There are four Regional Seas Commissions in Europe, covering the Baltic Sea (Helsinki or HELCOM), the North Sea (OSPAR), the Mediterranean Sea (Barcelona) and the Black Sea (Bucharest).This report draws on the most recent action plans related to marine litter in each region:

- Helsinki Commission's 'Baltic Sea Action Plan' has sections relating to marine litter[197];
- OSPAR produced a dedicated 'Marine Litter Action Plan' in 2015;[198]
- The Barcelona Commission was supported by UNEP to produce a specific regional action plan on marine litter; [199] and

[197] HELCOM (2007) *Baltic Sea Action Plan*, http://www.helcom.fi/baltic-sea-action-plan/action-plan/
[198] OSPAR (2015) OSPAR Marine Litter Action Plan Brochure
[199] MAP (2013) Regional Plan for the Marine Litter Management in the Mediterranean UNEP (DEPI)/MED WG. 379/5

- The Bucharest Commission includes sections on tackling garbage pollution and litter from fisheries within their 'Strategic Action Plan'.[200]

These plans will all be referred to as RSAPs (Regional Seas Action Plan).

Additionally, the fishing and aquaculture sector is subject to separate regulation through the **Common Fisheries Policy** (Regulation (EU) No 1380/2013 amended by Regulation (EU) 2015/812), and **Regional Fisheries Management Organisations** (the North East Atlantic Regulatory Commission covering the North Sea and the Baltic, and the General Fisheries Commission for the Mediterranean).

Table 13 below maps legislation and non-legally-binding instruments (in grey) relevant to each potential category of waste that could contribute to marine litter and referred to in relevant parts of this report. The general geographic scope, whether global, by maritime regions, or European, is also indicated.

[200] Bucharest Commission (2009) *Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea*, accessed 25 August 2015, http://www.blacksea-commission.org/_bssap2009.asp#_Toc222222312

Table 13. International Legislative Instruments Relevant to Sea-based Sources of Marine Litter

	Global	Regional Level	European Union Legislation
Overarching	**UNCLOS, CLOS** general mandate and legal framework **ISM Code** Defining good practice with respect to safety and waste management (see Appendix A.2.2.3) **Honolulu Strategy and GPML** Building international consensus for strategic action (see appendices A.2.2.1 and A.2.2.2)	**Barcelona Convention** Mandate for collective action to protect the Mediterranean **Bucharest Convention** Mandate for collective action to protect the Black Sea **Helsinki Convention** Mandate for collective action to protect the Baltic Sea **OSPAR Convention** Mandate for collective action to protect the North Sea **Bonn Agreement** Mechanism for the North Sea states and the EU	**Directive 2008/99/EC** Protection of the Environment through Criminal Law **Directive 2004/35/EC** Environmental Liability (Polluter pays) **Marine Strategy Framework Directive (MSFD)** Focus on achieving Good Environmental Status (GES) **Waste Framework Directive** Waste management principles onshore **Community Vessel Traffic Monitoring and Information System** **Reporting Formalities Directive2010/65/EC** Rationalises reporting formalities into a 'National Single Window' **ISM Code Directive** Mandatory application of the ISM Code
Port State Control	**Paris MoU (also Black Sea MoU, Mediterranean MoU)** Establishing a system of Regional Port State Control		**Port State Control Directive** Brings Paris MoU principles into EU legislation, mandates inspection regime
Dumping	**London Convention** Restricts dumping to licensed wastes **London Protocol** Restricts licensed dumping further to only a specified list of wastes	**Regional Seas Protocols/ Annexes (All Regional Seas)** **Regional Seas Action Plans**	

	Global	Regional Level	European Union Legislation
Discharge of Ship-Generated Wastes (Garbage and Sewage)	**Garbage:** **MARPOL Annex V** Prohibits discharge from most European Seas, through designation as 'special areas' MARPOL Annex V Guidelines **Sewage:** **MARPOL Annex IV** Restricts discharge (bans it within the Baltic Sea Special Area)	**Regional Seas Protocol/Annexes (1/4 Regional Seas),Amendments** Regional Seas Action Plans	**Port Reception Facilities Directive** Mandating notification and delivery of ship-generated wastes at Ports, and provision of adequate reception facilities
For comparison: Discharge of Ship-Generated Wastes (Oil)	**MARPOL Annex I and II** Prohibits most discharge	**Regional Seas Conventions (All Regional Seas)** **Regional Seas Protocols (All Regional Seas)**	**Port Reception Facilities Directive** As above **Ship-source Pollution Directive** Harmonises and strengthens legal basis for enforcement of MARPOL Annexes I and II **Community Vessel Traffic Monitoring and Information System**
Lost Containers	**Nairobi Convention on the Removal of Wrecks** **SOLAS Convention** on the Safety of Life at Sea ISM Code Safety and Environmental Management Standards (see Appendix A.2.2.3) CTU Code Guidelines for Cargo-Securing Manual		**ISM Code Directive** Mandatory application of the ISM Code
Wastes gathered at sea (e.g. in fishing nets)		**Helsinki Commission Decision** Regional Seas Action Plans	

	Global	Regional Level	European Union Legislation
Fishing and Aquaculture		**Regional Fisheries Management Organisations** FCO Convention on Conduct of Fishing Operations in the North Atlantic	**Common Fisheries Policy** No specific policies on Litter, but provides a mandate to encourage sustainable practices

The International Maritime Organisation (IMO) oversees most of the international legislation discussed here, and the IMO Marine Environment Protection Committee (MEPC) is the decision-making subsidiary body of the IMO Council on issues concerned with the prevention and control of pollution from ships.

3.2 Garbage

This section reviews the legislation relating to the discharge of garbage from ships and offshore platforms into the sea.

Garbage is defined within MARPOL Annex V to cover all waste produced during the normal operation of a ship, including:

> *'all kinds of food wastes, domestic wastes and operational wastes, all plastics, cargo residues, cooking oil, fishing gear, and animal carcasses generated during the normal operation of the ship and liable to be disposed of continuously or periodically except those substances which are defined or listed in other Annexes to the present Convention'*[201]

The term Garbage therefore is a 'catch-all' definition for wastes generated on ships that aren't covered by other Annexes. Annex V explicitly covers wastes including:

1) plastics
2) food wastes
3) domestic wastes
4) cooking oil
5) incinerator ashes
6) operational wastes
7) cargo residues not covered in other Annexes

[201] MEPC (2011) Amendments to the Annex of the Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships, 1973. (Revised MARPOL Annex V) Resolution MEPX.210(62). MEPC 62/24. Annex 13

8) animal carcasses
9) fishing gear
10) cleaning waste water

Notably, recent amendments to MARPOL Annex V:

- introduced 'special areas' where the discharge of garbage is prohibited;
- added Cargo Residues not covered under other MARPOL Annexes to within the definition of 'Garbage'; and
- added a prohibition on the disposal of incinerator ashes.

International focus on the problems presented by the disposal of Garbage from ships has been relatively recent compared with the attention given to pollution by oil. Whereas developments in legislation there have been prompted by large-scale, high-profile and high-impact spillages requiring significant resources to clean-up, the problems caused by the discharge of garbage have historically received less urgent international attention.

Similarly, whilst the international community has developed information and detection systems to attempt to monitor, identify and detect oil pollution (which floats on the surface)[202], the discharge of garbage provides few opportunities for direct detection. At the European level, there is a general consensus that issues related to port reception facilities are a main driver of illegal discharge. In the Commission's Ex-Post Evaluation of the PRF Directive, port users identified issues relating to the cost and availability and convenience of PRFs as the main 'common reasons' for illegal discharges at sea.[203]

Therefore, at the international level, the attempt to address the issue of pollution by garbage rests on two main legislative instruments:

- At a global level, through the IMO: MARPOL Annex V, which prohibits the discharge of almost all garbage at sea (with even more stringent prohibitions inside special areas, which covers all main European Seas); and
- At a European level, through the PRF Directive, which attempts to ensure waste is delivered to ports by mandating:
    - Ports to have adequate PRFs with respect to both the needs of users and the environment;
    - Vessels to deliver all wastes and provide advance notification of waste delivery; and
    - States to inspect and enforce (this is predominantly carried out within the framework of the PSC Directive on Port State Control).

---

[202] CleanSeaNet

[203] Panteia, and DG MOVE (2015) *Ex-Post Evaluation of Directive 2000/59/EC on Port Reception Facilities for Ship-Generated Waste and Cargo Residues*, 2015, http://ec.europa.eu/transport/modes/maritime/studies/doc/2015-ex-post-evaluation-of-dir-2000-59-ec.pdf

Despite this relatively comprehensive legal prohibition and theoretical obligations on all parties, it is clear that significant problems with marine litter remain and garbage from ships is a significant contributor to that problem. Remaining key issues discussed within the literature and referenced in strategic action plans (including Regional Seas action plans) include, most prominently:

- Providing a fee system that removes incentives to discharge garbage illegally;
- Concern that inspections of ships may not be well targeted at the problem of tackling marine litter;
- A lack of co-ordinated waste management information and reporting, despite the various existing obligations, caused by multiple systems; and
- Enabling 'fishing for litter' activities.

Many of these have been highlighted already by various strands of the ongoing review into the PRF Directive. This review summarises these and others.

3.2.1 Prohibition of Discharge in the Marine Environment

MARPOL Annex V prohibits the discharge of Garbage (including Cargo Residues not covered by other Annexes).

The Directive on the Protection of the Environment through Criminal Law requires Member States to ensure that such discharge is a criminal offence, that legal persons can be held liable, and that sanctions are effective, proportionate and dissuasive.

Geographical Scope: All EU Member States have ratified MARPOL Annex V, meaning that discharge is prohibited throughout all EC waters. Additionally, all European seas are special areas under MARPOL for garbage (the implications of which are explained below).

Vessel Flag: All EU states are signatories to MARPOL, and so under UNCLOS and the Port State Control regimes of the Paris MoU, all EU states and ports are theoretically able and bound to enforce the provisions of MARPOL on all ships within EC waters, irrespective of flag. Therefore, Flag States and Port States are enabled and obliged to inspect and/or detain ships suspected of illegal discharge, irrespective of flag.

Vessel Types: MARPOL Annex V applies to all ships, which means all vessels of any type whatsoever operating in the marine environment, from merchant ships, fishing vessels, passenger ships and non-commercial ships such as pleasure crafts and yachts, as well as to fixed or floating platforms.

Waste Types: Within special areas (as all European Seas are), the only exceptions to the prohibition on discharge are:

- Comminuted or ground food wastes (reduced to particles of <25mm) more than 12 nautical miles from the nearest land or ice shelf; and
- Cargo Residues 'that cannot be recovered using commonly available methods for unloading', so long as certain conditions are met, including:
    - There is not an adequate reception facility at either the departure or destination port, and

- The CR does not contain 'substances classified as being harmful to the Marine Environment' (as defined in MEPC 2012 guidelines; all synthetic polymers are included in this definition).[204]

Comminuted food waste is only a source of marine litter if it is contaminated with packaging waste, and likewise, Cargo Residues are only able to contribute to marine litter if they contain materials whose discharge is prohibited. The occurrence of these types of contamination is unknown.

The PRF Directive places the complementary obligation on ships: to deliver all wastes to a reception facility for that kind of waste at port (and to provide advance notification of this waste), with the exception of sewage that is planned to be discharged of legally (see Section 3.8). No such explicit requirement exists for waste from offshore platforms.

3.2.2 Provision and Use of Disposal Facilities

MARPOL Annex V (Regulation 8) imposes an obligation on the State Parties to ensure ports plan for and provide facilities for the reception of Garbage. These reception facilities must be adequate to meet the needs of ships using the port, without causing undue delay for ships.

The Port Reception Facilities (PRF) Directive (2000/59/EC) sets out the responsibilities of the various operators involved in the delivery of ship-generated waste at EU ports, as well as the obligations of port users using them. It aims to significantly reduce the illegal discharge of ship-generated waste and cargo residues into the marine environment by improving the availability and use of port reception facilities.

Geographical Scope: The PRF Directive legislation applies to all ports within Member States – *where "port" shall mean a place or a geographical area made up of such improvement works and equipment as to permit, principally, the reception of ships, including fishing vessels and recreational craft.*[205] Ports receiving only military vessels are exempt (though Member States should attempt to make such vessels act in a manner consistent with the Directive). Subsequently, Member States have been permitted to draw up plans at a regional – rather than port – level.

Vessel Flag: All ships, irrespective of their flag, calling at a port in a Member State must comply with the PRF Directive. As before, as all European states are signatories to MARPOL, under UNCLOS and the Port State Control regimes of the Paris MoU, all EU states and ports are able and bound to enforce the provisions of MARPOL on all ships within EC waters, irrespective of their flag.

---

[204] MEPC (2012) 2012 Guidelines for Implementation of MARPOL Annex V. Resolution MEPC.219(63). MEPC 63/23/Add.1. Annex 24

[205] Port Reception Facilities Directive, Article 2

Vessel Types: In terms of what vessels should be provided for, the PRF Directive is phrased comprehensively – port reception facilities should be made available '*adequate to meet the needs of ships normally visiting the port* ', however there is no further specification of what 'adequate' provision entails. A consequence of this is that ports may consider they are not obliged to have capacity for the large quantities of waste produced by cruise ships, for instance (especially when they must cover the costs of this waste treatment under Port Fees). Generally speaking however, the requirement means that facilities should cover all types of vessels and their waste, save military vessels, which are not included in the requirements of the Directive. Military vessels may account for around 3% of the person time spent at sea (Figure 15, Section 2.6.5.1)

In terms of users, the Directive applies generally to *all ships, including fishing vessels and recreational craft, irrespective of their flag, calling at, or operating within, a port of a Member State, with the exception of any warship, naval auxiliary or other ship owned or operated by a State and used, for the time being, only on government non-commercial service.*

Additionally, the PRF Directive notably does not include waste from offshore platforms – as waste loaded onto a ship which subsequently reaches a port would not be classified as 'ship-generated wastes'. It would, nonetheless, be delivered to a port reception facility or directly to onward waste management which must comply with other legislation (in particular the Waste Framework Directive). Some elements of the use of Port Reception Facilities do not apply to fishing vessels and recreational vessels carrying <12 people; for example paying mandatory indirect charges and mandatory notification (see 3.2.5). According to our own research, such vessels could account for 34% of the person time spent at sea (Figure 15– Section 2.6.5.1).

Ships '*engaged in scheduled traffic with frequent and regular port calls*', where there is '*sufficient evidence of an arrangement to ensure the delivery of ship-generated waste and payment of fees in a port along the ship's route*' may be exempted by Member States. This does not constitute a gap in provision, but it may constitute a gap in information as these ships do not necessarily routinely submit information available to inspection authorities. One conclusion of an EMSA workshop on cost recovery systems and also the more recent Evaluation of the PRF Directive was the need for greater clarity on defining 'scheduled traffic with frequent and regular port calls' – though this lack of definition is not likely to directly affect levels of marine litter, it does affect port waste management plans, port fees and information available to ports and inspection authorities. According to our own research, passenger vessels, which are likely to meet the criteria, could account for 20% of the person time spent at sea (Figure 15, Section 2.6.5.1).

Waste Types: The PRF Directive covers in theory all types of waste that falls within the MARPOL Annex V definition of 'Garbage'. However as ports are only bound to 'meet the needs of users' and the 'environment' with respect to facilities, this is generally interpreted within international guidance as where users have no need for facilities for a certain type of waste, ports do not have to provide it.

Stakeholders have raised concerns that without an explicit mention, provision of PRFs for some waste types are being overlooked – for instance, one stakeholder in the PRF evaluation had the misconception that that the PRF Directive did not cover the expanded range of garbage now prohibited under the scope of the Revised MARPOL V – for instance, wood, and potentially incinerator ashes. There are also concerns that some types of waste are overlooked in the development of PRFs and plans, for instance bulky waste and WEEE.[206] An upcoming revision of Annex II to the PRF Directive will update the waste notification form and provide more clarity for stakeholders. Additionally, there are exemptions for solid cargo residues (included within MARPOL Annex V categorisation of 'Garbage' as regards the charging of indirect fees, and mandatory delivery.

Voluntary Measures: The voluntary ISO standard ISO 16304:2013 has been developed covering the arrangement and management of Port Reception Facilities (see Appendix A.2.2.4.1).[207] Establishment of PRF systems has been supported by inclusion with Regional Seas Action Plans (see Appendix A.2.1.2).The lack of harmonised or common fee systems is regarded as a barrier to uptake. The Helsinki Commission has implemented a 'no-special fee system' - where a fee is applied whether facilities are used or not, removing a financial incentive to discharge wastes illegally (see Appendix A.2.2.10 for a brief introduction to the Baltic system). The other Regional Seas Commissions have actions to implement no-special-fee systems where appropriate, and the Black Sea Commission aims to develop a harmonised fee/cost recovery system for the region.

Legislative Gaps: The legislation is theoretically comprehensive regarding the provision of facilities by ports, as well as their use. However:

- Many ports take a less active role than required in the supervision of waste delivery. For instance, in many ports ships are able (or expected) instead to arrange with a third-party contractor for waste receipt and disposal, rather than the port itself ensuring this arrangement is carried out.
- Secondly, the question of how to ensure that ships are sufficiently incentivised to deliver wastes to these facilities is ongoing (see WP 1.1.). There are numerous suggestions that the major barrier to reducing marine litter is the lack of a harmonised system of port fees, potentially with a high indirect fee component (such as the 'no special fees' system) where a fee is applied whether facilities are used or not. The legislation would need tighter framing to support the development of harmonised fee structures. This is discussed in section 3.10.4.

---

[206] IEEP (2013) *Reducing ship generated marine litter - recommendations to improve the PRF Directive*, Report for SAR, 2013
[207] ISO (2015), ISO 16304:2013, available from http://www.iso.org/iso/catalogue_detail.htm?csnumber=56129

- There are exemptions for vessels such as fishing vessels and recreational vessels from indirect fees. For fishing vessels this could especially hinder fishing for litter programmes.
- There are also exemptions for solid cargo residues (included within MARPOL Annex V categorisation of 'Garbage') as regards the charging of indirect fees, and mandatory delivery.
- There is the potential for differing interpretations of 'adequate' in determining the capacity of reception facilities that ports are required to provide. This might relate to acceptance of certain waste types, or how much waste can be delivered without additional charge within a 'no special fee' system.
- The general exemption of military vessels and ports is a gap (military vessels are generally excluded from IMO conventions).

3.2.3 Waste Management

Waste management regulations support the reduction of marine litter by ensuring waste is appropriately handled on board vessels, and crew and passengers are aware of their responsibilities.

MARPOL Annex V and the ISM code place obligations on ships to have garbage management plans in place and for crew and passengers to be familiar with their obligations. The PRF Directive does not go into detail on waste management on board vessels but requires ships to have 'sufficient dedicated storage capacity for all ship-generated waste'.

The Honolulu Strategy notes that "Increased availability and use of low-cost and convenient waste storage options at sea would increase proper waste disposal in port reception facilities".[208]

The PRF Directive also requires states to ensure that ship-generated wastes are managed (treatment, recovery and disposal) in accordance with relevant European legislation on waste (e.g. the Waste Framework Directive).This definitely applies to shore-side management of wastes, but it is unclear, both legally and practically, whether there are corresponding requirements for waste management on board vessels. T. Ports are currently not specifically obliged to provide facilities for separate collection of dry recycling garbage, though ships may collect recycling in this way. Even though this may not have direct implications for levels of marine litter, it may impact the willingness and motivation of crews to recycle. Port users regularly complain if they have gone to the effort to separate their waste only to see it mixed together again at the ports.[209] The

---

[208] NOAA, and UNEP (2011) *Fifth International Marine Debris Conference: The Honolulu Strategy*, accessed 23 October 2013, http://5imdc.wordpress.com/about/honolulustrategy/
[209] Panteia, and DG MOVE (2015) *Ex-Post Evaluation of Directive 2000/59/EC on Port Reception Facilities for Ship-Generated Waste and Cargo Residues*, 2015,

Waste Framework Directive preamble notes that the Sixth Community Environment Action Programme calls for measures aimed at ensuring the source separation, collection and recycling of priority waste streams – it seems that ports have the central role in facilitating progress towards this for the maritime community.

Geographical Scope: The ISM code is compulsory in Europe for a set range of ships (see vessel types), and all EU Member States have ratified MARPOL Annex V. The PRF Directive applies to all Member States.

Vessel Flag: All ships, irrespective of their flag, calling at a port in a Member State must comply with the PRF Directive.

Vessel Types: More stringent waste management requirements (whether in MARPOL Annex V or the ISM code) only apply to larger ships, and do not apply to smaller recreational vessels and fishing vessels.

- Under MARPOL Annex V, every ship of 100 gross tonnes and above and every ship certified to carry 15 or more persons is required to carry a garbage management plan. However, less than 1% of the world fishing fleet has a gross tonnage of over 100 tonnes.
- The ISM Code is mandatory in Europe for a more limited range of ships than the MARPOL provisions, additionally excluding cargo ships of less than 500 gross tonnes and all fishing and recreational vessels.

Waste Types: Waste management plans should cover all waste within the Garbage category.

Voluntary measures: These include:

- Corporate policies: the EMSA (2007) study on ships producing reduced quantities of waste (p61)[210] notes that owing to the quantities of waste that Cruise Ships generate many cruise lines are voluntarily developing comprehensive waste management policies.
- The (voluntary) ISO code ISO 21070:2011, 'Management and handling of shipboard garbage' is a new standard for the environmentally sound management of ship's waste (see Appendix A.2.2.4.2).[211]
- Voluntary indexes, such as the Clean Shipping Index (see Appendix A.2.2.7.2).

Potential gaps in legislation therefore include:

---

http://ec.europa.eu/transport/modes/maritime/studies/doc/2015-ex-post-evaluation-of-dir-2000-59-ec.pdf

[210] EMSA (2007), 'Study on ships producing reduced quantities of ship-generated wastes', p61

[211] Condino, D. (2013) Environmentally Sound Management of Ship's Waste and Adequate Port Reception Facilities, paper given at World Ocean Council Sustainable Ocean Summit, Washington D.C., 23 April 2013, http://oceancouncil.org/site/summit_2013/Presentation%20PDFs/2-PORT%20WASTE%20SECURED%20PDFS/2-PORTWASTE_Condino%20nn.pdf

- Large numbers of smaller recreational and shipping vessels have no requirements for on-board waste management of Garbage, beyond the provision of adequate capacity to store waste likely to be generated.
- More detailed aspects of waste management (i.e. focusing on waste minimisation and technologies) are handled through voluntary guidance, including the MARPOL Annex V guidelines.. The legislation supporting waste minimisation efforts is reviewed in the section below.

3.2.4 Waste Minimisation

The Honolulu Strategy (B2) reads 'Develop incentives and markets to strengthen implementation of waste minimization and proper waste storage at sea'. This is not currently very well supported by international legislation.

Few legislative instruments exist to effectively incentivise waste *minimisation* at sea (i.e. technologies, environmental standards on products used on vessels, and increasing re-use).For instance, a range of specific kinds of waste in particular industries or communities may benefit from better development of deposit-refund systems, and disincentivising or prohibiting the use of items more likely to turn into Marine Litter (for example, particular commonly used aquaculture equipment, catering-associated supplies, plastic bags and beverage cans).Sound environmental management is primarily driven by companies and voluntary indexes (for example, see those listed in Appendix A.2.2.7).

The PRF Directive allows that 'fees may be reduced if the ship's environmental management, design, equipment and operation are such that the master of the ship can demonstrate that it produces reduced quantities of ship generated waste' (informally termed a 'Green Ship'), and that 'Common criteria could facilitate the identification of such Ships'.[212]Though ports are therefore allowed to provide discounts on port fees for 'green' vessels, this is uncoordinated (one Port User comments that 'Rules are different in every single port') and may just apply for instance to fuel type used, or the existence of an environmental management system.[213] It does not appear to be acting as a systematic incentive.

This kind of scheme may be important, since otherwise 'no special fee' systems remove some of the cost incentive for ships to minimise wastes.

Voluntary Measures: Include:

- Guidelines, for instance Lloyd's Register Guidance on MARPOL Annex V, which covers waste minimisation, with recommendations for ship-owners and

[212] Port Reception Facilities Directive, Article 15/Article 8.2c
[213] Panteia, and DG MOVE (2015) Evaluation of PRF Directive - Interim Report, Annex 3, pp100-102

operators concerning decreasing the amount of material brought on-board (including specifications for reduced packaging in contracts with suppliers);[214]
- Corporate priorities and policies – for instance, EMSA (2007) cites an example of a cruise line that has implemented waste reduction actions across its fleet, and Appendix A.2.2.9 provides an example of a corporate zero solid waste policy.[215]

Potential gaps in legislation therefore include:

- A lack of measures designed to support and encourage actions at a port level to reduce the amount of waste generated by ships. These actions could be more effective for smaller ships more likely to source supplies through local merchants or through port-based supply chains.
- A lack of a clearly defined EU-wide assessment standard to support reduced port fees for Green Ships in the context of a more harmonised port fees system. The EMSA (2007) report highlights several such standards that might be more widely adopted. Waste minimisation could be incentivised through part of the criteria including the installation of appropriate technology, and the presence of procurement policies, rather than just meeting common standards.

3.2.5 Waste Information and Reporting

MARPOL Annex V, the ISM Code and the PRF Directive each require the collecting and/or reporting of information regarding discharge of wastes:

- Under MARPOL Annex V, every ship of 400 gross tonnes or more is required to carry a Garbage Record Book to record the details of waste disposal or discharge of any kind.
- Similarly, the ISM Code also contains requirements for all vessels to record volumes and types of waste (in accordance with MARPOL 73/78) and method of disposal.[216]The ISM Code is mandatory in the EU for a more limited range of ships than MARPOL Annex V (see Section 3.2.3).
- Under the PRF Directive, all ships other than fishing vessels and recreational crafts authorised to carry no more than 12 passengers are required to give ports advance notification of waste to be delivered.

Additionally, now some of this information is collected at a European or MoU-area level, and so it can be made available to inspection authorities. As of June 2015, the information system SafeSeaNet, established under the framework of the Directive on Community Vessel Traffic Monitoring and Information System (2002/59/EC as amended by 2014/100/EU), through a ‘National Single Window’, contains waste notifications sent

---

[214] Lloyd’s Register (2014) Garbage Management According to the Revised MARPOL Annex V
[215] EMSA (2007), ‘Study on ships producing reduced quantities of ship-generated wastes’, p63
[216] Butt, N. (2007) The impact of cruise ship generated waste on home ports and ports of call: A study of Southampton, *Marine Policy*, Vol.31, pp.591–598

by larger ships to port/coastal authorities identifying the types and quantities of waste and cargo residues that ships are carrying.[217]

Geographical Scope: All EU ports and seas are covered by each piece of legislation.

Vessel Flag: The PRF and MARPOL requirements apply in EU ports and seas irrespective of a ship's flag. The ISM code is mandatory for ships with Member State flags (but only duplicates PRF Directive requirements).

Vessel Types: Smaller ships (including most fishing vessels) are not required to carry Garbage Record Books or required to give advanced notification to ports. This information will therefore not be included within SafeSeaNet or available to ports and inspection authorities. According to our own research, this could account for 34% of the person time spent at sea (Figure 15– Section 2.6.5.1). Discussion of the impact of this on inspection is presented in Section 3.2.6.

Additionally, MARPOL Annex V (Clause 4) also notes that the administration may waive the requirements for Garbage Record Books for fixed or floating platforms (although they may still be required to record volumes and types of waste and method of disposal in accordance with mandatory application of the ISM Code).The regime governing the production of waste information from offshore platforms is therefore uncertain. They must have a garbage management plan in place, but it is left to best practice and national legislation to determine what potential auditable waste information they produce. In the UK, for instance, offshore platforms may instead keep records via waste transfer notes to meet domestic 'Duty of Care' legislation.[218] Requirements for fixed and floating platforms may therefore in practice only be waived when an equivalent record exists, but this is not mandated explicitly within the legislation.

Waste types: Though all MARPOL Annex V wastes are required by the PRF Directive to be reported, there are fewer categories in the PRF notification form than within MARPOL Annex V. For instance, there is no separate category in the PRF notification form for incinerator ashes or fishing gear. Therefore, though the PRF Directive might be taken in practice to apply to all waste, there is some uncertainty over some wastes. The (as of June 2015) mandatory reporting into the National Single Window has rationalised reporting formalities which may address this issue in the short term, and a proposed revision of Annex II to the PRF Directive directly resolves these issues by harmonising the PRF notification form with the revised MARPOL Annex V.

Information Gaps: Critically, there is no current requirement under the PRF Directive to give ports or inspection authorities a record of quantities of wastes actually delivered, e.g. via waste delivery receipts.

---

[217] EMSA (2015) SafeSeaNet: Who Can Benefit and How, http://www.emsa.europa.eu/ssn-main/who-can-benefit-and-how.html

[218] Oil and Gas UK (2014), 'Waste – handling of waste offshore', available from http://www.ukooaenvironmentallegislation.co.uk/contents/topic_files/offshore/waste.htm

Waste delivery receipts are generated, but not collected or stored, in the way that notification forms are. Under MARPOL, larger ships should be recording this in their Garbage Record Book, which is physical and therefore only accessible on *inspection*, not as part of data used to *detect* potential offences.

This information could be used in order to identify potential offenders. A workshop on the PRF Directive noted gaps in relation to access to information to enable detection – in particular, information on waste delivered to previous ports. IEEP notes the potential for duplicated effort or disinformation from the separation of the waste notification form, the waste delivery receipt and/or any further communications with those actually collecting the waste.[219]

Carpenter (2005) suggests that:

> *'The introduction of logbooks for vessels using EU ports, where vessels masters have no choice but to record information on where they last discharged waste, together with the volumes of waste generated during the voyage to those ports, would provide a very rapid and verifiable system of data collection to identify the effectiveness of the Directive'*[220]

At the port level, one theme arising during review of the PRF Directive is that even the current level of information is often partial, delayed or missing. Ports do not necessarily co-ordinate the collection and removal of waste or receive the relevant receipts. In many cases, in contravention to the PRF Directive, the ship deals directly with third-party contractors, and IEEP (2013) reports some uncertainty regarding the definition of the 'responsible authority' who is supposed to receive the notification form.[221] This impinges both on a Port's ability, and the inspection authorities' ability to detect potential offences in time to inspect ships before they leave port.

There has been further variation in reporting due to a difference in the MARPOL and PRF Directive notification report categories of waste. Unlike the PRF form, the MARPOL form groups cargo residues alongside other household-like and packaging wastes, but distinguishes between ground and not-ground garbage. This makes it harder to establish consistent information, though this has been addressed for now in the National Single Window and will be addressed by the upcoming revision of Annex II to the PRF Directive.

The proposed revision of the waste notification form would require ships to additionally report waste delivered at the previous port – this would go a long way towards addressing the issues discussed here. However, relying on ship-recorded data rather than actual receipts may still leave the system vulnerable to falsification.

---

[219] Ibid.

[220] Carpenter, A. (2005) *The Reduction of Ship-Generated Waste in the North Sea: A Contemporary Analysis*, dissertation submitted at The University of Leeds, 2005

[221] IEEP (2013) *Reducing ship generated marine litter - recommendations to improve the PRF Directive*, Report for SAR, 2013

Voluntary Measures: IEEP (2013) notes that ports such as Rotterdam and Amsterdam have implemented an electronic system where all information regarding ship waste handling is entered.[222]Ports are less likely to implement this kind of system if they do not currently play a large role in waste handling themselves.

Potential gaps in legislation identified by this review therefore include:

- There is no obligation to record waste actually delivered:
    - For larger ships (which maintain garbage record books), in electronic form accessible to inspection authorities – although it is proposed that delivery information is included within the PRF notification form; and
    - For smaller ships, in any form.
- Ports do not play a central role in waste management, and therefore lack information. IEEP (2013) recommends:
    - Clearer definition of 'Responsible Authority';
    - Guidelines under the PRF Directive for a 'more centrally managed' ship waste handling system, in which all waste management at Ports is coordinated centrally by the responsible authority, including arrangements, information, payments and receipts.
    - There is no provision for monitoring waste disposal (beyond establishing that a suitable contract is in place) from ships excused from the mandatory discharge requirements (see Section 3.2.2).

3.2.6 Inspection and Detection

Satellite monitoring systems like CleanSeaNet focus primarily on detecting oil discharges, and as EMSA (2012) notes, the risk of being caught is often lower further from the coast. Detection of illegal discharge of garbage is hard to do directly.[223]Therefore the primary approach to detection is indirect, focusing on:

- Using waste delivery information or ship-based information to identify suspected offenders; or
- Inspecting vessels in port either to obtain evidence relating to illegal discharge of wastes or the failure to comply with the provisions of the PRF Directive.

Inspection Authorities are able to use the sources of information described above in Section 3.2.5 to track potential offences. This is specifically now enabled by the delivery of advance waste notifications to ports (and now, to SafeSeaNet (see 3.2.5)).

The PRF Directive (Article 11) mandates inspections relating to compliance with the specific provisions of the PRF Directive. However, The PRF Evaluation finds that a low

[222] Ibid.

[223] EMSA (2012) *Addressing Illegal Discharges in the Marine Environment*, 2012

number of PRF inspections have been conducted, partly because of a lack of fit with existing inspection frameworks (under the PSC Directive).

The Port State Control (PSC) Directive and the Paris MoU establish frameworks for inspections for compliance with international environmental regulations. Both the Paris MoU (through the 'New Inspection Regime') and the PSC Directive prescribe a risk-based approach to identifying ships to prioritise for inspection. Information on past inspections and non-compliance – stored by EMSA's information system Thetis and categorising ships as 'High Risk' 'Standard Risk' or 'Low Risk' – allows inspection authorities to target particular ships and companies with a history or likelihood of poor compliance, which increases the efficacy of inspections while reducing the burden on compliant companies.

Panteia and DG Move (2015) report that PRF-mandated inspections, (and, also, inspecting ships suspected of illegal discharge of garbage), happen sometimes under the same framework as the PSC inspections, sometimes under a different framework, and sometimes not at all. IEEP (2013) and the PRF Evaluation study (2015) state that in many ports it is the PSC authorities that inspect ships.[224,225]It is suspected that with inspections carried out to focus on high risk ships identified under the PSC framework – more potentially concerned with poor environmental/pollution or safety standards than garbage management – there is the risk that waste management concerns (and smaller ships) will be overlooked. A stakeholder comments, for example, that inspections tend to prioritise these 'social issues' and are not directed towards the prevention of illegal waste discharges – though others reported that PSC inspections did check for garbage-related issues.[226]

Paris MoU PSC inspections in 2014 found in total 596 MARPOL Annex V violations (most likely ships without garbage books and/or waste management plans, though there is at least one incident in the US of a food comminuter not working properly) down from 889 in 2013.[227] We are not aware of the existence of any information regarding the number of inspections (specifically in relation to Garbage so it is not possible for us to determine the level of inspections, how they change over time, or the true detection rate. We are unable to find any information regarding the inspection and detection of offences in relation to the provisions under the PRF Directive) specifically.

Geographical Scope: The legislation is EU-wide, though inspection resources and prioritisation might limit the extent of geographic coverage within countries.

[224] Panteia and DG Move (2015), Annex 3 to the Evaluation of the PRF Directive – Interim Report, pp53-55

[225] IEEP (2013) *Reducing ship generated marine litter - recommendations to improve the PRF Directive*, Report for SAR, 2013, p25

[226] Stakeholder comments reported in Panteia and DG Move (2015), Annex 3 to the Evaluation of the PRF Directive – Interim Report

[227] Paris MoU (2014) *2014 Annual Report on Port State Control*, 2014

Vessel Flag: The PSC Directive and International MoUs (Paris, the Mediterranean and the Black Sea) allow Port States to inspect foreign flagged ships, and establish frameworks for inspections. Regulation 9 of the Revised MARPOL Annex V gives permission for a Port State to inspect a foreign ship when it is suspected that those on board are not familiar with the obligations regarding waste management and discharge.

Vessel Types: Smaller ships are presumably absent from Thetis, which contains the register of ships used to target inspections, (therefore potentially 'under the radar' for PSC inspectors) and most are exempt from the requirement to keep garbage record books or notify ports of waste anyway (another potential basis for inspection). The PRF Directive states that 'Member States shall establish control procedures, to the extent required, for fishing vessels and recreational craft authorised to carry no more than 12 passengers to ensure compliance with *the applicable requirements of this Directive*'.

Without examining national legislation, however, it is uncertain to what extent this is enacted by Member States, and with what effect, and there is no mention of this within the action plans produced by Europe's relevant Regional Seas Commissions. Military ships are also not covered by the requirement of the PRF Directive and so are not inspected with respect to it either.

We have also been unable to ascertain whether and what inspection frameworks offshore installations fall under: they do not directly use ports, so there is no natural point of inspection.

Waste Types: The legislation provides for inspections on the basis of Garbage irrespective of waste type. However, as noted above, it may be that 'adequate storage capacity' may be under-defined for some waste types.

Potential legislative gaps relevant to inspection and detection therefore exist:

- Most crucially, the current information available to enforcement agencies on ship garbage is not sufficient to enable detection of illegal discharge. As EMSA (2012) note:

  Information from vessel tracking and waste reporting systems is also not sufficient to enable law enforcement authorities to determine whether waste is being disposed of legally. The range of systems in place in different ports makes checking Port Waste Facility receipts (where they exist) against Record Books extremely difficult.[228]

- The inspection framework for garbage is under-defined, given that existing PSC inspections (under the PSC Directive) that place a priority on high-risk ships, are likely to focus on other issues, and only a subset of ships are required to submit waste notification forms. IEEP (2013) recommends:

[228] EMSA (2012), Addressing Illegal Discharges in the Marine Environment, p46

    - the production of guidelines for inspection, covering selection criteria of vessels to be expected, definition of 'sufficient dedicated storage capacity', inspection procedures and applicable enforcement tools;
    - The development of clearly defined selection criteria, under the PSC framework, to inspect ships specifically related to ship-generated waste; and
    - Defining clearly the relationship between PSC and PRF inspections.
- The OSPAR marine litter plan has an action to 'seek to influence the Paris MoU to take the risk of illegal waste discharge into consideration for the prioritisation of PSC inspections'.
- Smaller vessels may be 'under the radar' – they provide no information and there is little inspection and enforcement regarding potential waste discharge. They are exempt from garbage record books, waste management plans, waste notification forms, and potentially, inspection regimes. There is scope to address this within the PRF Directive and associated work, either:
    - broadening responsibilities for waste recording to mandate the collection and storing of information (through waste notification, or, more practically, waste receipts); and/or
    - identifying best practice with regards to provisions for smaller ships and support this through legislation.
- Obligations of Member States regarding waste management reporting requirements and inspection of offshore installations may be under-defined.

3.2.7 Enforcement and Sanctions

The basis for enforcement action taken by Port States and Coastal States against foreign-flagged vessels is provided by a combination of UNCLOS, which gives states jurisdiction over their Exclusive Economic Zone (EEZ) and continental shelf, combined with agreements establishing Port State Control (the Paris MoU and, at the EU-level, the PSC Directive), which allow for inspections of foreign-flagged ships in ports. The Directive on the Protection of the Environment through Criminal Law should ensure Member States have defined the offence as a crime and can identify a legal person responsible.[229] Therefore Port States and Coastal States are able to take action against a ship of any flag for the illegal discharge of waste in their waters.

The European legislation allows for ships to be held in port (PRF Directive - Article 11) or detained (PSC Directive - Article 19) where they are found not to comply. Further legal action including fines and prosecutions can be pursued by any of the Flag State, Port

[229] Additional legislation on the prohibition of the discharge of Garbage is treated differently to the discharge of oil at a European Legislation level. The Ship-Source Pollution Directive only refers to MARPOL Annex I and II wastes, since the provision of common and effective sanctions (the main rationale for the SSPD) are considered covered sufficiently by the Directive for the Protection of the Environment by Criminal Law.

State, or Coastal State. ‘Flag of convenience’ states (states which attract ships to register under their flag by offering more lenient requirements) may be less interested in assisting with investigations than EU Member States, and so efforts to prosecute may be hindered.

The PRF Evaluation found that only a minimal number of sanctions have been given to port users in relation to PRF requirements. EMSA (2012) notes that ‘the number of prosecutions remain low’ (for pollution offences in general), whilst the large majority of these will be for oil discharges.[230] The report also notes that some prosecutions are made for violations of MARPOL Annex V, a number on the basis of evidence provided by cruise ship passengers.

While this information refers to sanctions successfully applied, there is a lack of data on the extent of enforcement actions brought against ships, either for offences under the PRF framework or for suspected offences of illegal discharge – though the OSPAR Marine Litter Plan has an action to analyse the penalties and fines for waste disposal offences at sea. This research found no data regarding charges brought against or sanctions applied to offshore platforms. This type of data could be used as an indicator of whether the current legislative framework is enabling effective enforcement action (though the data may reflect challenges with the implementation of the legislation rather than issues with the legislation itself).

The difficulty in obtaining strong evidence to bring ships suspected of illegal discharges to court leads some countries (for example Denmark) to impose ‘administrative fines’ instead, which just require strong suspicion that a legal entity (a person or registered company) has committed an offence, and recommends that sanctions are built into guidance issued to inspection authorities.[231]

Most initial efforts have concentrated on combatting pollution by oil, and so the techniques and procedures are more advanced for oil pollution than for pollution by garbage.[232]It is clear that currently, ensuring the adequacy of port reception facilities and appropriateness of fee structures are viewed as the main weapon against marine litter from ships. Improving detection and enforcement of offences relating to the discharge of garbage, though a challenge in the marine environment, may not be getting sufficient attention.

3.3 Cargo Residues

Resolution MEPC.201(62) amended MARPOL Annex V to include solid Cargo Residues and washwater from cleaning them out within the definition of ‘Garbage’, and the PRF

[230] EMSA (2012) *Addressing Illegal Discharges in the Marine Environment*, 2012
[231] IEEP (2013) *Reducing ship generated marine litter - recommendations to improve the PRF Directive*, Report for SAR, 2013
[232] EMSA (2012) *Addressing Illegal Discharges in the Marine Environment*, 2012

Directive mandates delivery of Cargo Residues in accordance with MARPOL 73/78 (Article 10). However, some may legitimately be discharged at sea (see Section 3.2.1).

Furthermore, the PRF Directive specifies that the delivery of Cargo Residues falls outside the fee system mandated for Ship Generated Waste, resulting instead in direct fees being paid by the user of the facility.

The 2012 IMO Guidelines for the implementation of Annex V (the "Guidelines") state that ports, terminals and ship operators should consider cargo loading, unloading and on board handling practices in order to minimise production of cargo residues. However, solid cargo residues that are a potential source of marine litter are also likely to be able to be unloaded using commonly available methods.

Potential legislative gaps relevant to cargo residues include:

- A lack of a strict requirement for shippers to declare whether or not cargoes they ship are "harmful to the marine environment" (HME) – this is within the Guidelines, but not mandatory; and
- There is no list of solid bulk cargoes or assessment of individual cargoes that are HME: this causes potential variance in assessment. This list (potentially, as with dumping, a 'reverse list' which specifies cargos that are not harmful) may be developed outside legislation and subsequently referenced.[233]

3.4 Incinerator Ashes

Resolution MEPC.201(62) Corr.1 added a prohibition on the discharge of Incinerator Ashes to MARPOL Annex V, but did not include it within the definition of 'Garbage'. Therefore MARPOL Annex V (Regulation 8) does not explicitly mandate the availability of PRFs for incinerator ashes. Incinerator ashes do however generally fall 'under the scope' of Annex V and so may be included in the definition of 'ship generated wastes' within the PRF Directive. Incinerator ashes are not currently given a particular category under the PRF advance notification form (Annex II to the PRF Directive).

3.5 Fishing Gear

Fishing Gear is included within the definition of 'Garbage' in MARPOL Annex V. However, it requires a distinct set of management practices from other ship-generated waste, as the distinction between 'discharge' and 'accidental loss' is often not clear, nor is how much effort a ship would be required to go to in order to recover gear.

[233] Ince & Co (2013) *MARPOL ANNEX V: new amendments relating to disposal of cargo residues*, accessed 28 May 2015, http://incelaw.com/en/knowledge-bank/publications/marpol-annex-v-new-amendments-relating-to-disposal-of-cargo-residues_2

Unlike the discharge of Garbage, the loss of fishing gear is often not intentional, and much fishing gear waste results from particular materials and practices. Section 4.0 below provides an overview of policies aimed at reducing lost and abandoned fishing gear, and highlighted here are potential areas where legislation may play a role. It is worth noting also that especially where introducing policies that impact on fishing practice, it is important to gain industry support for all such policies and it is worth highlighting the additional benefits to the industry these policies can provide.

Other regulation of the fisheries and aquaculture sector – for instance, through the Common Fisheries Policy and Regional Fisheries Management Organisations – has the scope to encompass concerns about marine litter from fisheries and aquaculture, including in particular fishing gear.

Both the Common Fisheries Policy and the Regional Fisheries Management Organisations are primarily concerned about the sustainable management of fish stocks. However, they provide scope for regulation especially where litter is shown to have an negative impact on the ecosystem.

Article 34 'Promoting Sustainable Aquaculture' commits the Commission to establish non-binding Union strategic guidelines on common priorities and targets for the development of sustainable aquaculture activities. However, minimising marine litter does not appear to fit under any of the main objectives for such common priorities or targets. (Article 34.1)

The Regional Fisheries Management Organisations are active in setting standards for gear:

- The North East Atlantic Fisheries Commission (NEAFC) regulate around gear marking, and the avoidance, recovery and reporting of Abandoned, Lost or otherwise Discarded Fishing Gear (ALDFG).
- The General Fisheries Commission for the Mediterranean (GFCM) – have some remit to specify equipment to minimise the impact on ecosystem. They have recently adopted specific decisions dealing with the issue of by-catch. No information or legislation specific to waste is easily accessible via their website.

Regional Seas Action Plans contain several measures specifically relating to waste from the fishing industry and aquaculture (see Appendix A.2.1.2), so as practice develops there may evidence of effective solutions in the near future, and there may be scope for Regional Fisheries Management Organisations to take more account of the evidence and activities of the RSAPs around preventing marine litter from fisheries and aquaculture.

3.5.1 Prohibition of Discharge

MARPOL Annex V (Regulation 7) allows for 'the accidental loss of fishing gear from a ship provided that all reasonable precautions have been taken to prevent such loss'. Though this establishes an approximate standard, there is an area of ambiguity regarding the definition of 'all reasonable precautions'. Provisions under MARPOL Annex V and the PRF directive (focusing on deliberative criminal activity) are not necessarily sufficient to address issues of negligence, or to set a standard for what is considered ‘reasonable’, and it would seem unfeasible in most cases to gain sufficient evidence to take effective enforcement action.

The NEAFC Scheme of Control and Enforcement, Article 7, requires that vessels with fixed fishing gear shall have equipment on board to retrieve lost gear, and shall attempt to retrieve it and notify authorities, and also mandates identification and marking of gear as in the FCO Convention on the (1967) Annex II identification and marking of gear.[234]

The ownership of nets or other fishing implements may be distinguished by private marks.

3.5.2 Provision and Use of Legal Disposal Options for Damaged/ Recovered Fishing Gear

Since fishing gear is included within the term ‘Garbage’ in the revised MARPOL Annex V, it should be covered by the provisions of the PRF Directive ensuring adequate reception facilities.

In terms of users, the exemption of fishing vessels from mandatory notification and indirect fee requirements (though not mandatory delivery) means that incentivisation and enforcement of waste delivery is likely to be less effective than for other types of Annex V waste.

3.5.3 Fishing Gear – Materials and Management

Article 7.2 of the Common Fisheries Policy allows the Union to implement technical measures to achieve their objectives, including specifying fishing gear to minimise the negative impact on the ecosystem, whilst Article 17 encourages Member States to incentivise fishing vessels deploying selective fishing gear or using fishing techniques with reduced environmental impact, such as reduced energy consumption or habitat damage – this might include fishing gear of techniques designed to minimise loss of gear.

The NEAFC, under Convention Article 7a, may consider “the regulation of fishing gear and appliances, including the size of mesh of fishing nets.”

The NEAFC Scheme of Control and Enforcement Article 7 requires that fishing vessels with fixed gear should have equipment on board to retrieve lost gear, should attempt to retrieve it, and should notify authorities with the location of the lost gear if they are unable to retrieve it.

Specific measures to mandate the use of specific equipment to minimise gear loss have been suggested, including:

---

[234] NEAFC (2015) Scheme of Control and Enforcement 2015, accessed 14th January 2015, http://www.neafc.org/scheme/2015/julytodecember

Mandating the carrying of GPS equipment: Ships with GPS are able to locate precisely where they left fishing gear, ensuring they can return and retrieve it. These systems could be made mandatory within the EU and there are obvious benefits to fisheries. The Honolulu Strategy includes the suggested action "Ensure fishery regulations address the need for locating and removal of ALDFG" under Strategy C3.[235] The HELCOM RSAP has actions to promote and disseminate best practice in relation to on-board waste management, ALDFG, and derelict fishing gear (RS5,RS6), and develop elaborate guidelines on best practice to reduce the input of ALDFG (RS7).

There is the potential to introducing standards or restrictions relating to the products designed to enter the Marine Environment:

- To ensure that items designed to be broken or lost within the marine environment (such as dolly ropes) must be made of material not harmful to the marine environment (for instance, that are made of natural or bio-based materials that biodegrade);
- To ensure that products designed for long-term use within the marine environment don't degrade within the marine environment. This would for instance address the issue of Styrofoam floats that break up causing plastic pollution by requiring that they are have a durable shell that prevents their degradation. The Mediterranean RSAP recommends the application of 'the use of environmental degradation of nets, pots and traps concept', although this is primarily to reduce ghost catching rather than marine litter – if they are plastic-based and degrade into smaller plastic particles, then the other problems associated with plastic in the ocean remain. [236] The HELCOM RSAP has an action to investigate the use and prevalence of dolly ropes (RS9) to assess the need for further action.

Annex II of the Convention on Conduct of Fishing Operations in the North Atlantic[237], Annex II, already specifies that gear should be marked to indicate ownership. This is reinforced by the NEAFC Scheme of Control and Enforcement Article 7, which mandates identification and marking of gear as in the FCO Convention.

There is the potential to increase the possibility of enforcement and encourage greater responsibility by ensuring systems of gear marking are applied across regional seas:

- In the Mediterranean RSAP, appropriate application of gear marking is an objective for 2017.

---

[235] NOAA, and UNEP (2011) *Fifth International Marine Debris Conference: The Honolulu Strategy*, accessed 23 October 2013, http://5imdc.wordpress.com/about/honolulustrategy/, p40

[236] MAP (2013) Regional Plan for the Marine Litter Management in the Mediterranean UNEP (DEPI)/MED WG. 379/5

[237] FCO (1967) Convention on Conduct of Fishing Operations in the North Atlantic

Key waste items might be suitable for deposit-refund systems:

- The Mediterranean RSAP recommends the establishment of 'Mandatory Deposits, Return and Restoration System' for expandable polystyrene boxes in the fishing sector.
- The HELCOM RSAP has an action to identify the options to address key waste items from the fishing and aquaculture industry, including through deposit schemes and extended producer responsibility (RS8)

Fishing practices could be further regulated, through:

- Introducing zoning for static and non-static gear – a significant proportion of gear is lost through tangling of different fishing gear in fishing hotspots. Zoning policies (separating static and non-static gear users), or a system of reporting on gear positioning, may help reduce this and reduce the loss of nets.
- Controlling soak times – the time that nets are left in place could be controlled. A stakeholder at the Icelandic Recycling Fund reporting that reduced soak times was responsible for a definite reduction in fishing gear litter.

In Iceland, however, soak times have reduced without any regulation, driven by a market demand for fresh fish. In quota-controlled areas, where the quality of the catch is of higher importance, limiting soak times may be particularly appropriate and attract industry support.

The OSPAR and HELCOM RSAPs include actions to identify options to address key waste items from the fishing industry and aquaculture. [238]

Additionally, contained within the Mediterranean RSAP is 'cost effective measures to prevent litter from dredging'.

Various initiatives exist to recycle end-of-life gear, see Section 4.9.2. These initiatives typically partner with the recycling and manufacturing industries and aim to reduce litter by a providing free disposal route for waste items. There is no legal barrier to such recycling operations in the EU.

3.5.4 Inspection and Detection

Currently there is limited scope for detection and enforcement of MARPOL violations through lost/abandoned fishing gear. Were some of the measures suggested above introduced around products and standards, this could enable a system of inspection. However there is the potential risk that inspection itself may be a cause of marine litter as, depending on the sanction, non-compliant gear may be disposed of in advance of inspection.

---

[238] OSPAR (2015) OSPAR Marine Litter Action Plan Brochure

Also, enforcement may be difficult in the scenario where nets in the environment could be traced back to their owners - as the owner could have made every reasonable effort to retrieve the lost gear. However under the NEAFC regulations, lost gear must be reported, and the cost of recovery can be claimed from the identified owner of the gear.

3.6 Containers Lost at Sea

Including the issue of containers going overboard within the scope of this research (where possible and appropriate) is no doubt a reflection of the steady increase in global trade via container shipping. Port container traffic (the flow of containers from land to sea transport modes, and vice versa) is measured in twenty-foot equivalent units (TEUs), a standard size container. 90% of good traded globally are transported by sea. In 2004 global port container traffic was 0.33 billion TEU; this has risen to over 0.65 billion TEU in 2013.[239]

The World Shipping Council (WSC) surveyed its member companies (in 2011 and 2014), which operate 90% of the global containership capacity. The results of the surveys indicate that there were on average 546 containers lost at sea each year, not counting catastrophic events (such as collisions, structural failures and ship grounding), and 1,679 containers lost at sea each year including catastrophic events.[240] The report notes that containers lost overboard represent a very small fraction of the global container shipping trade, the industry has been actively supporting a number of efforts to enhance container safety that should help reduce the number of containers lost at sea. Research conducted by the Surfrider foundation for a report that will be published in 2016 found that 1,300 containers were lost annually on average (equivalent to 5,395 tonnes just on the weight of the containers alone, and not their contents) and that 17,000 containers had been lost over the last 25 years.[241] The contents are highly variable and posed a variety of hazards to the marine environment, depending on whether the goods were manufactured solid items, hazardous waste, or foodstuffs – which can have considerable impacts even though they biodegrade. Even the coatings of the containers, if they contain zinc based anti-corrosive additives, are harmful to the marine environment.

Internationally, the regulation of containers lost at sea falls primarily under safety legislation, as containers vulnerable to loss at sea also endanger life. Since the causes are primarily a lack of suitable loading and securing, attempts to address the issue focus on the tightening of waste management standards.

[239] World Bank (2015) *Container port traffic (TEU: 20 foot equivalent units)*, accessed 5 January 2015, http://data.worldbank.org/indicator/IS.SHP.GOOD.TU/countries/1W?display=graph
[240] World Shipping Council (2014) *Survey Results for Containers Lost At Sea - 2014 Update*, 2014, http://www.worldshipping.org/industry-issues/safety/Containers_Lost_at_Sea_-_2014_Update_Final_for_Dist.pdf
[241] Information received directly from the Surfrider foundation.

3.6.1 Waste Management

Several recent initiatives have been undertaken to improve the safety and management of cargo to reduce the number of containers lost at sea, including:

- An amendment to the Safety of Life at Sea (SOLAS) Convention requiring mandatory container weight verification;
- A new voluntary Code of Practise for the Packing of Cargo Transport Units (CTU Code); and
- Amendments to the voluntary IMDG Code and ISO standards.

Amendments to the SOLAS Convention

The IMO's Maritime Safety Committee (MSC) at its 94th session (November 2014) adopted an amendment to the SOLAS convention requiring mandatory container weight verification, and making the shipper responsible for obtaining the gross mass of a container and providing this information in advance to the ship's Master and terminals. The changes will come into force in July 2016.[242] Mis-declared container weights undermine attempts to appropriately stack and secure containers and so have contributed to the loss of containers at sea, as well as to other safety and operational problems.

New Code of Practice for Packing of Cargo Transport Units (CTU Code)

The IMO, the International Labour Organization (ILO), and the United Nations Economic Commission for Europe (UNECE), with industry support, have produced a new code of practice for the packing of CTU, including containers, outlining specific procedures and techniques to improve safety, such as how to ensure equal distribution of weight inside the container, proper positioning, blocking and bracing according to the type of cargo, and other safety considerations. The new code has been approved by the IMO and the UNECE and received final approval by the ILO in November 2014.[243]

Amendments to IMDG Codes and ISO standards

A requirement that containers with reduced stacking or racking capacity be marked accordingly so they can be identified, stowed and lashed safely on the ship is being introduced to the relevant ISO standards, and is included in the IMO's Safe Container Convention and International Maritime Dangerous Goods (IMDG) Code.

The IMO has requested the International Organization for Standardization (ISO) review and revise its standards regarding lashing equipment and corner castings. The ISO is working on these issues with the industry's active participation.

---

[242] Lloyds Register Marine (2014), IMO Maritime Safety Committee (MSC 94) Summary Report, http://www.lr.org/en/_images/213-46840_MSC_94_Report.pdf

[243] MSC (2014) MSC.1/Circ. 1497, http://www.worldshipping.org/industry-issues/safety/MSC_1-Circ_1497_-_CTU_Code_Jan_2015.pdf

The IMO has also issued revised Guidelines for the Cargo Securing Manual that must be developed for all containerships and which prescribe how containers are to be loaded, stowed and secured throughout the voyage, taking into account these new requirements and the CTU code.[244]

Potential Gaps in Legislation

Depending on the level of industry participation in the above voluntary standards, there may be a justification for making some standards relating to cargo securing mandatory.

3.6.2 Inspection and Enforcement

There have been concerns that the legal framework for goods transportation by container ships were undefined, relating to the legal status of the containers and issues of locating fault or liability. In their White Paper from 2013, Surfrider note an existing legal loophole towards the container ships, the containers themselves, and their loss and load. In particular, they were concerned that there was no law to define who is responsible for it (given that, relatedly, there may be multiple causes – improper fixing, overloading), or even the legal status of those containers: whether they represented wastes or wrecks. There was also no mechanism for a mandatory requirement to report losses.[245]

Legal uncertainty of this kind presents a barrier to attempts to prosecute, and for the law to provide an effective deterrent. Without clear means of establishing liability, then the applicability and effectiveness of sanctions are unclear. The Nairobi International Convention on the Removal of Wrecks which has recently come into force (April 2015)[246] now provides a legal basis for coastal States to remove, or have removed, from their coastlines, wrecks which pose a hazard to the safety of navigation or to the marine and coastal environments, or both. It is intended to make shipowners financially liable and require them to take out insurance or provide other financial security to cover the costs of wreck removal. It will also provide States with a right of direct action against insurers. At present there are only 25 contracting countries, five of which are in Europe; but this does cover around 60% of the gross tonnage of the world fleet.[247] The definitions in the convention are broad and a wreck can be construed to mean lost containers. Efforts must be made for all EU countries to ratify it, which would mean that any ship passing through a state’s waters would be responsible for its container losses in those waters.

An alternative, defining lost containers as ‘wastes’, would have been to give ‘cargo’ a status comparable to fishing gear within MARPOL Annex V (the loss of cargo would be

---

[244] MSC (2014), MSC.1/Circ. 1353, http://www.worldshipping.org/industry-issues/safety/MSC_1-Circ_1353-Rev_1_-_Revised_Guidelines_For_The_Preparation_Of_The_Ca___.pdf
[245] Surfrider Foundation Europe (2013) *A White Paper on Maritime Safety*, December 2013
[246] http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/Nairobi-International-Convention-on-the-Removal-of-Wrecks.aspx
[247] http://www.imo.org/en/About/Conventions/StatusOfConventions/Pages/Default.aspx

viewed as illegal discharge, with the exception of losses when 'reasonable precaution' has been taken to prevent such loss). Since weight-verification is mandatory, the stacking, loading and securing of containers would then be the main potential cause of loss. The application of international standards could then be evidence of 'reasonable precautions' to prevent the loss of cargo, and therefore to clear those responsible for loading and securing containers from potential criminal responsibility.

3.7 Waste Collected Whilst at Sea (i.e. 'Fishing for Litter')

'Fishing for litter' projects have received recent attention as both a method of 'clean-up' and a way to raise awareness among fishing communities of the problem of Marine Litter. Whilst not specifically covered by any IMO or EU legislation, they have been considered by most Regional Seas Commissions and the development of fishing for litter projects appears as one of the few actions addressed at sea-based sources of litter (alongside PRFs and fee systems) in Regional Seas Action Plans. The OSPAR Commission calculates that if 500 vessels were recruited into their fishing-for-litter scheme, they could expect a collection rate of 2000 tonnes per year.[248]

The costs of subsequent waste treatment would currently be determined by the individual schemes. The Baltic 'no special fee' system was amended by the Helsinki Commission to allow waste caught in fishing nets to be included within the no special fee system to enable 'fishing for litter initiatives'. Whilst this might be explicitly mandated within a similar amendment to the PRF, it is likely to be best considered as part of a wider amendment focusing on a common (or regionally harmonised) port fees system.

3.8 Sewage

As noted in the introduction, the disposal of sewage may contribute to marine litter through the presence of plastic personal hygiene products and other items disposed alongside sewage.

MARPOL Annex IV places restrictions on the discharge of Sewage. Otherwise, it is covered by the same pieces of legislation as Garbage; although generally fewer of their requirements apply. The PRF Directive (Article 7) mandates the delivery of sewage to port (all 'ship-generated waste'), though a footnote to Annex II (the notification form) allows for ships to declare that they will make an authorised disposal at sea. This however would have to happen before the ship arrives in port, because of the mandatory delivery requirement.

MARPOL Annex IV also requires ships to be equipped with either an approved sewage treatment plant or an approved sewage comminuting and disinfecting system or a sewage holding tank.

[248] OSPAR Commission (2007) *Guidelines on how to develop a fishing for litter project*

3.8.1 Prohibition of Discharge into the Marine Environment

Under MARPOL Annex IV, sewage may be discharged at a regulated discharge rate when outside 'special areas' for sewage and more than 3 miles from land if the sewage has been comminuted or disinfected, and more than 12 nautical miles from land if the sewage is raw.

However, the Annex also allows (in Regulation 11 paragraph 2) for states to impose less stringent requirements.

Geographical scope: All EU28 states are signatories to MARPOL Annex IV. There is no EU-wide transposition or clarification of the requirements of Annex IV.

The Baltic Sea is a MARPOL Special Area for sewage (introduced by Resolution MEPC.200(62)), pending sufficient notification that adequate facilities are in place. The discharge of sewage from passenger ships (a ship which carries more than twelve passengers) within the special area will be prohibited, except when the ship has in operation an approved sewage treatment plant which has been certified by the Administration.

Vessel types: Ships weighing less than 400 gross tonnes that carry fewer than 15 persons are exempt from the provisions of the revised Annex IV. Only passenger ships with more than 12 passengers face the extra restrictions inside special areas.

Potential gaps in legislation: Unlike with garbage, restrictions on the discharge of sewage into the sea do not apply to ships weighing under 400 tonnes which carry fewer than 15 people or 12 passengers.

3.8.2 Provision and Use of Disposal Facilities

The PRF Directive requires ports to have port reception facilities to meet the needs of ships to discharge ship-generated wastes, including sewage. However, since many ships have the option of legal discharge at sea, it is less clear what the 'needs of ships' are regarding sewage disposal at port. Although they are required to deliver sewage to ports if they do not have sufficient storage space, for many ships there are legal routes at sea prior to arriving at the port, and their storage space is adequate for time spent in areas where sewage disposal at sea is prohibited.

In theory, the indirect fee requirement of the PRF Directive should apply to sewage in so far as it is a ship generated waste (to which the fee requirement applies). However because the stipulation invokes ship generated waste as a whole, the application of direct fees to some types of waste and indirect fees to others has been construed as consistent with this requirement. Therefore sewage in practice may be entirely paid for via direct fees. In this event the disposal of sewage at sea is incentivised.

The amendment to MARPOL Annex IV in relation to the Baltic Sea special area introduces a requirement for ports inside special areas to provide adequate reception facilities. Implementation of the MARPOL 'Special Area' status for sewage was delayed until there were adequate port reception facilities to receive the sewage. Notification has been submitted as a joint statement from all states apart from Russia that their ports now have adequate facilities for sewage reception and requesting the MEPC to set a date under which the special area requirements will come under effect.[249]

Voluntary Measures: Prior to the Baltic Sea being made a special area for Sewage, members of the Helsinki Commission developed agreements to deliver sewage to ports.[250]

3.8.3 Waste Management

A 2008 amendment to MARPOL Annex IV requires ships covered by the provisions of the Annex (all ships above 400 tonnes or carrying more than 15 people) to be equipped with an appropriate shore discharge connection and either:

- An approved sewage treatment plant;
- An approved sewage comminuting and disinfecting system; or
- A sewage holding tank.

Ships must be inspected periodically to confirm compliance, and issued with International Sewage Prevention certificates.

Similarly, this provision does not apply to smaller ships (under 400 tonnes) and ships carrying fewer than 12 passengers.

3.8.4 Information, Inspection and Enforcement

Since ships have to carry International Sewage Prevention certificates, these can be inspected, ensuring that appropriate equipment is in place and has been approved.

Sewage is recorded in its own category on the PRF Directive waste notification form, so information about sewage to be discharged is available – however, there is no duty to record when sewage is discharged legally, so there is little potential (outside the Baltic Sea) to use this notification channel in conjunction with delivery notes to indicate potential illegal discharge .

3.9 Dumping of Wastes (and other matter)

This section reviews legislation relating to the dumping of wastes and other matter in the Marine Environment.

Dumping of wastes is a potential source of marine litter. The London Convention, and the subsequent London Protocol, are the main international agreements concerning the

---

[249] Panteia, and DG MOVE (2015) *Ex-Post Evaluation of Directive 2000/59/EC on Port Reception Facilities for Ship-Generated Waste and Cargo Residues*, 2015, http://ec.europa.eu/transport/modes/maritime/studies/doc/2015-ex-post-evaluation-of-dir-2000-59-ec.pdf

[250] Helsinki Commission (2007), Helcom Baltic Sea Action Plan, available from http://www.helcom.fi/baltic-sea-action-plan/action-plan/

dumping of wastes at sea. This is re-enforced at a Regional Seas Level, with Annexes or Protocols to each Regional Seas Convention specifically on dumping.

The legislation surrounding the dumping of waste is clear. A license must be obtained for dumping from the state which has jurisdiction over the sea area where the dumping would occur, and in most areas, only a very limited list of wastes can be considered for a license. However, there are differences in approach between the London Convention and the London Protocol (see Section 3.9.1 below), and Regional Seas Commissions differ as to whether they follow the text of the Convention or the Protocol.

3.9.1 Prohibition of Discharge into the Marine Environment

Article 210 of UNCLOS requires States to adopt laws and regulations to prevent, reduce and control pollution of the marine environment by dumping, and gives states exclusive jurisdiction over permitting within their territorial sea, EEZ and continental shelf.

Article 2010.4 of UNCLOS calls for the creation of global rules and standards on dumping, which are set out in the London Convention and Protocol and backed up by similar agreements at a Regional Seas level.

Geographic coverage: Neither the London Convention nor the London Protocol has been ratified by all EU Member States:

- As of 15th April 2015, 21 of the EU28 Member States have ratified the London Convention.[251]. Austria, Czech Republic, Estonia, Latvia, Lithuania, Romania and Slovakia have not ratified it. However, those states with sea borders are all parties to either the Helsinki or Bucharest Conventions which place an equivalent restriction on dumping. Therefore the requirements of the London Convention have been adopted directly or indirectly by all EU Member States with territorial seas.
- The Protocol entered into force in March 2006 and there are 15 EU28 countries which have ratified it (including Estonia).[252] [253] Poland, Portugal, Malta, Greece, Finland, Croatia and Cyprus have not.

Of the four Regional Seas Commissions involving EU countries (relating to the North Sea, the Baltic Sea, the Mediterranean Sea and the Black Sea):

- the OSPAR Commission (the North Sea) has adopted (via an Annex) the stricter provisions of the London Protocol;

---

[251] NOAA, and UNEP (2013) *IMO Status of Conventions*, accessed 15 October 2013, http://www.imo.org/About/Conventions/StatusOfConventions/Pages/Default.aspx

[252] IMO (2013) *London Convention and Protocol*, accessed 22 October 2013, http://www.imo.org/OurWork/Environment/SpecialProgrammesAndInitiatives/Pages/London-Convention-and-Protocol.aspx

[253] NOAA, and UNEP (2013) *IMO Status of Conventions*, accessed 22 July 2015, http://www.imo.org/About/Conventions/StatusOfConventions/Pages/Default.aspx

- the Helsinki Commission (the Baltic Sea) has a stricter provision than the London Convention, only permitting dredged material under certain circumstances;
- an amendment was tabled for the Barcelona Commission (the Mediterranean Sea) to adopt the terms of the London Protocol, but did not enter into force; and
- the Bucharest Commission (the Black Sea) adopts the categories of the London Convention.

Therefore, Croatia, Cyprus, Greece, Malta, and Romania, as EU Member States with sea borders within the Bucharest or Barcelona Commissions, who have not ratified the London Protocol, may be permitting a wider range of wastes and other matter to be dumped into the sea. Moreover, non-EU states bordering the Mediterranean Sea may also be permitting wastes to be dumped in the Mediterranean Sea outside the EU EEZ.

However, in granting a license, even these countries should take into account the environmental impact of the dumped waste, which should include the propensity to cause harm to the marine environment, and the viability of alternative methods of disposal. Waste that could produce marine litter is therefore unlikely to receive permits.

Regional Seas Commissions may establish programmes for assessing and controlling dumping at a Regional level – for instance, the Mediterranean Action Plan (MAP) Phase II commits to collecting information on the issuing of permits, create guidelines for monitoring of disposal sites and thereby assess the implementation of their Protocol on dumping, and consider the need for additional measures. This would help assess whether licenced dumping at present causes any significant level of marine litter.

Flags: Dumping without a license in the EEZ/continental shelf of a country is illegal irrespective of the flag state.

Vessel Types: Dumping from all types of vessel, aircraft and offshore platforms are covered under the London Convention and the Regional Seas Protocols/Annexes.

Waste Types: The London Convention divided wastes and other matter into three categories – those for which dumping is prohibited, those which require a special permit, and all others (requiring a general permit).

The ‘London Protocol’ was agreed in 1996, to further modernise the Convention and, eventually, replace it. The Protocol applies a ‘reverse list’, prohibiting all dumping except for eight types of waste that may be considered for dumping:

- Dredged material;
- Fish waste;
- Vessels, platforms or other man-made structures;
- Inert, inorganic geological material;
- Organic material of natural origin;
- Bulky items primarily comprising iron, steel and concrete; and

- CO2 storage in sub-seabed geological formations.[254]

The move from the London Convention, a permissive approach to ocean dumping, towards a more restrictive precautionary approach under the Protocol, represents a shift in attitude towards waste and the environment towards greater restriction and control.[255]

Potential gaps in legislation: An examination of the licensing practices of these states would be necessary to determine the extent to which more permissive licensing regimes are, in practice, a concern, or an actual cause of quantities of marine litter.

There is some indication in Regional Seas Action Plans that dumping is still regarded as a concern (see Appendix A.2.1.2). The Black Sea Strategic Action Plan management target 59 is 'Improve regulations/ management of dredging / dumping activities', indicating that there is room for improvement on current practice.

3.9.2 Inspection and Detection

This review has not uncovered legislation specifically enabling inspection and detection of ships suspected of unlicensed or illegal dumping at sea. It is likely that coastal surveillance is in use, alongside identification of waste management reporting irregularities within individual MS.

3.9.3 Enforcement and Sanctions

The Directive for the Protection of the Environment through Criminal Law would apply to wastes dumped without a licence: therefore, liability should be clear and sanctions should be effective. Illegal dumping is still an issue for the Mediterranean - Article 9.9 of the Mediterranean Marine Litter Regional Plan commits states to close existing illegal dump sites.

Without calling at ports of the Member State in question, enforcement of the offence, as with illegal discharge, would require the co-operation of the destination Port State and/or Flag State in applying a sanction or in prosecuting those liable for the offence.

3.10 Summary of Legislative Gaps

The legislation surrounding the discharge of waste into the ocean that contributes to marine litter is theoretically comprehensive. There are very few gaps in relation to the

[254] Haag, F. (2013) Sea-based sources of marine litter: the IMO perspective, paper given at GLOC-2, Montego Bay, Jamaica, 2 October 2013, http://www.gpa.unep.org/index.php/global-partnership-on-nutrient-management/publications-and-resources/second-global-conference-on-land-ocean-connections-gloc-2/214-haag-seabased-sources-of-marine-litter-the-imo-perspective/file?limit=100

[255] VanderZwaag, D.L. (2011) The International Control of Ocean Dumping: Precautionary Currents, Sea of Challenges

prohibition of discharge, and inspection regimes and effective sanctions are mandated by European legislation.

However, there are weaknesses and ambiguity within the current legislative framework around fees, waste management and reporting obligations, as well as inspection and enforcement that means it remains hard to establish common fee systems, consistently high performing waste management practice, and to maintain an effective detection system and devote resources to garbage-related enforcement.

This section presents a summary of the main gaps identified by thematic area.

3.10.1 Geographical Scope

MARPOL defines Special Areas for Garbage covering all European Regional Seas, and so there is a comprehensive prohibition on the discharge of Garbage within Europe. MARPOL and the PRF Directive can be enforced on ships of any flag state, even non signatories/non-Member States within EU waters. The Baltic Sea is close to being approved as a Special Area for Sewage, potentially pending further improvement of reception facilities at Russian ports.

Whilst Regional Seas Conventions (which include bordering non-EU countries) have protocols/Annexes regarding pollution of the seas, only the Helsinki Convention makes specific reference to addressing pollution from discharge of garbage, by applying the provisions of MARPOL Annex V, though all have subsequently taken some actions in relation to tackling marine litter.

Since anti-pollution measures are largely directed against oil-based pollution, emergency response and liability for clean-up, there are a limited range of approaches to tackle sea-based sources of marine litter – with efforts focusing on ensuring waste is delivered to port reception facilities (mandated by MARPOL Annex V and detailed at the European level by the PRF Directive).

The Ship-Source Pollution Directive (SSPD) only refers to MARPOL Annex I and II wastes, since the provision of common and effective sanctions (the main rationale for the SSPD) for the illegal discharge of other MARPOL wastes are considered to be covered sufficiently by the Directive for the Protection of the Environment by Criminal Law. It is uncertain however whether in practise this Directive gives sufficient mandate to criminalise the discharge of garbage at sea.

There are some states which may still have a more permissive licensing regime for dumping (through adopting the classifications of waste within the London Convention rather than the London Protocol).

Both the Mediterranean and the Black Sea in particular include non-EU waters and ports outside the scope of European legislation (in particular PRF requirements). Therefore it remains important for EU Member States to seek to include their fellow Regional Seas Commission members within equivalent and common regimes of waste information systems, inspection, and fee systems as mandated within the EU.

3.10.2 Types of Vessel

This review has highlighted a number of areas where exceptions in regulations mean that certain vessel types are not covered by regulations to the same degree.

- There is no requirement for small ships to have waste management plans or garbage record books (see Table 14);
- No information is required to be collected or reported on legal waste disposal for small recreational vessels (see Table 14); and they are exempt from the requirement to pay any indirect fee component. Recreational vessels may account for around 23% of the person time spent at sea (Figure 15, Section 2.6.5.1) and 19% of total waste generated at sea (Figure 19, Section 2.6.5.3).
- No information is required to be collected or reported on legal waste disposal for fishing vessels; and they are exempt from the requirement to pay any indirect fee component. Fishing vessels may account for around 11% of the person time spent at sea (Figure 15, Section 2.6.5.1) and 30% of total waste generated at sea (Figure 19, Section 2.6.5.3).
- No information is required to be reported to ports or inspection authorities on legal waste disposal for ships engaged in scheduled traffic with frequent and regular port calls; and they can also be made exempt from requirements to pay any indirect fee component. Passenger vessels, which meet this criteria, may account for around 20% of the person time spent at sea.
- Given that small ships have a general exemption from Annex IV, they may legally discharge untreated sewage.
- Military ships and ports are exempt from adequate provision, mandatory delivery, notification and indirect fee component requirements of the PRF Directive. Naval vessels may account for around 3% of the person time spent at sea.

In particular, in the case of small recreational vessels and fishing craft, Member States are left to establish their own information/enforcement regimes relating to controlling garbage.

Fishing vessels contribute towards the problem of marine debris particularly in terms of ALDFG, which is understood to have a considerable impact on marine species (although this may be because ALDFG is easily recognisable compared to other types of marine debris)[256] [257], therefore the exclusion of most fishing vessels from MARPOL waste management requirements on the basis of size and from PRF Directive reporting

---

[256] Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

[257] STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

requirements and fee structure stipulations because of the vessel type, leaves a particularly significant gap.

Cruise ships have the potential to generate wastes similar in volume and character to those generated by hotels. According to our own research, cruise passengers and crew could account for 17% of the person time spent at sea. According to a 1999 Royal Caribbean Cruises Environmental Report, packaging materials from consumables and spare parts for a ship can generate up to 15 tons of waste in a single day.[258] The majority of current legislation regarding pollution and shipboard waste was developed prior to the rapid growth of the cruise market; as a consequence there exists no international legislation addressing the particular issues surrounding pollution and waste management on these vessels. [259] For example, it may be that the PRF is not explicit enough about the division of responsibility to ensure adequate reception facilities for all kinds of waste from cruise ships exists at their ports of call.

Different legislation adopts varying boundaries to their requirements as to which ships are exempted. Table 14presents a non-exhaustive list of the exemptions in place.

Table 14. Exemptions from Marine Debris Legislation

Exemption Basis	Exemption Boundary (from which requirement)
Tonnage	<100 tonnes (MARPOL garbage management plans) <300 tonnes (Community Vessel Traffic Monitoring and Information System: Automatic Identification Systems) <400 tonnes (MARPOL Garbage Record Books) <500 tonnes (Mandatory ISM Code)
Fishing vessels	Exempt (PRF advance notification and ISM Code; PRF mandatory indirect fee systems)
Recreational vessels	<=12 passengers (PRF advance notification, mandatory indirect fee systems) <=15 persons (MARPOL Garbage management plans)

[258] UNEP, and Caribbean Environment Programme (2007) *The Caribbean Environment Programme: Draft Cruise Ship Discharge Assessment Report*, accessed 19 November 2013, http://www.cep.unep.org/publications-and-resources/databases/document-database/other/cruiseship-discharge-assessment-report.pdf/view

[259] Butt, N. (2007) The impact of cruise ship generated waste on home ports and ports of call: A study of Southampton, *Marine Policy*, Vol.31, pp.591–598

Exemption Basis	Exemption Boundary (from which requirement)
Offshore platforms	May be exempted by Member States from the requirement to keep Garbage Record Books. Out of scope for PRF Directive

There are obvious advantages to providing these exemptions in many cases, and it may well be that the requirements are not judged necessary - For example, it may be that information systems to understand and control litter from smaller recreational ships and fishing vessels can be established without requiring legislative change. However, these exemptions make it harder to conduct effective prioritisation, inspection, and enforcement for these ships.

Whether issues associated with each vessel type are best dealt with through legislation or industry action is not straightforward. However there is scope to address some issues within the PRF Directive and associated work, by:

- Broadening responsibilities for waste recording to mandate the collection and storing of information (through waste notification, or, more practically, waste receipts); and/or
- Identifying best practice with regards to provisions for smaller ships and support this through legislation.

Lastly, offshore platforms may be excused from the MARPOL Annex V requirement to keep Garbage Record books. Perhaps more importantly, the PRF directive cannot cover offshore platforms, and there are no equivalent explicit delivery and information requirements – they do not prepare notification forms, and there is no central platform accessible to inspection authorities relating to waste delivered to ports from offshore platforms.

3.10.3 Waste Types

Litter removal – for instance, litter caught in fishing nets – is not provided for within any existing legislation. At a minimum, ships should not be charged for waste they collect at sea and return to ports. Whilst this might be explicitly mandated within a similar amendment to the PRF, it may be best in the context of a harmonised fee system.

There is no requirement to record the legal discharge of sewage (and, potentially, incinerator ash). In addition, sewage may be legally discharged in various circumstances and prohibitions on discharge could be made more stringent.

There may be some waste types (such as abandoned fishing gear) where the introduction of more guidance or legislation around identifying ownership (e.g. gear marking) would have a positive impact, as well as more guidance on the provision of disposal facilities.

Disposal of WEEE from ships is not explicitly dealt with by MARPOL Annex V or the PRF Directive and provision for its reception and disposal may be improved if it were.

Additionally, the disposal of Cargo Residue is exempt from requirements to include some proportion of indirect fee in the charging structure.

The proposed revision of Annex II of the PRF Directive is updating the notification form to ensure that all wastes covered by the revised MARPOL Annex V are covered more explicitly, and in this way remove some ambiguity from the implementation of the Directive. This will help the requirements of the Directive to be applied more stringently i.e. to more waste types.

3.10.4 Legal Disposal Options

Most notably, with the exception of the Baltic Sea, regional seas lack harmonised systems of port fees. There are numerous suggestions that the major barrier to reducing marine litter is the lack of a harmonised system of port fees, potentially with a very high component of indirect fees (such as ‘no special fees’ system, i.e. 100% indirect fees) where the costs of waste delivery are paid for at a set rate regardless of use. The legislation may need tighter framing to support the development of harmonised fee structures. In particular, an approach seems required which:

- Removes incentives for waste disposal at sea (by having a high component of indirect fee);
- Ensures a level playing field between ports;
- Has a low administrative burden;
- Covers costs; and
- Manages to maintain incentives for waste minimisation.

An update to the PRF Directive should remove ambiguity. Some clarity may be required on terminology: whilst MEPC 83 (44) provided guidance for the term “adequate” (in relation to PRFs) in March 2000, there is no prescriptive standard to be adhered to (it remains qualitative). Furthermore, MEPC resolutions are not mandatory instruments, meaning the term can still be interpreted in many ways.

3.10.5 Waste Management

Detailed aspects of waste management (i.e. focusing on waste minimisation and technologies, and storage) are handled only through voluntary guidance, including the MARPOL Annex V guidance.

Though there is little evidence of an impact on Marine Litter, the gap in ambition over the quality of recycling between some ships and ports (where recycling is separately collected on ships but comingled at ports) may be preventing optimal levels of waste management and quality of recycling streams from the maritime community.

3.10.6 Waste Minimisation

There is a potential lack of measures designed to support and encourage actions at a port level to reduce the amount of waste generated by ships. These actions could be more effective for smaller ships more likely to source supplies through local merchants or through port-based supply chains.

A range of specific kinds of waste in particular industries or communities may benefit from better development of deposit-refund systems, and disincentivising or prohibiting the use of items more likely to turn into marine litter (for example, particular commonly used aquaculture equipment, catering-associated supplies, plastic bags and beverage cans).

Secondly, there is no clearly defined EU-wide assessment standard to support reduced port fees for Green Ships in the context of a more harmonised port fees system, though EMSA (2007) highlights several such standards that might be more widely adopted. Waste minimisation could be incentivised through part of the criteria including the installation of appropriate technology, and the presence of procurement policies, rather than just meeting minimal requirements.

There may be a justification for making some standards relating to cargo securing mandatory, depending on the level of industry participation in the voluntary standards described in Section 3.6.1.

3.10.7 Information

The current level of information on ship garbage may not be sufficient to enable detection of potential offenders (we suspect detection levels to currently be low) and therefore increase the rate of detection and sanctions, in particular:

- There is no obligation to report waste delivery receipts (though there will soon be the obligation for ships to report waste delivered at the previous port within the PRF notification form), or to share these across ports and make them available for analysis to detect potential offences;
- Ports do not play a central role in waste management, and therefore lack information. IEEP (2013) recommend:
    - Clearer definition of 'Responsible Authority'
    - Guidelines under the PRF Directive for a 'more centrally managed' ship waste handling system;
    - All waste management at Ports is co-ordinated centrally by the responsible authority, including arrangements, payments and receipts.

There are a number of potential inconsistencies in existing information requirements which may hamper planning and/or monitoring:

- The PRF notification form may not sufficiently distinguish separate streams of waste (for purposes of planning and also monitoring);
- There are multiple reporting formats: though this was addressed temporarily and in part through the adoption of the National Single Window; and now through SafeSeaNet, which as of June 2015 provides the electronic system for reporting waste notification. Additionally, the proposed revision of Annex II of the PRF Directive harmonises the PRF notification form with the MARPOL notification form.

3.10.8 Inspection and Detection

The inspection framework for garbage is insufficiently defined in the legislation and so is applied differently in different states and ports. PSC inspections do not cover all ships, focus on high-risk ships and are likely to focus on other issues. IEEP (2013) recommends:

- The production of guidelines on inspection, covering selection criteria, definition of 'sufficient dedicated storage capacity', inspection procedures and applicable enforcement tools; and
- 'Clearly defined selection criteria [under the PSC framework] to inspect ships should be developed specifically related to SGW'.

3.10.9 Enforcement and Sanctions

Gaps relating to information, inspection and detection prevent the wide application of sanctions and prevent them from being an effective deterrent.

Without data on enforcement and fines for discharge of garbage, it is hard to assess whether there is a need for further common application of appropriate sanctions.

Flag of convenience states may hinder enforcement though not being covered by co-operation clauses within the legislation.

A lack of legal clarity on the status of (and liability for) the loss of containers at sea may be preventing the application of effective sanctions.

3.11 Summary

This study reviews the legislative support for activities which combat sea-based sources of marine debris, from waste reduction through to enforcement. The legal provisions for each of the main waste types and pathways are analysed separately.

There are few gaps in European legislation prohibiting discharge of wastes, setting inspection regimes and imposing sanctions. However, there are weaknesses and ambiguities within the current legislative framework around the delivery by ships of their waste to port reception facilities, obligations for waste management and reporting, and inspection and enforcement. The following remain weaknesses/gaps in the current legal regime:

- Lack of harmonisation in CRS, not sufficiently removing incentives to discharge waste at sea,
- Lack of an effective system for detecting offences; and
- Insufficient resources devoted to garbage-related enforcement.

Actions with the most potential to tackle marine litter that can be addressed through updating the current legislative framework include:

- A harmonised CRS at a regional level that:
    - incentivises both waste minimisation at sea,
    - removes disincentives to deliver at ports, and
    - is tailored appropriately to very different users (for instance, cruise ships).

- Removing exceptions such as those for military vessels, small vessels and fishing vessels. Fishing vessels and recreational vessels account for a large proportion of both the person time spent at sea and the total waste generated at sea (see Section 2.6.5.1 and Section 2.6.5.3).
- Ensuring inspection agencies have accurate information on legal garbage disposal in order to detect infringements (see Section 3.10.7). This could be achieved through:
    - The mandatory reporting of waste delivery receipts and centralising handling of waste notification and delivery information at ports, and an effective exchange of this information between inspection authorities
    - Clarifying and harmonising inspection regimes under the PRF so that appropriate numbers of ships can be efficiently assessed for the risk of illegal discharge of garbage and inspected.

  These changes would also be greatly supported by a higher level of involvement by port authorities in waste management and associated process, which could be more clearly mandated by the legislation.

Furthermore, these actions require not only legislative changes, but also co-ordinated action at a regional level, and between ports. In most cases, further problem definition and further consultation with stakeholders would be necessary in order to recommend specific legislative change to address these gaps. Voluntary measures may also be used to address gaps in addition to, or instead of, legislative approaches.

In addition, more attention could be given to supporting waste minimisation initiative at the level of specific industries, for instance in product standards that take into account potential impact on the marine environment.

Waste generated by offshore platforms is covered by many pieces of legislation, though not often explicitly mentioned, and obligations are not as comprehensive as for vessels. Offshore platforms cannot be covered within the PRF Directive and inspections, or the Port State Control regimes (both port-based systems for ships which call at ports), and can be exempted from requirements for garbage record books. We do not know how much waste is generated nor whether the rules are complied with.

4.0 Task 1.3: Marine Litter Reduction Actions for the Fisheries and Aquaculture Sectors

The objectives of Task 1.3 are as follows:

- Fully considering available information and pilot studies, identify options to contribute to the 2020 fishing gear reduction goal and to support the European

Commission in co-leading OSPAR action 35 on addressing key waste items from the fishing industry and aquaculture;

- The identification of options should serve as a basis for an expanded list of possible activities which would contribute to the OSPAR action, taking also into account OSPAR specificities covering not only fishing gear, but other sources and types of litter originating from the fishing and aquaculture sectors; and
- Such options should be based on an analysis of these sources and types of litter and should include a cost-benefit analysis of reduction options, including, where feasible, an estimation of the percentage reductions which could be brought about through their implementation. It should also take account of the results of relevant marine litter retrieval projects.

Marine debris is increasingly recognised as in important international issue that will require the co-ordination and co-operation of many stakeholders. In response to this issue a number of voluntary agreements and goals have been adopted by different groups. In this review we analyse measures that could contribute to two key litter reduction goals.

We first discuss the differences in how the measures act: either reducing the stock of litter through removal activities or reducing the inflow of litter through preventative action, and in many cases targeting specific sources and pathways of litter. Estimates of the amount of fishing and aquaculture debris entering the marine environment are presented in order to understand the scale of the problem.

This then informs an analysis of the two litter reduction goals:

- A 30% reduction target set in the EU Circular Economy Package (COM(2014)398); and
- The OSPAR action to address key waste items from the fishing industry and aquaculture.

These goals are assessed against the existing methods for monitoring marine debris in order to understand how they will be baselined and progress measured. Through this analysis we identify the likely key items of litter from these sources, and discuss which litter items may be under-represented in the sampling results. The harm caused by key items has in part been analysed in the literature and is presented below, specifically for gillnets and items that cause issues through interaction with fishing gear and vessels.

Some Member States have already undertaken measures to tackle marine debris at a national level and other projects exist at regional, local and pilot level. The different approaches involved, both existing and proposed, are introduced. Where case study evidence is available this is used to demonstrate the potential for litter reduction and cost-effectiveness of individual projects. Costs and benefits identified are related to the stakeholders affected and the potential for action at a European or Member State level is discussed. Finally the potential contribution towards the litter reduction goals is discussed in terms of widespread adoption of the measure, impact upon litter levels and relative cost-effectiveness. The most promising measures are highlighted in a final summary of litter reduction strategies.

Revision of Objectives

One objective of this study was to perform a cost-benefit analysis of the litter reduction options. Cost-benefit analysis identifies the costs and benefits of a project and monetises these in order to determine if the benefits outweigh the costs. We found that the full cost-benefit method cannot currently be applied to the litter reduction measures presented here due to gaps found in research and understanding.

For example, the harm caused by marine debris includes ingestion by animals (from zooplankton to whales), entanglement of animals leading to physical impairment or death, and the transportation of invasive species (rafting), but the degree to which this harm is inflicted by different types of debris is not known nor are there established methods of monetising the harm caused.

Therefore it is not possible to quantify and monetise the full benefits of reducing this litter. Specific elements of the harm caused by marine debris have been quantified and monetised, mostly where they relate to direct costs to fishers such as the value of the gear lost, the value of certain species that are caught in the lost gear (which varies by fishery and end-market), and the costs involved in freeing fishing gear and vessels that are entangled in marine debris. These benefits are explored and described in detail and highlight the added advantage of litter reduction measures that impact on these areas.

It is similarly difficult to compare costs of different litter reduction measures as case studies rarely provide a detailed enough breakdown to permit a like-for-like comparison. Furthermore, costs to implement measures will vary greatly not only due economic factors such as the local labour market but also due to other factors such as the steps required to implement a measure under different local regulation, fishing practices, and commercial practices. This limits the degree to which costs from case studies can be taken to be representative of widespread implementation.

The cost-effectiveness of case studies must also be interpreted with caution. Many of the projects that have reported results and costs do so for the initial years of a project or a pilot project. As many of these projects rely on stakeholder awareness and voluntary participation the cost-effectiveness is likely to increase as participation increases and project start-up costs are no longer applicable, or could be annualised over a greater number of years. This is the case in some of the annual results and costs published. The true cost-effectiveness of a mature project may not be known nor are the economies of scale of a larger deployment of the measure.

The case studies do, however, provide some indication of costs which are then discussed in terms of wider implementation and assessed to either be low, medium or high relative to the other litter reduction measures presented. In lieu of robust cost-benefit analysis, the costs and benefits particular to each type of intervention are discussed and related to the stakeholders affected.

The objectives also include, where feasible, an estimation of the percentage reductions which could be brought about through their implementation. Such an estimate relies on three crucial pieces of information:

- The total amount of debris entering the oceans each year from fishing and aquaculture, and the amount already accumulated;
- The proportion of these figures that comes from the specific item type, source or pathway that is addressed by the measure; and
- The cost-effectiveness of the measure in reducing debris.

A quantification of debris from fishing and aquaculture is presented in section 4.2, but it was found that there are too many knowledge gaps to make accurate estimates at this time. It was therefore not possible to estimate the potential contribution to the reduction targets of each measure.

Presentation of Costs

All costs are presented in Euros at the 2015 value. Where necessary, costs have been inflated to present day values using the EU Consumer Price Index of the 1st of January on the year of the data publication and the 1st of January 2015. Where costs were published in other currencies they were first converted to Euros using historical rate tables for the 1st of January on the year of the data publication and then inflated to 2015 values. Where costs were given in direct correspondence with stakeholders they have been converted to Euros using the exchange rate of the day.

4.1 The Flow of Marine Debris

It is important to understand how marine debris is created as different measures target different sources and pathways of litter. It is also important to understand the distinction between the cumulative stock of existing litter and the inflow of new litter to this stock. This has bearing when considering what can be monitored and therefore how reduction goals will be applied and which measures will be employed to meet those goals.

4.1.1 Sources and Pathways of Litter

There are many sources of littered items originating from the fishing industry and aquaculture. The amount of material lost by each pathway and source is unknown but, as explained in the following section, some are highlighted in the literature as important in terms of:

- Tonnage thought to be lost;
- Harm caused by the litter; and/or
- Potential for mitigating action.

Some items such as nets can be worth a great deal of money and are abandoned only when they become caught on other objects making it very difficult for the owner to retrieve them. End-of-life nets on the other hand have very little value and can be difficult and costly to dispose of on land leading to burning or dumping at sea. In addition, many items are considered disposable and are lost through poor waste management. Other items are lost, or parts are lost, due to the design of the item itself.

For example, dolly rope is used to protect nets from wear and tear when trawled along the ocean floor and sheds fragments of plastic string as the nets are dragged along. Other items are lost due to operational risks such as loss of fishing gear in poor weather. Illegal, unreported and unregulated (IUU) fishing is thought to be a major contributor to abandoned, lost or otherwise discarded fishing gear (ALDFG) as those operators are unlikely to comply with regulations or apply measures to reduce losses. They are also assumed to dump illegal gear when they come under monitoring, control and surveillance. Gear conflict, i.e. one vessel's fishing gear interfering with another vessel's gear, is a commonly reported reason in surveys of fishers, but this may partly reflect their grievance with this problem which causes them considerable cost and disruption.

4.1.2 Stock vs. Inflow

It is important to distinguish between the stock of litter that already exists in the marine environment, and the inflow of litter that is added to that stock each year. Some litter reduction measures, such as litter retrieval projects, address the stock of litter and not the inflow. Other measures, such as litter prevention projects, address the inflow of litter and so affect the future stock but have no impact over the litter items already lost. The relative difference in scale of the stock and inflow of litter varies geographically and is important to consider when choosing which litter reduction measures to implement. If the inflow of litter for a pathway or region is low then the cost-effectiveness of further reducing the inflow may be limited and it may be better to address the existing stock. However, if the inflow is not low then it may be more effective in the long run to reduce the inflow given that sustained reductions will equate to significant litter reductions when projected forwards over future years.

Measures that remove debris from the marine environment address the stock of existing litter. Such measures include:

- Litter retrieval (vessels purposefully locating and removing litter);
- Litter retention (vessels retaining the litter that is caught during normal fishing operations and returning that litter to shore); and
- Gear buy-back (incentivised litter retention and responsible waste management).

These measures have a number of distinct advantages:

- The projects can reduce litter originating from a wide range of pathways and sources, including litter from other nations, if present in the marine environment; and
- The results of the projects are easy to measure as the material recovered can be analysed by item type.

Preventative measures may be more effective where the inflow of litter is relatively large. Preventative measures include:

- Gear marking
- On-board technology to avoid or locate gear
- Spatial management and zoning schemes
- Mapping and reporting navigation hazards

- Reuse, recycling and disposal
- Market-based instruments for waste management
- Industry best management practices
- Shifting consumption away from harmful products via bans or taxes
- Strengthening implementation and enforcement of legislation and agreements
- Port state control to reduce IUU fishing
- Awareness-raising

Key advantages of preventative measures are:

- Targeting schemes in order to deliver the highest cost effectiveness, for example by targeting the biggest polluters, the most commonly polluted item types or the item types that cause the most harm once littered. Targets can be adapted to local priorities.
- Litter tends to entangle more marine fauna when first lost with the effects diminishing over time. For example, nets are thought to first fill with fish then collapse resulting in a decrease in catch rate. Removing existing litter may not mitigate the majority of the impacts due to the delay between the item being lost and it being removed. Preventing litter prevents all of the potential impacts from occurring and so is more effective, all other things being equal.
- Although fishing and aquaculture litter enters the marine environment from a few point sources (vessels and aquaculture farms) it can become distributed over a large area. Locating and removing litter over a large area can be costly and so prevention of litter at source is likely to be much more cost-effective.

There are no accurate methods of directly measuring the inflow of litter from marine-based sources over a large area as most existing survey methods are more representative of the stock of litter in the ocean. Until such methods are developed it is therefore likely that targets will be set against the stock of litter present. Any reduction in stock will require a greater amount of litter to be removed from the marine environment each year than enters the marine environment. Accordingly, it would seem sensible to seek to undertake actions to minimise the inflow of litter in order to have the greatest chance of achieving an overall reduction in stock through removal activities.

4.2 Quantifying the Problem

Fishing and aquaculture can produce many different types of litter. Debris items found, and attributed to, these industries are:[260]

- Dolly ropes

---

[260] TSG ML, and JRC (2013) *Guidance on Monitoring of Marine Litter in European Seas*, 2013, https://circabc.europa.eu/d/a/workspace/SpacesStore/b627cfb6-cece-45bc-abc1-e4b3297adb91/DRAFT%20MSFD%20Monitoring%20Guidance%20TSG-ML%2011072013.pdf; www.dollyropefree.com;

- Nets
- Net repair pieces
- Oyster/mussel net
- Fishing line, monofilament line
- Rope
- Floats for fishing nets
- Buoys
- Fenders
- Strapping bands
- Fish/shellfish storage boxes
- Feed bags/boxes
- Bait containers/packaging
- Crab/Lobster pots, crates and tops
- Octopus pots
- Oyster trays
- Oyster 'sticks'
- PPE (e.g. rubber gloves, boots)
- Tags
- Plastic sheeting (e.g. from mussel culture - "Tahitians")
- Light sticks & packaging (sometimes used in conjunction with FADs)
- Fish aggregation devices (FADs)
- Fish hooks
- Bobbins (for fishing reel)
- General boat waste (e.g. Jerry cans, oil cans, buckets)
- Other fishing related items (weights, swivels, sinkers, lures, hooks)

These items can be made from different materials, some natural and some synthetic. However, there is a prevalence of plastic material used especially in objects that need to be cheap, strong and lightweight such as fishing line, fishing nets, floats, buoys and packaging. Different litter items are found in different environments due to the way in which they were littered and the properties of the object itself such as its buoyancy and disintegration rate. Domestic waste or 'garbage' will also be generated but its quantity, composition and management is not considered likely to differ from other land or sea-based sources and is therefore covered elsewhere in this study.

MacFadyen et al. (2009) compares the various estimates for the proportion of marine debris that originates from the fishing industry.[261] For example, one source estimates that the fishing and shipping industry may be responsible for between 50% to 90% of debris found on rural beaches; and a beach survey in Japan of over 35,000 objects found

[261] Macfadyen, G., Huntington, T., and Cappell, R. (2009) *Abandoned, lost or otherwise discarded fishing gear*, 2009

that between 1% and 11% of items were fishing net and gear, however 27% was polystyrene which arguably could also be associated with fishing and aquaculture industries. For the purposes of this report it is important to consider the inflow and stock of debris from countries within the European Economic Area (EEA) as alongside EU member states this group includes Iceland and Norway which account for around 40% of the fish production of the entire group and are both contracting parties of OSPAR.[262] Estimates of marine debris in the EEA presented in the report include a beach survey in the UK by the Marine Conservation Society (MCS) in which 11% of items were fishing debris (the second biggest source in their method of categorisation), and conversely a five-country UNEP survey suggested that fishing gear was relatively rarely found along beaches of the Mediterranean. We reviewed beach clean-up data with respect to at-sea sources in Section 2.6.4. The regional variability suggested by the differences in these estimates implies that this type of debris depends on local factors, most likely the level of local fishing effort and practices, relative to other sources of debris. Caution should therefore be taken when aggregating to a European or Global level. Similarly, a high degree of variability is seen in aquaculture debris. The majority of litter found in a study in Chile was polystyrene from mussel farms, and polystyrene buoys from aquaculture industries were also found to be the most common item in a beach survey in Korea.[263] [264] A different story is seen in the UK where latest MCS beach survey found that polystyrene buoys made up only 0.02% of all litter items and all polystyrene accounted for 8%.[265] Again, the variability is likely to be linked to the size of the local aquaculture industry and its practices relative to other sources of marine debris. MacFadyen et al. (2009) concludes that there is no adequate information on the global overall proportion of marine debris that is ALDFG.

Despite the lack of data it is nevertheless important to at least understand the scale of losses from the fisheries and aquaculture industry relative to each other and to marine debris in general. This can be achieved by combining information from different sources and making realistic assumptions. However, these estimates can only be considered 'ball-park' figures until they can be refined through further research.

One approach to estimating waste arisings from the fishing and aquaculture sectors is to perform a calculation based on waste generation per capita (as was done in 2.6.5). Another approach to reach an estimate of the total waste arising for the fishing and aquaculture industries is to make a calculation based on an estimate of the waste

---

[262] FAO (2012) *FAO yearbook. Fishery and Aquaculture Statistics 2012*, 2012, http://www.fao.org/3/a-i3740t/index.html

[263] Hinojosa, I.A., and Thiel, M. (2009) Floating marine debris in fjords, gulfs and channels of southern Chile, *Marine Pollution Bulletin*, Vol.58, No.3, pp.341–350

[264] Hong, S., Lee, J., Kang, D., Choi, H.-W., and Ko, S.-H. (2014) Quantities, composition, and sources of beach debris in Korea from the results of nationwide monitoring, *Marine Pollution Bulletin*, Vol.84, No.1-2, pp.27–34

[265] 2014 Marine Conservation Society Great British Beach

produced per tonne of fish farmed or captured and scaled to the EEA level. If the estimate includes operational losses, regarded at present as 'unavoidable', they would be subtracted, where known, to calculate the amount of waste requiring active management by the industry. If the estimate does not include operational losses, this would have to be added in order to understand the total waste generated. It is not known what proportion of the waste which is not lost at sea is illegally dumped at sea, and so an assumption is made based on littering and flytipping behaviour seen on land. This provides a conservative estimate of intentional dumping as the nature of the waste and operational practices mean that waste management is more demanding in the marine environment, and therefore arguably a greater proportion is likely to be dumped at sea. The figures used to derive these estimates are explained below.

Two estimates exist for waste arisings from fisheries in Norway: 22,000 tonnes of plastic waste (potentially including packaging and 'non-gear' waste), and 2,000 tonnes of plastic from fishing nets and trawl equipment. [266] [267] The method used to derive the first estimate is not explained. The second of the two estimates is based on consultation with manufacturers and waste management companies in 2011 and so is assumed to be the more accurate and recent figure; however the degree to which littered objects are accounted for is uncertain as the figure is derived from sources at different ends of the product life-cycle. The 2,000 tonne figure equates to roughly 0.2 tonnes per fisher or 1kg per tonne of output production (fish, crustaceans, etc.).[268] A study for the Icelandic Recycling Fund calculated the quantity of fishing gear waste by material type for different fishing methods.[269] The study estimated around 2,800 tonnes of fishing gear waste is generated per annum, more waste than estimated in Norway despite the Icelandic industry being smaller. We conservatively use the smaller Norwegian figure to estimate EEA waste arisings. Plastic waste from aquaculture gear (livestock rings, feed pipes, breeding nets, ropes and floats) is estimated to amount to 13,500 tonnes per annum in Norway; roughly 2.3 tonnes per employee or 11kg per tonne of output production.[270]It is reasonable to assume that the quantity of waste produced is directly related to the level of fishing and farming effort, for which output production figures can be used as an approximation. If the Norwegian estimate is representative of the industry as a whole this equates to somewhere in the region of 7,000 tonnes of plastic fishing waste and 30,000 tonnes of plastic aquaculture waste in the EEA based on FAO output production figures. Waste items of other materials are currently unquantified.

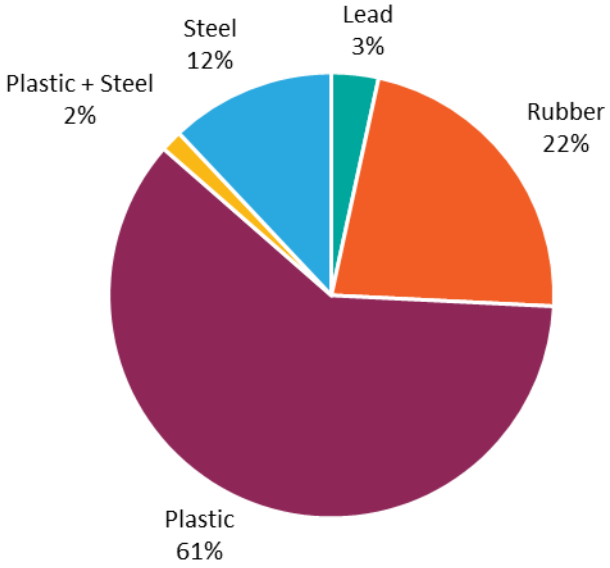
---

[266] Ove D. Jakobsen, and Øystein Nystad (2010) *Collaborative Waste Management*, 2010
[267] MEPEX (2013) *Økt utnyttelse av ressursene i plastavfall*, March 2013
[268] FAO *World fisheries production, by capture and aquaculture, by country*, 2013
[269] Unpublished. Data taken from presentation Guðlaugur Gylfi Sverrisson (2014), *Marine litter – monitoring and management in the Nordic context*
[270] The Norwegian Ministry of Trade, Industry and Fisheries *Aquaculture*, accessed 4 September 2015, http://www.fisheries.no/aquaculture/Aquaculture/#.VenkWfmnTX-

The study on the quantity of fishing gear waste generated in Iceland shows that plastics dominate the waste stream and that rubber and steel are also major fractions. The study also showed that different fishing methods produce quite different compositions of waste, and different quantities of waste per tonne of catch as shown in Figure 26, and so the overall composition of the waste stream in any region will depend on the mix of fishing methods employed.[271]

As the composition of fishing gear waste in the EEA is not known we use the Icelandic composition to calculate how much non-plastic waste is generated. The plastic composition of aquaculture waste is assumed to match that of the debris found in marine debris surveys (by item count).[272] Total waste generated is therefore in the region of 12,000 tonnes for the fishing industry and 41,000 tonnes for aquaculture.

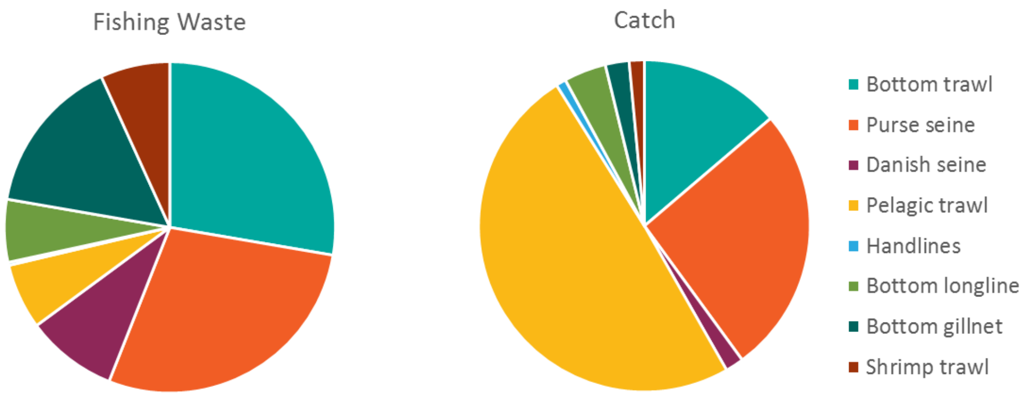
Figure 25. Composition of Fishing Gear Waste in Iceland



[271] Statistics Iceland (2004) *Catch, value and processing of catch 2003*, July 2004

[272] An average was taken from the proportion of plastic found *by item count* in three different types of survey: 68% in MCS Great British Beach Clean 2014, 64% Dive Against Debris, 84% 2015 Dutch International Bottom Trawl Survey.

Figure 26. Icelandic Fishing Gear Waste and Catch by Weight, circa 2003



The literature currently only provides information on operational losses from gillnets, which are likely to be a major, if not the major, loss in this area; as well as threads unavoidably lost from dolly rope. Estimates of accidental operational losses in gillnet fisheries in the north east Atlantic, are shown in Table 15. These estimates were first concisely summarised in Brown and MacFadyen (2007) following estimates of losses derived from interviews with fishermen in the FANTARED 2 project (2003) and have since been used in many papers summarising losses such as World Animal Protection (2015), and further detail was added in MacFadyen et al. (2009) report to UNEP FAO on ALDFG.[273] [274] [275] [276] Brown and MacFadyen (2007) first commented that the fisheries studied "include most of the major net fisheries in Europe", but this is later clarified in MacFadyen et al. (2009) which comments that, alongside being potentially outdated information, the fisheries represent only a small fraction of gillnet fisheries in the whole north east Atlantic region. In lieu of any more recent or more comprehensive estimates these figures are used for estimates of accidental operational losses. The weight of the nets will vary by their type and by the weights, lead lines or frame ropes used to weigh them down. For simplicity, 1 km of gillnet is assumed to weigh roughly 0.88 tonnes.[277] The total estimated losses are then in the order of 927 tonnes of net lost per year for the fisheries presented.

---

[273] Brown, J., and Macfadyen, G. (2007) Ghost fishing in European waters: Impacts and management responses, *Marine Policy*, Vol.31, No.4, pp.488–504

[274] EC contract FAIR-PL98-4338 (2003) *FANTARED 2 - A study to identify, quantify and ameliorate the impacts of static gear lost at sea*, 2003

[275] World Animal Protection (2015) *Fishing's Phantom Menace. How Ghost Fishing Gear is Endangering Our Sea Life*, 2015, http://www.worldanimalprotection.org.uk/sites/default/files/uk_files/documents/sea-change-tackling-ghost-fishing-gear-summary.pdf

[276] Macfadyen, G., Huntington, T., and Cappell, R. (2009) *Abandoned, lost or otherwise discarded fishing gear*, 2009

[277] 50 m of Spanish monkfish net weights 44 kg: The Scientific, Technical And Economic Committee for Fisheries *Deep-sea Gillnet Fisheries*

Table 15. Summary of Estimations of Net Loss in Selected Continental Shelf Fisheries in the North East Atlantic[278]

Fishery	Length of net lost (km)	Number of nets lost
Baltic (Sweden)	156	1,448
North Sea & NE Atlantic (Norway)*	69	685
UK (all coastal fisheries)	36	325
English Channel and North Sea (France)	8	
Brittany (France)	6	
Cantabria (North Spain)*	606	6,064
Algarve (Portugal)*	160	16
Mediterranean (France)**	13	
Total	*1,053*	

Note: for fisheries marked with an asterisk (*) the estimated length of ghost nets/year was not available and so figures have been estimated from the number of nets lost, assuming an average net length of 100m. The method was partially applied to fill gaps for the French Mediterranean, marked (**).

Brown and MacFadyen (2007) also presents an estimate of 1,254 km of net lost in deep water net fisheries in the north east Atlantic, citing the FANTARED 2 report by Hareide et al. (2005).[279] This figure is considerably larger than the total losses of the other individual fisheries studied, and equates to roughly 1,104 tonnes of net lost per year.[280] MacFadyen et al. (2009) explains that the calculation uses anecdotal evidence from one shark vessel that suggests 30 km of net is routinely discarded due to damage on a typical

[278] After: Macfadyen, G., Huntington, T., and Cappell, R. (2009) *Abandoned, lost or otherwise discarded fishing gear*, 2009

[279] Hareide, N.R., Rihan, D., Mulligan, M., et al. (2005) A preliminary Investigation on Shelf Edge and Deepwater Fixed Net Fisheries to the West and North of Great Britain, Ireland, around Rockall and Hatton Bank., 2005, http://brage.bibsys.no/xmlui/handle/11250/103720

[280] Brown, J., and Macfadyen, G. (2007) Ghost fishing in European waters: Impacts and management responses, *Marine Policy*, Vol.31, No.4, pp.488–504

45-day trip[281] and the level of the fishing effort is in the region of 1,881 days. This figure therefore relates to intentional dumping activities rather than accidental operational losses. Furthermore, Brown and MacFadyen (2007) notes that the European Commission introduced a temporary ban of gillnet fishing below 200m in this area from February 2006 to address the threat that net loss and dumping pose to deep sea species. The North East Atlantic Fisheries Commission (NEAFC) extended the ban to its Regulatory Area, and in 2006 the European Commission revised the measure to include a permanent ban on all deep water gillnet fisheries at depths below 600m and imposing limits on the length of nets deployed and soak time in the remaining fisheries of depths less than 600m.[282] The deep water losses presented cannot therefore be included in estimates of current annual losses but if accurate may be indicative of historic dumping, from when the deep water fisheries were developed around the mid-1990s, and of large losses in deep water gillnet fisheries elsewhere in the world. The figure also indicates that some fishers were willing to dump significant quantities of gear into the ocean when it became unfit for further use.

Other losses reported in the literature are small in weight by comparison. Dolly rope is used to protect trawl nets as they are dragged over the ocean floor but results in small plastic threads being torn off and lost into the marine environment. It is estimated that 15 to 25 tonnes of plastic a year is lost in this way.[283] Less research has been conducted on other fishing items or debris from aquaculture and so there is no basis on which to form quantitative estimates of losses. Pots and traps may be important in some areas, however studies of Portuguese and UK fisheries found losses to be minimal due to low loss rates and high retrieval rates.[284] However, this area requires further research, especially in the context of the large amount of waste potentially produced by the aquaculture industry, and this will aid in refining the estimates presented here.

Losses are reported in both sectors due to poor waste management practices. Fishing items can be washed overboard especially when left on deck or the harbour wall. This often includes waste items such as pieces of rope and net sections that have been removed, and packaging such as bait boxes. The quantity of losses is unknown. Losses are also reported in the Norwegian aquaculture industry when waste items such as fish farming rings and feed pipes are offered to members of the local community for reuse. [285]These are large items (10 to 15 tonnes of plastic) and may be attractive to community members for a range of purposes such as construction. However, recipients of the waste

[281] The source of this anecdotal evidence is unclear as it is not presented in Hareide et al. (2005).
[282] Large, P.A., Graham, N.G., Hareide, N.-R., et al. (2009) Lost and abandoned nets in deep-water gillnet fisheries in the Northeast Atlantic: retrieval exercises and outcomes, *ICES Journal of Marine Science: Journal Du Conseil*, Vol.66, No.2, pp.323–333
[283] *DollyRopeFree*, accessed 27 July 2015, http://www.dollyropefree.com/
[284] Brown, J, G. Macfadyen, T. Huntington, J. Magnus and J. Tumilty (2005) *Ghost Fishing by Lost Fishing Gear*, Report for DG Fisheries and Maritime Affairs of the European Commission, 2005
[285] Personal communication with Peter Sundt, Mepex Consult

items can store them for long periods on the harbour wall leading to losses in stormy weather. Again, there is insufficient information to estimate the quantities lost.

It is not known what proportion of fishing and aquaculture waste is intentionally dumped at sea, and so a realistic estimate must be made. For land-based waste Jambeck et al. (2015) assumes 2% is littered, based on data from the United States.[286] Translated to the marine environment this is likely to be a very conservative figure as the difficult nature of the waste, the ease of the act of dumping waste at sea unobserved, the lack of accountability, and a historic culture of such activity mean that dumping behaviour is much more likely at sea than on land. Intentional dumping is also likely to be of large items such as nets and pots which are difficult to dispose of on land. These items are a few orders of magnitude heavier than most other waste items and so the proportion *by weight* of waste dumped will therefore be high relative to the number of *incidents* of dumping. Furthermore, dumping need not be universal for it to be significant in terms of material lost and so dumping activities by a small number of vessels may contribute large quantities of debris, as shown in the figures of historic dumping activities in selected deep water fisheries in the north east Atlantic presented in Brown and MacFadyen (2007). We therefore assume a further 5% of waste is intentionally dumped at sea. This would mean around 800 tonnes of fishing waste and 3,000 tonnes of aquaculture waste are dumped at sea every year**.**

A summary of the estimates of marine debris originating from the fishing and aquaculture industries is presented in Table 16. Unfortunately, there are currently too many knowledge gaps to be able to estimate an accurate figure of total losses from the fishing and aquaculture industries. Using the estimates in Table 16 as a lower bound and total waste arisings as the upper bound, debris inflow may be in the order of **1,700 to 12,000 tonnes of fishing waste** and **3,000 to 41,000 tonnes of aquaculture waste per annum.** As explained above, these are first approximations using the available research and bridging information gaps with reasonable assumptions. As such the values should be refined in future work but can currently be used to understand the range of magnitude of the debris from these industries entering the marine environment each year. An estimated 68,500 to 275,000tonnes of plastic enters the marine environment each year in the EU from all sources.[287] Assuming, as reported in survey data, that plastics account for around 72% of all marine debris gives a total of **between 95,000 tonnes and 383,000 tonnes per annum of marine debris**.[288] The degree of uncertainty in the estimates of marine debris from all sources and the quantities from fishing and aquaculture prevent any further comparison.

---

[286] Jambeck, J.R., Geyer, R., Wilcox, C., et al. (2015) Plastic waste inputs from land into the ocean, *Science*, Vol.347, No.6223, pp.768–771

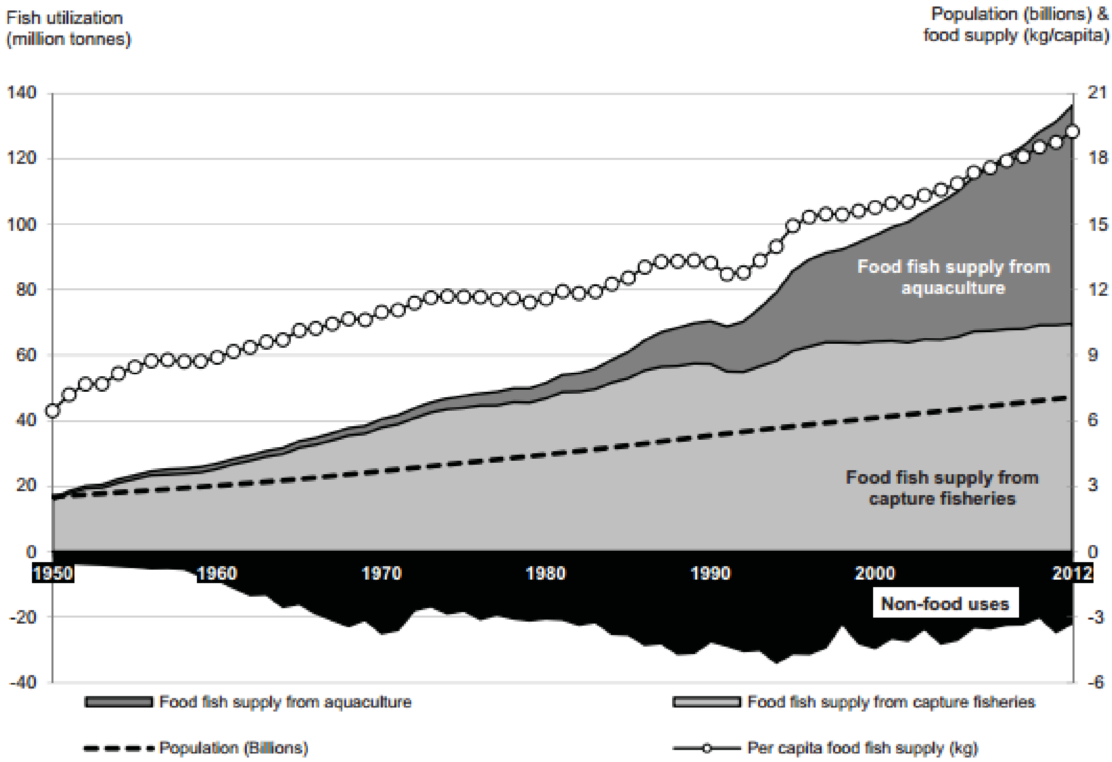
[287] See Table 27 – Summary of Secondary Plastic Flow Estimates in Task 2 of this study.

[288] An average was taken from the proportion of plastic found *by item count* in three different types of survey: 68% in MCS Great British Beach Clean 2014, 64% Dive Against Debris, 84% 2015 Dutch International Bottom Trawl Survey.

Table 16. Estimates of Annual Losses, in tonnes, from Fishing and Aquaculture Industries in the EEA

	Fishing	Aquaculture	Notes
Operational losses: Gillnets	At least 927	-	Fisheries studied potentially represent only a small fraction of all European fisheries.
Operational losses: Dolly rope	20	-	Creates many items of plastic string debris.
Other operational losses	Unknown	Unknown	Other losses include: other types of net, pots and traps, and smaller items such as strapping bands and fish boxes.
Losses from poor waste management	Unknown	Unknown	E.g. items washed overboard on ships. Aquaculture waste is reportedly lost when given away for reuse and left unsecured at ports and harbours.
Dumping of waste	786	2,870	Based on estimates of waste arisings of which 7% is assumed to be intentionally dumped.
Sum of estimates presented	*1,733*	2,870	

Figure 27. Evolution in Global Fish Supply[289]



The global supply of fish, shown in Figure 27, has increased dramatically since the 1950s, with an increasing proportion supplied from aquaculture. The total stock of the debris accumulated over this period can be estimated by applying the estimates of current annual inputs to the historic trend in industry growth. In the estimate of the lower bound we assume that waste management practice has improved considerably over this period and that the current rate of dumping is a third of the level in 1990. We also include an estimate for intentional dumping of gillnets in deep water fisheries in the north east Atlantic following Brown and MacFadyen (2007), discussed above. On that basis, **the total accumulated stock of debris in the EEA may be in the order of 130,000 to 550,000 tonnes from the fishing industry and 95,000 to 655,000 tonnes from aquaculture**.

4.3 Location of Industry

The amount of this gear that is lost to the marine environment will depend on various factors such as:

- The size of fishing and aquaculture industries;
- Operational practices and type of gear used;

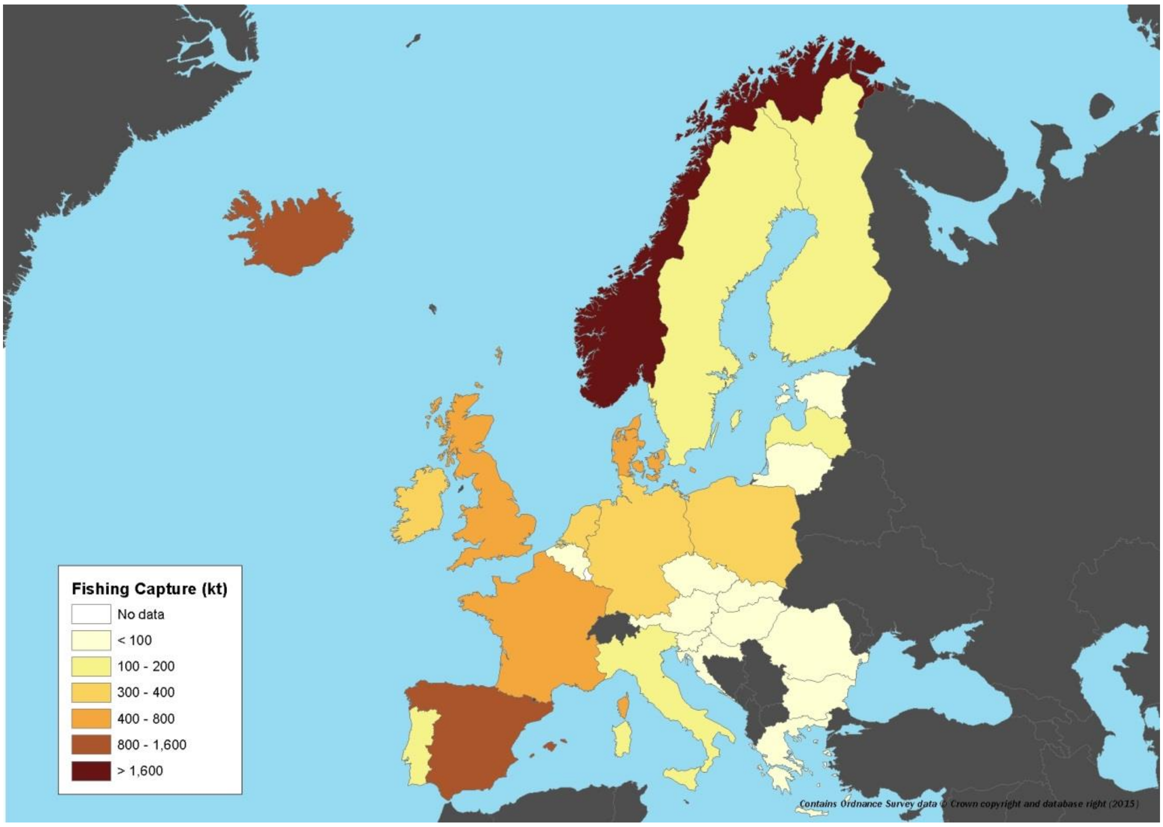
[289] FAO *Fishery and Aquaculture Statistics Yearbook*, 2012

- Waste management practices;
- Adequacy, availability and affordability of waste disposal;
- Market structure and dynamics, e.g. number and size of operators, competitiveness; and
- Strength of regulation and enforcement.

Each of these factors will vary by location and the relationship between them is complicated. For example, areas with a larger industry will use more gear and generate more waste, but conversely may have better operational and waste management practices, and stronger regulation and enforcement of malpractice. The level of accidental loss and intentional dumping is likely to be much higher in some areas than in others, but there is currently insufficient data to understand regional variation and the drivers behind it. Output production figures for fishing and aquaculture are published on a national level by the FAO, providing the first step to identifying regional sources of debris and where litter reduction measures may be targeted, the key contributors being those with a combination of large industries and a high rate of gear loss.

The size of the national fishing industries within the EEA in terms of weight of catch (fish, crustaceans, molluscs, etc.) is shown in Figure 28. Please note that colours used to present the results do not represent equal bands on the scale, rather each band is twice the size of the previous one. This is to provide greater definition at the lower end of the scale where the majority of countries are located. Three countries dominate fishing in terms of weight captured. Norway has by far the largest production with just over 2 million tonnes in 2013, and the next two largest producers are Iceland (1.4 million tonnes) and Spain (1.0 million tonnes), followed by Denmark (0.7 million tonnes), the U.K. (0.6 million tonnes), France (0.5 million tonnes) and the Netherlands (0.3 million tonnes).

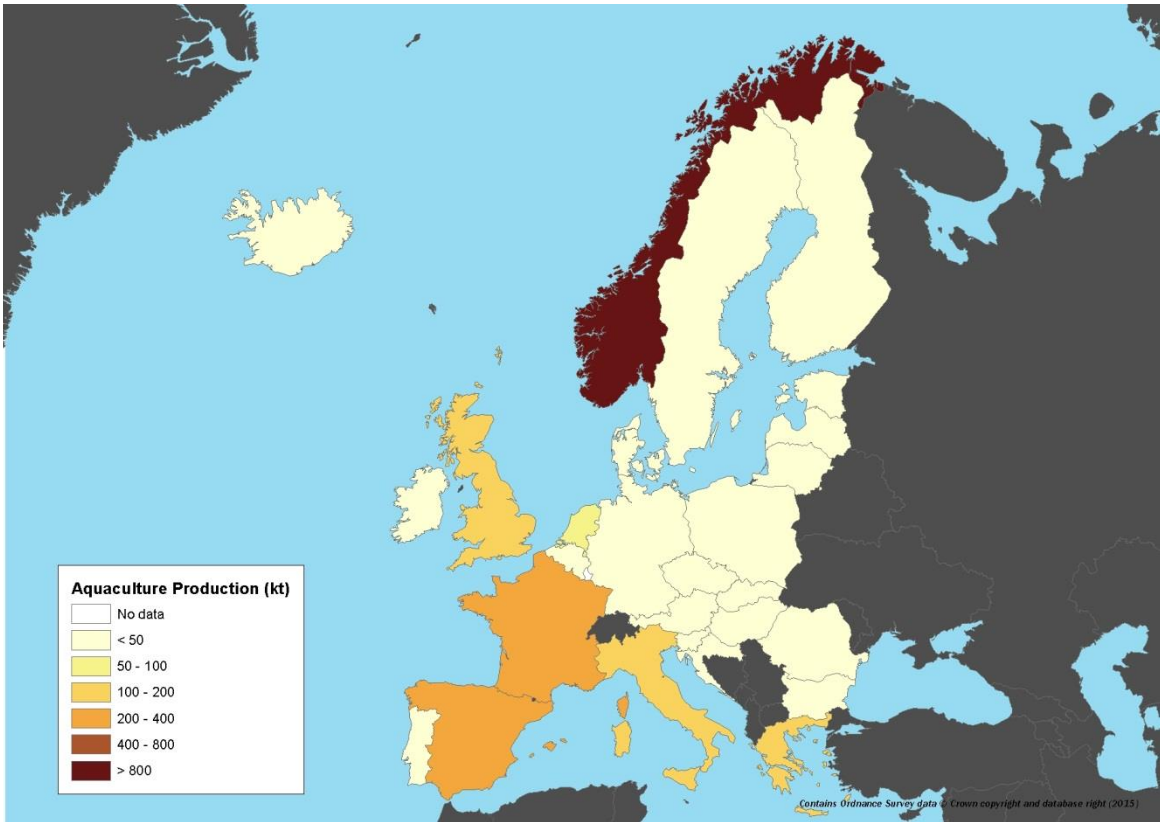
Figure 28: Fisheries production by capture, 2013[290]



The size of aquaculture industries within the EEA in terms of weight of production (fish, crustaceans, molluscs, etc.) is shown in Figure 29. Note that aquaculture generally produces less than fishing captures and so the scale of the coloured bands in Figure 29 has been reduced accordingly. Norway has by far the largest production with 1.2 million tonnes in 2013, equal to the collective production of all other countries shown. The next largest producers are fairly closely grouped; namely Spain (224 kilotonnes), France (202 kilotonnes), the U.K. (195 kilotonnes), Italy (162 kilotonnes), and Greece (145 kilotonnes).

[290] Food And Agriculture Organization Of The United Nations *World fisheries production, by capture and aquaculture, by country (2013)*. No data was available for Liechtenstein, and Luxembourg, but they are not expected to have large industries. Malta and Cyprus, not shown on the map, account for 2 kt and 1 kt of capture accordingly.

Figure 29: Aquaculture production by capture, 2013[291]



4.4 Litter Reduction Goals

Litter reduction goals exist at different levels across the EEA. This study will review two key targets in the European context: the target set out in the European Commission's communication on the circular economy package and the action set out in the OSPAR Regional Action Plan.

4.4.1 Circular Economy Package Target

The European Commission published a communication in 2014 entitled "Towards a circular economy: A zero waste programme for Europe". The strategy it set out, known as the circular economy package, is currently being revised and is due to be presented in late 2015 according to the Commission. The 2014 communication stated that:[292]

---

[291] Food And Agriculture Organization Of The United Nations *World fisheries production, by capture and aquaculture, by country (2013)*. No data was available for Liechtenstein, and Luxembourg, but they are not expected to have large industries. Malta and Cyprus, not shown on the map, account for 4 kt and 5 kt of aquaculture production accordingly.

[292] European Commission (2014) Towards a Circular Economy: A zero Waste Programme for Europe. COM(2014)398

To address specific waste the Commission:

- proposes an aspirational target of reducing marine litter by 30 % by 2020 for the ten most common types of litter found on beaches, as well as for fishing gear found at sea, with the list adapted to each of the four marine regions in the EU

As already mentioned, this target is likely to be measured using monitoring of the stock of litter in the marine environment, and will therefore require a negation of the annual inflow of litter in addition to further removal of litter from the stock in order to produce a measurable reduction. It will not be possible to reach this target by preventative measures alone as they have no impact upon the existing stock of litter in the oceans. Measures that address the stock of litter such as litter removal or litter retention will therefore be a requirement.

However, if only measures addressing the stock of litter are employed then these measures will have to remove a quantity of litter equal to the inflow each year just to reach steady state and prevent the stock of litter from growing. Therefore where the inflow of litter is large, it may be most cost-effective in the long-term to address the inflow of litter first via preventative measures. The balance and timing of different measures will largely depend on regional and local factors that will be decided by Member States and reassessed as they progress towards the targeted levels of litter reduction.

It will be important to understand whether the target refers to a 30% reduction by item count or weight or volume or even another metric such as incorporating the potential harm caused by the litter. If measured by item count then measures to reduce small and abundant litter items such as small pieces of string, plastic and polystyrene may produce the biggest impact. However, if measured by weight then it may be more cost-effective to target items that are relatively less common but much heavier, such as whole nets. Surveys generally record item counts as the other metrics are considerably harder to measure. However the MSFD Technical Subgroup on Marine Litter (TSG ML) has identified the need to develop a table with conversion factors from number of items to weight of items, which enables simple weight estimates, and the need for further research into the harm caused by marine litter and to develop indicators of that harm, which could lead to the adoption of different metrics.[293]

Further work will be required to resolve these issues and define a target under conditions that can be monitored accurately and is representative of wide-scale reductions in litter.

---

[293] TSG ML (2011) *Marine Litter - Technical Recommendations for the Implementation of MSFD Requirements*, Report for JRC-IES, 2011, http://books.google.be/books/about/Assessing_potential_ocean_pollutants.html?id=klYRAAAAYAAJ&redir_esc=y

4.4.2 OSPAR Action

Under the heading “Incentives for responsible behaviour/disincentives for littering”, the OSPAR Regional Action Plan for Prevention and Management of Marine Litter in the North-East Atlantic, known as OSPAR RAP ML, sets out the collective action (number 35) as follows:[294]

> *Identify the options to address key waste items from the fishing industry and aquaculture, which could contribute to marine litter, including deposit schemes, voluntary agreements and extended producer responsibility*

The document defines this as a collective action requiring joint regional effort and one that will be developed and implemented by the OSPAR Contracting Parties acting collectively within the framework of the OSPAR Commission. The Contracting Parties are comprised of the fifteen following governments: Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom, together with the European Union.

Key waste items may refer to those most prevalent in the marine environment (by item count, weight or volume) or those that cause the most harm. The lack of specificity means that litter reduction options may focus on any of these aspects as best fits the local situation. The OSPAR Commission is concerned with the protection of the marine environment of the North-East Atlantic and so the key items for this region must be considered. In this context the survey results in Section 4.5 are highly relevant. It is also thought that a large number of gillnets are lost or dumped in certain deep water fisheries in the North East Atlantic.[295]Debris accumulates due to losses from gear conflict exacerbated by long soak times, and dumping of nets where vessels have no capacity to carry to them to shore. The scale of the total losses and discards is unknown but anecdotal evidence suggests up to 30kms of gear are routinely discarded per vessel per trip, with up to 50 vessels operating in the area and trip lengths varying between 4 - 8 weeks.[296] In fact, losses were estimated to total 25,080 nets lost every year (1,253km of net) in 2005, although a temporary ban on deep water gillnet fishing was implemented in 2006 to address the issue.[297] [298] With such a large quantity of gillnet losses identified

---

[294] OSPAR Commission (2014) *Regional Action Plan for Prevention and Management of Marine Litter in the North-East Atlantic*, 2014, https://www.cbd.int/doc/meetings/mar/mcbem-2014-03/other/mcbem-2014-03-140-en.pdf
[295] Brown, J., and Macfadyen, G. (2007) Ghost fishing in European waters: Impacts and management responses, *Marine Policy*, Vol.31, No.4, pp.488–504
[296] MARELITT (2013) *Pilot project:removal of marine litter from Europe’s four regional seas - Assessment Report*, December 2013
[297] Hareide, N.R., Rihan, D., Mulligan, M., et al. (2005) A preliminary Investigation on Shelf Edge and Deepwater Fixed Net Fisheries to the West and North of Great Britain, Ireland, around Rockall and Hatton Bank., 2005, http://brage.bibsys.no/xmlui/handle/11250/103720
[298] Brown, J., and Macfadyen, G. (2007) Ghost fishing in European waters: Impacts and management responses, *Marine Policy*, Vol.31, No.4, pp.488–504

in the North-East Atlantic it would be logical for these nets to be included as a key item in the OSPAR action.

4.5 Litter Composition and Monitoring Methods

In undertaking action to reduce litter from the fisheries and aquaculture sectors it is important to understand the key debris items. Indeed the OSPAR RAP ML action 35 specifically mentions that the options should address such key items. Key items are often identified as those most prevalent in the marine environment. Not many survey results are reported on a per item basis, but are instead aggregated by material type or presumed source. However, MCS beach survey data does contain this detail and a report on the Dutch portion of the international bottom trawl survey results can also be used for this purpose. Both datasets are from the OSPAR region and match the types of surveys identified in the MSFD and OSPAR monitoring requirements. These considerations and the results of the surveys are discussed below in order to identify some of the key waste items from the fishing and aquaculture industries.

4.5.1 Monitoring Requirements

It is important when considering litter reduction to employ a monitoring regime that accurately and comprehensively reflects litter levels throughout the marine environment, taking account of spatial variability. Criteria and methodological standards on good environmental status of marine waters, with regards to the Marine Strategy Framework Directive (2008/56/EC), are set out in Commission Decision 2010/477/EU. The criteria and indicators relating to marine debris are given under Descriptor 10:[299]

> *Descriptor 10: Properties and quantities of marine litter do not cause harm to the coastal and marine environment.*
>
> *The distribution of litter is highly variable, which needs to be taken into consideration for monitoring programmes. It is necessary to identify the activity to which it is linked including, where possible, its origin. There is still a need for further development of several indicators, notably those relating to biological impacts and to micro-particles, as well as for the enhanced assessment of their potential toxicity.*
>
> *10.1. Characteristics of litter in the marine and coastal environment*
>
> - *Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source (10.1.1)*

---

[299] European Commission (2010) Commission Decision of 1 September 2010 on criteria and methodological standards on good environmental status of marine waters (notified under document C(2010) 5956)

- *Trends in the amount of litter in the water column (including floating at the surface) and deposited on the seafloor, including analysis of its composition, spatial distribution and, where possible, source (10.1.2)*
- *Trends in the amount, distribution and, where possible, composition of micro-particles (in particular microplastics) (10.1.3)*

10.2. Impacts of litter on marine life

- *Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis) (10.2.1).*

This indicator needs to be developed further, based on the experience in some sub-regions (e.g. North Sea), to be adapted in other regions.

Descriptor 10 suggests that Member States will be expected to monitor:

1) Litter washed ashore (e.g. beach litter);
2) Litter in the water column;
3) Litter floating at the surface;
4) Litter deposited on the seafloor;
5) Micro-particles, in particular microplastics; and
6) Litter ingested by marine animals.

Monitoring activities 1 to 4 above are the most relevant for litter that can be positively identified as fishing gear or originating from fishing and aquaculture industries. These types of litter can form microplastic particles through degradation and these particles and other small litter items can be ingested by marine animals. However, litter identifiable as originating from fishing and aquaculture industries tends to be relatively large in size and when degraded into smaller particles (such as strands of rope, bits of polystyrene, and plastic fragments) the source of the litter can be harder to identify. Although reductions in these types of litter can contribute to targets measured using monitoring activities 5 and 6, unless the fraction originating from fishing and aquaculture industries can be identified these monitoring activities are less relevant for measuring progress towards targets set specifically for litter from fishing and aquaculture industries. If the EC target and OSPAR action are to be monitored using the criteria and indicators of Description 10 of Commission Decision 2010/477/EU it is most likely that they will be monitored:

- At the shoreline (e.g. beaches);
- In the water column;
- Floating at the surface; and
- At the seafloor.

Below we look at results from an established beach litter survey and a bottom trawl survey. These monitoring methods are regarded by the MSFD Technical Subgroup on Marine Litter (TSG ML) as having a high and medium/high level of maturity and a high and medium level of detail generated respectively.[300] They are therefore amongst the most appropriate for baselining and monitoring for targets at present.

OSPAR has adopted beach litter as a common indicator, and ingestion in fulmars as a common indicator in the Greater North Sea (other species are candidate indicators in other areas). Seafloor litter is also a candidate indicator. Common indicators are the most broadly adopted by Contracting Parties and are to be included in the next Joint Assessment and Monitoring Programme. Candidate indicators support monitoring commitments and requirements of Contracting Parties.[301] The advice document issued by OSPAR on marine litter for MSFD descriptor 10 shows that there is a high level of consensus between Contracting Parties for monitoring beach litter by item count using the OSPAR Beach Litter Monitoring Programme as a GES indicator. When the report was published nine of the twelve Contracting Parties were already engaged in beach litter surveys.

Item counts from bottom trawl surveys of the sea floor also had a high level of consensus for use as a GES indicator, and five of the twelve Contracting Parties were involved in the existing monitoring programmes. We therefore conclude that beach surveys and bottom trawl surveys will be important methods of monitoring marine debris in future OSPAR litter reduction action. Surveying litter by weight is only mentioned for litter ingested by animals, such as that found in the stomachs of fulmars. The lack of understanding around the harm caused by populations of litter and individual litter items is highlighted as a factor in the difficulty in setting targets.[302]

4.5.2 Beach Surveys

Beach Survey Results

Beach surveys are the most common type of marine litter survey and are often combined with clean-up events. Several organisations co-ordinate international beach litter surveys within Europe including OSPAR and the Ocean Conservancy.

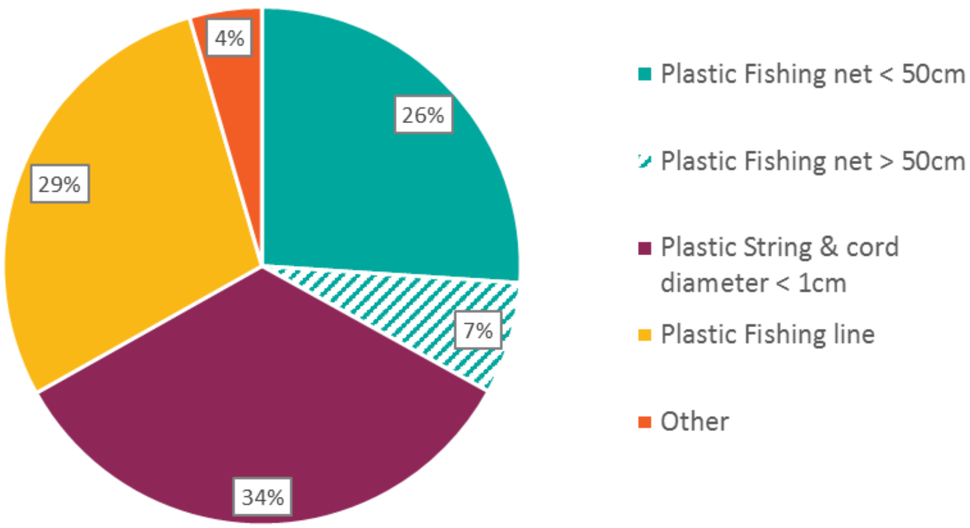
[300] TSG ML, and JRC (2013) *Guidance on Monitoring of Marine Litter in European Seas*, 2013, https://circabc.europa.eu/d/a/workspace/SpacesStore/b627cfb6-cece-45bc-abc1-e4b3297adb91/DRAFT%20MSFD%20Monitoring%20Guidance%20TSG-ML%2011072013.pdf

[301] TSG ML, and JRC (2013) *Guidance on Monitoring of Marine Litter in European Seas*, 2013, https://circabc.europa.eu/d/a/workspace/SpacesStore/b627cfb6-cece-45bc-abc1-e4b3297adb91/DRAFT%20MSFD%20Monitoring%20Guidance%20TSG-ML%2011072013.pdf

[302] OSPAR Commission (2012) *MSFD Advice document on Good environmental status - Descriptor 10: Marine Litter*, January 2012, http://ospar.org/documents/dbase/publications/p00585/p00585_advice_document_descriptor_10_marine%20litter.pdf

The MCS organises a beach litter survey and clean-up event every year in the UK. In 2014 this event was called the Great British Beach Clean. MCS provided the item count for the 2014 event, which can be analysed by individual item type and source. The item types used to classify the litter match those used in OSPAR litter surveys and the results feed into the Ocean Conservancy's International Coastal Clean-up. Each of the item types is attributed to one of the following sources (a one to one mapping): Public, Fishing, Sewage Related Debris (SRD), Shipping, Fly Tipped, Medical or Non-sourced. Fishing litter accounts for 11% of the total item count in the 2014 Great British Beach Clean, although 40% of litter items were classified as non-sourced which includes *inter alia* plastic pieces, various polystyrene items and lightweight rubber gloves and so presumably some of this will originate from fishing and aquaculture litter. Of the items in the survey attributed to fishing litter, plastic fishing nets are split into two size fractions: pieces small than 50 cm and pieces larger than 50cm. When the two fractions are combined, plastic fishing net is shown to be the joint most commonly found fishing litter item, as shown in Figure 30. Many of the smaller pieces of net found on beaches are thought to be discarded during net repair at the quayside.[303]

Figure 30. Major types of fishing litter found during MCS Great British Beach Clean 2014



The 'other' category consists of the items: Metal Fishing weights / hooks / lures (1.1%), Plastic Floats (Fishing / buoys) / Reels (1.0%), Rubber Gloves (heavy duty) (0.7%), Plastic Fish boxes (0.3%), Plastic Lobster / crab pots / tops (0.3%), Rubber Boots (0.3%), Rubber Tyres with holes (0.2%), Polystyrene Fish boxes (0.2%), Polystyrene Buoys (0.2%), Metal Lobster / crab pots / tops (0.1%), Wood Lobster / crab pots / tops (0.04%).

[303] Stakeholder interview.

The MCS beach survey results indicate that only a small portion of beach litter can be directly attributed to fishing litter. Of course this will vary depending on how the source of an item is identified. Arguably some of the items classified as non-sourced will originate from fishing industries and not all of the plastic string and cord of diameter less than 1cm will necessarily be fishing litter, as is the case with the MCS classification. A more thorough analysis of each item found may add clarity to this issue. If only a small quantity of fishing litter is found on beaches then it may be difficult to measure progress made towards targets.

Beach Survey Variability

The survey results for the 2014 MCS Great British Beach Clean show a high degree of spatial variability both in the quantity of the litter found and the composition. The map in Figure 31 shows that twice as many litter items can found per km in one beach compared to another survey site located close by. At a national scale the item count data reveals that fishing litter varies in England, Wales, Scotland and Northern Ireland between 7% and 15% of the total litter, and is the second most common source of litter identified in all countries except Scotland, as shown in Figure 32.

Figure 31. Spatial variability of litter found during MCS Great British Beach Clean 2014[304]

[304] Marine Conservation Society *Great British Beach Clean 2014 Report*, http://www.mcsuk.org/downloads/pollution/beachwatch/latest2015/MCS_GBBC_2014_Report.pdf

Figure 32. Major sources of litter in UK countries found during MCS Great British Beach Clean 2014

Note: excluded source categories are 'fly tipped' and 'medical' which range from 0.03% to 2% of litter nationally.

4.5.3 Bottom Trawl Surveys

Bottom Trawl Results

The international bottom trawl survey (IBTS) is a well-established protocol that is used in trawling programs for the assessment of fish stocks and includes an element of litter monitoring. In the Dutch 2015 IBTS Q1 survey results 302 (83.8%) of litter items caught were plastic. The composition of the plastic items, by item type is shown in Figure 33. The figure shows that plastic litter items were dominated by synthetic rope and plastic sheet. Three quarters of items found were classified as smaller than 25cm^2. Only 5 items were classified as fishing net and these were all less than 1 kg.

The associated report concludes that the net used in the trawls has only a small chance of catching a litter item when it is presented in the trawl path, and that the likelihood varies with the litter item type and size of the item. Clearly this is a problem if trawl results are to be used to understand the relative prevalence of different item types. The report focuses on the catchability issues of small sized items but the method could equally under-represent large items. The composition by object size of litter caught in the trawl, shown in Figure 34, indicates that very few items greater than 400cm^2 were found. Further investigation is required to determine whether large items were not present in the survey area or whether this result is due to the survey method.[305]

[305] IMARES (2015) *Sea floor litter monitored using catches of the International Bottom Trawl Survey*, June 2015

Figure 33. Composition litter category plastic, Dutch 2015 IBTS Q1. Values are the absolute number of items for the categories containing more than 1% of the items.

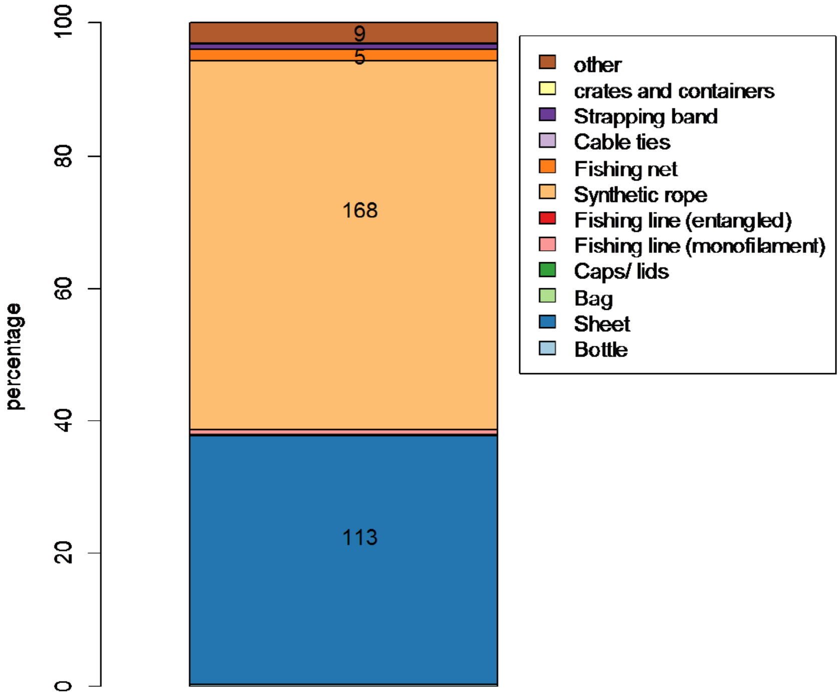
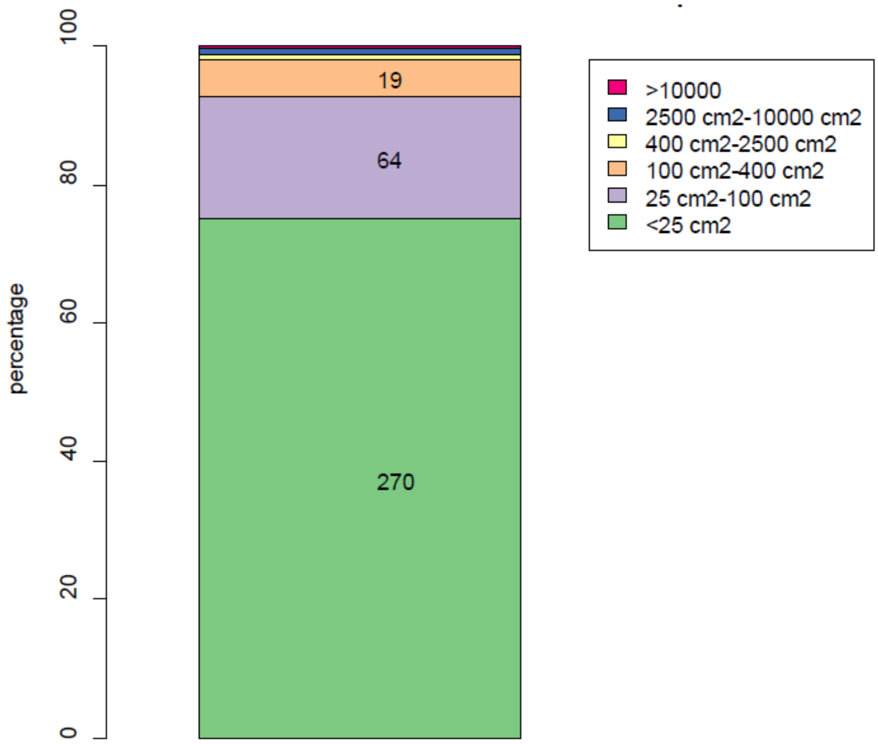


Figure 34. Size composition of the seafloor litter, Dutch 2015 IBTS Q1. Values are the absolute number of items for the categories containing more than 1% of the items.



Bottom Trawl Variability

Large spatial variability was seen in the bottom trawl survey results, with empty hauls positioned next to very large hauls. In many cases the amount of litter caught seems to be related to seafloor structures rather than the actual location. Total item count and composition was seen to vary significantly with previous years but this was thought to be due to the randomly chosen position of the trawls which changes each year and inconsistencies in use of the item type classifications between years and amongst different personnel.

4.5.4 Discussion of Monitoring Methods

The MCS beach survey results indicate that fishing nets are likely to be the item most commonly found on beaches that can be directly identified as fishing litter. Plastic string and cord of diameter less than 1cm and fishing line are also likely to be key items. The bottom trawl survey suggests that the items most commonly found through this method are likely to be synthetic rope and plastic sheeting. It is not known how much of this comes from fishing and aquaculture industries versus any other sector. The MCS methodology attributes rope with a diameter greater than 1cm to shipping litter and string and cord with a diameter less than 1cm to fishing; although in reality a portion of each size fraction will come from fishing and aquaculture. There is no further distinction for synthetic rope in the benthic trawl item type list based on diameter or any other attribute and the count of synthetic rope reported will therefore include items both large and small.

Intuitively, it is likely that much fishing and aquaculture litter is not easily transported by the oceans and deposited on beaches and so will be under-represented in beach surveys. This will likely be items that become snagged on the sea floor, heavy items that sink and object attached to heavy objects, such as larger pieces of fishing net and metal items including chains, weights, anchors, boxes and machine parts. The benthic trawl may under-represent items that are particularly small or particularly large. This could explain why fishing nets made up a much smaller proportion of the items found in the benthic trawl compared to the MCS beach survey, and those found were small sections weighing less than 1 kg.

The high degree of spatial variability in both methods suggests that a large number of survey sites will be needed to approach a representative sample of the marine environment. Neither method allowed for analysis of temporal variability as other factors were not sufficiently constrained to make inter-annual results comparable. However, a benchmark of temporal variability will need to be established to determine the extent to which surveys can be used to measure progress made towards targets.

In order to measure the impact of litter reduction measures and, most importantly, changes in the amount of litter present in the marine environment, robust monitoring methods are needed that accurately represent the amount of litter of all types present. The monitoring methods analysed above could form part of this procedure but certain gaps remain and other methods will need to be employed to monitor the fraction of litter that is missing or under-represented. Failure to do so would misrepresent the litter present, the impact of litter reduction measures taken and potentially distort the type of litter reduction measures chosen if targets are monitored against unrepresentative sampling techniques.

4.6 Key Items and Indicative Benefits of Litter Reduction

Nets are often highlighted in the literature as marine debris items of particular interest. Gillnets in particular can be very large and heavy, with 100m sheets connected in fleets up to 12km and each sheet weighing in the order of 880 kg (see Section 4.2). The impacts of reducing the amount of nets lost can be significant. Every net removed or prevented from being lost equates to a large amount of plastic and therefore a large amount of harm avoided. Furthermore, nets tend not to be so widely dispersed as other litter items and are often found at the location where they were lost. This results in relatively few items each of a large size concentrated in areas of high fishing activity or where they are easily snagged and caught on the sea floor making retrieval exercises more cost-effective by enabling the focussing of efforts on litter hotspots.

Nets are also thought to cause amongst the greatest harm per item lost, due to damage from entanglement with marine wildlife and other vessels on top of the harm associated with plastic debris in general. It is estimated that less than 1% of nets deployed in EU waters are lost.[306] However, the Swedish derelict fishing gear projects assessed by MARELITT show that the total length of nets being set is high and so this small percentage can relate to a large quantity of material. For example, the FANTARED project found that approximately 1% of gillnets used in the Swedish fleet are lost each year equating to approximately 165 km of net.

Other key benefits associated with reducing lost nets include:[307]

- Reduced gear/engine entanglement with lost/discarded gear, resulting in less sorting/disentanglement time, more fishing time, and reduced costs of any gear lost as a result of entanglement;
- Improved incomes associated with measures to reduce the number of lost nets, through a reduction in lost gear and associated lost fishing time involved with searching for lost gear, and reduced time purchasing and rigging new gear;
- Multiplier effects of increased fishing income;
- A large volume of plastic which can be profitably recycled under the right conditions;
- Habitat restoration;

[306] MARELITT (2013) *Pilot project:removal of marine litter from Europe's four regional seas - Assessment Report*, December 2013

[307] Brown, J., and Macfadyen, G. (2007) Ghost fishing in European waters: Impacts and management responses, *Marine Policy*, Vol.31, No.4, pp.488–504

- Reduction in mortality of marine species (marine mammals, birds, reptiles, etc. that become entangled in the nets, including protected and endangered species); and
- All the other benefits associated with reducing plastic pollution in the marine environment including those associated with microplastics created as the gear degrades, ingestion, toxicity, littering of beaches.

The key costs and benefits associated with gillnets in particular, as well as all gear that causes harm to fishing gear and vessels, are discussed in more detail in the sections below. However, these values are likely to significantly underestimate the total benefits of retrieving the debris or preventing it from being lost in the first place as they do not take account of the full range of benefits listed above. Although these benefits have not yet been fully quantified and monetised they may carry considerable value and should be kept in mind when considering the relative costs and benefits of any measure.

4.6.1 Gillnets

A 2007 study calculated the costs of ghost fishing using a model of a hypothetical EU gillnet fishery populated with realistic data based on interviews and published data from a UK gillnet fishery.[308] The study assumes that fleets of gillnets are set by each vessel, each fleet consisting of 100 individual nets. The length of a fleet of nets is 12 km with a value of €8,564. The value of markers and floats used on a fleet of nets is €2,284. The combined value of nets, floats and markers on a fleet of nets is therefore €10,846. The average life span of the gear is assumed to be 12 months for nets and 24 months for markers and floats. The value of the gear in the lost fleets is depreciated to 50% of the purchase cost, i.e. €5,423. This does not include the value to a recycler of an end-of-life net but as net recycling is not currently widespread in Europe this is an acceptable omission.

The study gives the revenue of landings from a single fleet in active use as €115,222 per year and assumes that 70% of the catch is quota controlled. The daily catch rate of ghost fishing in the model declines at an exponential rate to 5% of the 'active catches' (i.e. the gear's usual fishing potential in active use) after 90 days. It is calculated that over the first year a lost net will catch 15% of that caught by an active net. The value of the fish caught in the lost fleet of nets is therefore €10,596 quota controlled and €5,185 non-quota controlled stock. The quota controlled species caught in the lost net are either directly depleting the stock available to the fishers if caught or the future stock available through their reproductive potential. If we conservatively assume that only the quota controlled stock caught in the ghost net is a direct financial loss to the fishers then the combined value of the lost gear and fish caught in the fleet of nets is €26,400. If, as the

[308] Brown, J., and Macfadyen, G. (2007) Ghost fishing in European waters: Impacts and management responses, *Marine Policy*, Vol.31, No.4, pp.488–504

study assumes, each vessel loses on average one fleet per year then this is the annual cost to the vessel.

Assuming that costs have roughly tracked inflation and are broadly transferable within Europe then a scheme need only cost less than €26,400 per 12 km fleet of gillnet *prevented* from being lost in order for the scheme to be cost-effective based solely on the value of the gear and the quota controlled fish caught in the first year by the lost nets. Gillnets will most likely be lost with some fish already caught in the net and so *retrieval* schemes, being unable to prevent this loss, are unlikely to avoid all of the costs outlined above. The amount of cost-savings realised depends on how quickly the nets are retrieved. As a minimum, *retrieval* schemes would need to cost less than €10,846 (the value of the gear alone) per 12 km fleet of gillnet retrieved in order for the scheme to be cost-effective under these conditions. Of course, retrieval programmes may incur additional costs in identifying the owner of the nets before the benefit of the recovered net value may be claimed. Other additional costs such as cleaning and repairing the nets will also apply, and would all have to be factored in to the cost of retrieval per fleet of gillnets.

The benefits of litter reduction measures will vary by fishery. For example, gillnets can collapse due to the weight of caught wildlife shortly after being lost causing the catch rate for fish to decrease sharply. However, other species will be attracted to the collapsed nets in search of food and some of these will in turn become entangled and attract the next set of predators. Therefore where the target species of a fishery is such a predator the value of the ghost catch can be assumed to be much less sensitive to time as the costs continue for the lifetime of the net. An analysis of lost fishing gear in Washington State calculated a cost:benefit ratio of 1:1.27 for retrieval of gillnets based on the value of Dungeness crab, *Cancer magister*, caught in the nets based on a catch-rate model.[309] However, in a later study the authors directly measured the catch-rate of the nets over time and found them to be much higher than previously thought resulting in a revised cost:benefit ratio of 1:14.5.[310]

4.6.2 Interaction with Fishing Gear and Vessels

Where measures address items that can get caught in equipment and propellers other benefits of reducing litter (from all sources) can be monetised. KIMO calculates that the annual cost to an average Shetland fishing vessel for these issues would be:[311]

- €4,500 - 9,000 due to lost time clearing nets of debris;

[309] Natural Resources Consultants, Inc. (2007) *A Cost-Benefit Analysis of Derelict Fishing Gear Removal In Puget Sound, Washington*, Report for The Northwest Straits Foundation, September 2007

[310] KIMO *Economic Impacts*, accessed 16 July 2015, http://www.kimointernational.org/Economic-Impacts.aspx

[311] KIMO, Mouat, J., Lopez Lozano, R., and Bateson, H. (2010) *Economic Impacts of Marine Litter*, Report for KIMO, 2010

- €320 – 1,300 cleaning equipment and nets of contaminants;
- €130 – 13,000+ due to time lost fixing nets;
- €80 – 650 due to time lost with fouled propeller;
- €2,600 – 13,000+ to repair nets;
- €60 – 400 to un-foul propeller; and
- €130 for gear box inspection.

The problem seems to affect almost all of the fishing fleet. KIMO notes:

> *Shetland fishermen responded that 92% had recurring problems with accumulated debris in nets, 69% had had their catch contaminated by debris and 92% had snagged their nets on debris on the seabed. Many also experienced fouled propellers and blocked intake pipes.*

The total annual costs per vessel are estimated to be between €8,000 and €40,000 assuming only one incident per year and working only 40 hours per week. These costs are thought to have the greatest impact on smaller vessels as they have fewer crew members and a lower profit margin; larger vessels are comparatively less impacted upon because they fish mid-water where interaction with debris is less likely. If a 30% reduction in marine debris is achieved we could expect to see incidents and costs reduce accordingly. A 30% reduction of these impacts would equate to an average annual cost-saving of €2,300 to €12,000 per vessel. As is shown in Section 6.3.2.7, 20 - 40% (by weight) of marine debris in the EU is likely to originate from marine sources. A 30% reduction in debris from marine sources alone will generate an average annual cost-saving of €700 to €3,500 per vessel per annum.

Litter from fishing and aquaculture industries will not account for the entire marine source fraction (some will be from shipping etc.) but this gives an indication of the potential cost-savings available by reducing those litter types. KIMO estimates that if 50% of the Shetland fishing fleet was affected in the same way the costs would amount to between €630,000 and €3,000,000. Using the same methodology, €57,000 to €290,000 of this cost-saving could be achieved from meeting the Circular Economy Package target for litter from marine sources.

4.7 Potential Impact of Litter Reduction Actions

Actions that address marine debris from fishing and aquaculture sectors have the potential for a large impact due for the following reasons:

- Items lost are often very large, but they are lost by a relatively small group of stakeholders. Therefore a large quantity of litter could be prevented through behaviour change in a focussed group of stakeholders.
- Certain debris items from these industries are particularly harmful (e.g. ghost fishing and cost of entangling vessels and gear) and so avoiding these losses provides particularly high benefits, see Section 4.6.
- The industry and actors involved in the losses are easily identified (i.e. some, but not all, fishers and fish farmers). There are many established methods of engaging these industries, including government departments for fishing and

aquaculture, industry bodies and associations, and groups that already work with these actors on environmental issues such as sustainable fishing and marine debris. A small, easily identifiable group with established routes of engagement is much easier to target and engage to create behaviour change.
- The stakeholders involved in the losses are also subject to some of the negative impacts of the debris (e.g. getting caught in vessels and active gear) and so they will naturally benefit from litter reduction. Being actors capable of litter reduction and recipients of the benefits makes a strong case for individual behaviour change.

By comparison other debris pathways, such as hygiene products in waste water or land-littered items in storm drains, often involve a large group of stakeholders losing small-sized items. Furthermore the actors involved are difficult to identify and therefore target with litter reduction measures, and are less directly affected by marine debris due to a lesser involvement in the marine environment. Therefore, without changes in product design, legislation, or market-based measures that act on the group as a whole, it can be said that creating behaviour change to reduce litter from these pathways may be more difficult than addressing debris from the fishing and aquaculture sectors.

4.8 Litter Removal

In this section we assess litter abatement measures that focus on litter removal rather than prevention. We analyse their identifiable costs and benefits, potential for wider implementation, and their potential contribution to the circular economy package target. These measures are split into three categories:

- Litter retrieval - vessels purposefully locating and removing litter;
- Litter retention - vessels retaining the litter that is caught during normal fishing operations and returning that litter to shore; and
- Gear buy-back - incentivised litter retention and responsible waste management.

In theory litter removal measures could address the stock of all marine debris. In reality the efficacy of measures depends on the efficiency of the removal method and the applied effort. With this in mind the different categories of litter removal are assessed below.

4.8.1 Litter Retrieval

Description

Litter retrieval projects involve removing litter from the ocean, often using specially chartered vessels. Litter is usually collected via trawls, dives, or using equipment such as creeper gear used to hook lost nets. The litter is then transported back to shore for recycling or disposal. Projects often include a monitoring element, most commonly an item count by type but sometimes weight and volume are also measured.

Litter retrieval tends to focus on litter hotspots on the ocean floor. Priority sites can be targeted, such as European Marine Sites or specific reefs, wrecks and other critical areas.

A significant impact can be made on litter levels in the target area but results are limited to this area. Retrieval can target a specific item type or include all types of litter found.

Case Study Results

A 2007 cost-benefit model analysis of net retrieval in an EU gillnet fishery found it not to be cost-effective having a cost:benefit ratio of 1:0.49.[312] However, once the retrieval gear has been developed for that specific area the retrieval operation becomes cost-effective with a cost:benefit ratio of 1:1.44.[313] Additionally further benefits obtained from retrieval such as avoided harm to wildlife and maritime economic activity (as discussed in Section 4.6.2) were not included in the calculation and would improve the cost:benefit ratio further. The model is constructed for a hypothetical EU gillnet fishery and is populated with realistic data based on interviews and published data from a UK gillnet fishery.

The cost:benefit ratio of net retrieval in Puget Sound, Washington State was calculated in a 2007 study and then revised in 2010 after applying a revised mortality rate. The 2010 study reports 132.5 days of derelict net removal, recovering 604 nets, at a total approximate cost of €419,374 between 2004 and 2007. The average cost of net removal was therefore 3,165 €/day, or 695 €/net. The study calculates that a given gillnet in Washington State entangles 4,368 Dungeness crabs during the impact lifetime of the net (assumed to be 10 years), at a loss of €17,006 to the commercial fishery. The average cost of locating and removing such a net in the study was €1,175, giving a cost:benefit ratio of 1:14.5 for the value of the Dungeness crabs alone. These benefits may be somewhat overstated since some crabs will be caught and killed before the lost gear can be retrieved. It was noted that the net would also have potentially killed seabirds, mammals, fish and other invertebrates as well as increasing threats to human safety, vessel navigation, habitat quality, and ecosystem health and that these costs were not included in the cost-benefit analysis.[314]

A Korean litter retrieval project recovered 21,871 T of litter over a 5 year period. Costs rose from 1.26 €/T in 2004 to 1.91 €/T in 2008, the reasons for which are not apparent from the report.[315]

---

[312] Brown, J., and Macfadyen, G. (2007) Ghost fishing in European waters: Impacts and management responses, *Marine Policy*, Vol.31, No.4, pp.488–504

[313] Natural Resources Consultants, Inc. (2007) *A Cost-Benefit Analysis of Derelict Fishing Gear Removal In Puget Sound, Washington*, Report for The Northwest Straits Foundation, September 2007

[314] Gilardi, K.V.K., Carlson-Bremer, D., June, J.A., Antonelis, K., Broadhurst, G., and Cowan, T. (2010) Marine species mortality in derelict fishing nets in Puget Sound, WA and the cost/benefits of derelict net removal, *Marine Pollution Bulletin*, Vol.60, No.3, pp.376–382

[315] Morishige, C. (2010) *Marine Debris Prevention Projects and Activities in the Republic of Korea and United States: A compilation of project summary reports. NOAA Technical Memorandum NOS-OR&R-36*, Report for National Oceanic and Atmospheric Administration, 2010, http://permanent.access.gpo.gov/gpo2954/koreawkshop.pdf

Specific Costs and Benefits and the Stakeholders Affected

There is some concern about the environmental damage that can be caused by removing lost nets and in some cases it may even be preferable to leave the nets *in situ*. Nets are often lost when they become caught on reefs and wrecks. Removing the nets can be a difficult task and may damage the underlying habitat if not done carefully. Removing the nets may also re-expose the features upon which the net became caught, and lead to other nets being lost. However, if the litter is damaging the habitat by remaining in place then removing the litter may lead to more favourable conditions for flora and fauna to flourish and potentially lead to increases in fish stocks. This may be of particular importance for European Marine Sites and other priority sites for biodiversity or fish stocks affected by litter.

If commercial fishers and fishing vessels are used to retrieve the litter they will most likely be compensated for their time.

Costs are likely to be high, as shown in the EU and US case studies above, but still worthwhile if targeting very harmful debris such as gillnets.

Potential for Action

Targeted projects are likely to be the most cost-effective and can be supported by measures that help locate lost gear such as better reporting of gear loss by the fishing vessels and sharing of survey and mapping information. Reporting of gear loss is mandatory in Norway and it is estimated that 80% of losses are reported through this system, although it would be difficult to estimate the amount that is not reported. Issues of capacity and jurisdiction can also hamper reporting of marine litter and its swift retrieval. Likewise, legal restrictions on the removal of marine debris except by the legal owner can be a barrier to retrieval operations. Examples include sabotage laws, burdensome certification requirements for vessels carrying ALDFG, and fishery regulations that prohibit vessels from carrying gear types for which they do not have a license.[316]

Standardised monitoring and reporting methods for the waste retrieved, and training on how to conduct these activities will help results to be compared and combined from similar projects. If accurate regional estimates for the stock or inflow become available in the future the results may be used to determine the contribution of the measure towards the marine litter reduction targets.

Contribution towards Circular Economy Package Target and OSPAR Action

Two case studies have been reviewed by the MARELITT project and the results published. One project with two participating vessels removed an average of 0.39 km of gillnets and 1.04 traps per day. The other project with one participating vessel removed an average of 0.16 km of gill nets per day and the number of traps was unknown. Using

[316] UNEP, and FAO (2009) *Abandoned, Lost or Otherwise Discarded Fishing Gear*, 2009

an average per boat performance from these two projects it would require 930 boat-days effort in order to remove the 165 km of gill net that is estimated to be lost each year by the Swedish fleet.[317] It is therefore unlikely that litter retrieval will in this case be an effective means of countering the current inflow of litter, let alone reducing the overall stock of litter lost.

Litter retrieval projects do provide a good deal of flexibility in their application. They can be used to address litter of every type from every source, including perhaps items missed by other measures, and so aquaculture debris can be reduced as well. As outlined in Section 4.6, fishing nets can account for a large amount of litter and removal of nets can have a big impact due to their physical size and the associated impacts such as entanglement. As in the case study, litter retrieval can also be used to target this key litter item. Litter retrieval is also unique in its ability to target accumulations of litter in litter hotspots and environmentally sensitive areas. In these circumstances, litter retrieval can be an effective means to reduce the existing stock of litter.

However, adoption of this measure to remove significant quantities of the stock of marine debris is not likely to be cost-effective due to the time cost of locating and removing the material. The Waste Free Oceans organisation came to the same conclusion in the assessment of a regular campaign of waste retrieval using a surface trawl net along the Belgian coast.[318]

4.8.2 Litter Retention

Description

During normal fishing activity marine litter may be brought aboard fishing vessels. For example, trawl nets may catch some litter which will then need to be removed before recasting the net. Litter retention projects facilitate vessels to store this litter on board and return it to shore to be properly processed. Projects typically provide fishers with sacks that can be used to store the litter on the vessel and handle onward transport and processing of the litter once it is brought to shore.

Case Study Results

The Fishing for Litter project is operated by KIMO International in Scotland, South West England, the Netherlands, Belgium, and the Baltic Sea. The Scottish project retained 242 tonnes over 3 years starting in April 2008 with a cost of 1,000 €/T of marine litter retrieved. Results build on the previous period 2005-2008 in which 117 tonnes were

[317] MARELITT (2013) *Pilot project:removal of marine litter from Europe's four regional seas - Assessment Report*, December 2013

[318] Vanagt, T., Vanaedenaerde, P., Van de Moortel, L., and Godfroid, P. (2012) Waste Free Oceans Belgium–a pilot study

recovered with a cost of 2,600 €/T.[319] The latest project reports are not yet published but it appears that the scheme continues to grow as 117 tonnes were landed in spring 2013 - 2014 alone.[320]

The Honolulu Derelict Net Recycling Program encourages responsible waste management by providing a container for ALDFG recovered by the local longline fleet. In the first year 11 tonnes were captured and transported to a nearby energy-from-waste plant.[321]

Specific Costs and Benefits and the Stakeholders Affected

Fishers and fishing vessel owners are the main actors in this measure. They are also direct recipients of the benefits, as the less debris present in the ocean the less there is to cause problems with the vessels and their work, and this may help to encourage participation in litter retention schemes. Fishers can also promote their participation in the measure as part of their environmental sustainability credentials. This is increasingly important for fishers competing in the modern marketplace and could resonate with fishers who identify themselves as 'guardians of the sea'.

There is insufficient evidence to make a direct comparison of cost-effectiveness of litter retention projects compared to litter retrieval. However, if the costs of outreach and encouraging participation are kept low, then it is likely that litter retention will be less costly per tonne collected as the cost of the journeys to collect the litter is absorbed into the fishing operations already taking place. Costs can be further reduced by waste management of the litter being handled via port reception facilities if no additional charge is made to the participating vessels for this service, for example through a 'no special fee' system. Case studies also comment on the litter prevention effect of directly engaging fishers in the removal of marine debris, although this impact has not been quantified. The majority of the costs are born by the organisations providing the containers, the on-shore waste management, organising the scheme and promoting participation.

Potential for Action

Fishers catch and remove marine debris as part of their normal fishing operations. With support this litter can be brought to shore and recycled or disposed of appropriately. The KIMO example shows that the costs of such schemes are currently high but that costs reduce as the project matures and economies of scale are achieved. If containers are provided free of charge to fishers to store the waste on board and zero-cost and

---

[319] KIMO (2011) *Final Report. Fishing for Litter Scotland 2008-2011*, 2011, http://www.kimointernational.org/WebData/Files/FFL%20Scotland/FFL%20Scotland%20Report%20FINAL.pdf

[320] KIMO *Fishing For Litter Spring Newsletter 2014*, http://www.kimointernational.org/WebData/Files/FFL%20Scotland/Spring%20Newsletter%2014.pdf

[321] UNEP, and FAO (2009) *Abandoned, Lost or Otherwise Discarded Fishing Gear*, 2009

convenient waste handling is provided at the port then the current burden of retaining and handling this waste is removed from the fishers.

Member States could work with ports and other industry organisations to provide the infrastructure and services required as well as perform the outreach and education necessary to achieve high levels of participation. If it were mandatory for fishing vessels to carry a container for retained debris the captured tonnages would be even higher.

Contribution towards Circular Economy Package Target and OSPAR Action

The magnitude of the impacts is dependent upon the number of fishing vessels participating in the measure. It is thought that 500 vessels participating in the OSPAR fishing for litter scheme could land around 2,000 tonnes per annum.[322] [323] Around 1,150 vessel-years effort would therefore be required to counteract the lower bound of the current inflow of debris from fishing and aquaculture, presented in Section 4.2, and a further 56,000 vessel-years effort to remove the existing stock of debris from fishing and aquaculture alone – even assuming no effect of diminishing returns as removal operations progress.

Litter reduction is also somewhat selective as only litter that comes in contact with, and is caught by, the active fishing gear will be removed. This will most likely not include many of the smaller litter items, especially microplastics, the larger and heavier litter items, such as large plastic sheets, and items that are entangled or embedded in other marine features, such as fishing nets. Debris items from aquaculture will therefore also be included where caught. Whilst this measure is unlikely to make a significant impact upon the level of marine debris it is clearly a good idea for fishers to retain any debris that they catch if this can be achieved in a relatively low-cost manner.

The potential contribution of this measure towards litter reduction targets will rely on the level of participation but it could nevertheless form an important part of the suite of measures employed, especially in engaging fishers and fishing vessel owners and awareness-raising.

4.8.3 Gear Buy-Back

Description

Gear buy-back schemes are very similar to litter retention but the fishers are paid for the litter delivered to shore.

Case Study Results

A waste fishing gear buy-back project operated in 51 local areas of 38 cities and towns within South Korea as of 2009. 29,472 tonnes were captured over a 5 year period. The fishers were paid roughly €6.48 per 100 L bag of recovered gear (not gear taken out

---

[322] OSPAR Commission (2007) *Guidelines on how to develop a fishing for litter project*

[323] MEPC, FOEI, and IMO (2008) Marine Litter and Port Reception Facilities. MEPC 57/8

by vessels). The cost-effectiveness of the project increased as the project matured and the amount captured increased. In 2004, 2,819 tonnes were captured at a cost of 0.58 €/T. In 2008 the project captured 8,797 tonnes at a cost of 0.31 €/T. This compares favourably with the litter retrieval project that operated in South Korea over the same period which cost 1.26 €/T at best, and the annual tonnage captured was on average higher in the gear buy-back scheme.[324]

4.9 Litter Prevention

There are many ideas for preventing marine debris from marine sources. A UNEP/FAO report into ALDFG and the Honolulu Strategy report outline the main existing measures and those proposed for future litter reduction.[325] [326] This section of the report presents measures chosen for ease of implementation, suitability for action by the European Commission and Member States, and potential impact on litter reduction.

Although there are many different types of litter prevention measure there are few case studies with publically reported costs and results. By their very nature, it is difficult to know the impacts of litter prevention measures. The quantity of material that is prevented from being lost is often impossible to measure, and as no rigorous methods exist to measure the inflow of litter to the marine environment we cannot measure the results through direct observation. For this reason it is more difficult to understand the impact and costs of measures that prevent rather than remove litter.

4.9.1 Reducing Gear Conflict and Navigation Hazards

Description

Fishing and aquaculture equipment can often be damaged or lost through conflict with other types of gear. A common example is where mobile trawling gear passes over static gear such as gillnets which are laid along the sea floor. The static gear may be damaged, or dragged to a different location where the owner will not find it, and the trawled gear may be damaged or become entangled and be lost by the towing vessel. Features below the sea surface, such as reefs and wrecks, can also be navigation hazards if vessels are not aware of their exact location.

---

[324] Morishige, C. (2010) *Marine Debris Prevention Projects and Activities in the Republic of Korea and United States: A compilation of project summary reports. NOAA Technical Memorandum NOS-OR&R-36*, Report for National Oceanic and Atmospheric Administration, 2010, http://permanent.access.gpo.gov/gpo2954/koreawkshop.pdf

[325] UNEP, and FAO (2009) *Abandoned, Lost or Otherwise Discarded Fishing Gear*, 2009

[326] NOAA, and UNEP (2011) *The Honolulu Strategy: A Global Framework for Prevention and Management of Marine Debris*, accessed 23 October 2013, http://5imdc.wordpress.com/about/honolulustrategy/

Gear marking

Standards for clearly marking the presence of static fishing gear are widely recognised as a mechanism for reducing gear conflict. Gear marking can also be used to identify the owner of gear, which can aid in gear retrieval operations and even enable reuse depending on the state of the gear. The FAO has produced guidelines on the marking of fishing gear and many fisheries laws now require fishers to mark their gear with tags in a prominent position.[327]

On-board technology to avoid or locate gear

GPS and sea-bed mapping technology reduces losses of fishing gear by avoiding obstacles and improves recovery of lost gear by noting the location when lost. Transponders fitted to gear to aid their use are increasingly used by large vessels and raise the likelihood of successful recovery when lost.

Spatial management and zoning schemes

Zoning waters allows other marine users to identify areas where fishing gear is likely to be present and so reduces the navigational hazard and the likelihood of gear being damaged or moved by accident. Spatial management is also used to segregate fishers through agreement and so serves to reduce ALDFG by reducing gear conflict and can reduce its impact by protecting sensitive habitats. Restrictions on the length of net used and soak time at different depths have also been employed in the EU in order to reduce gear loss.[328]

Mapping and reporting navigation hazards

Detecting, mapping and reporting navigation hazards can enable vessels to navigate safely and reduce the amount of gear lost to these hazards. Autonomous survey vessels with side scan sonar have been used for such purposes.

Specific Costs and Benefits and the Stakeholders Affected

Alongside the reduction in litter, gear conflict itself incurs considerable cost to fishing vessels as shown in Section 4.6.2, and measures that directly address these issues, above and beyond general litter reduction, will provide the greatest benefits.

Costs will vary depending on the type of measure employed but are likely to be of a medium level relative to other categories of intervention assessed in this study. Some of the measures carry a cost to vessels in terms of the equipment used, such as gear marking and carrying a GPS. Provided that the modified gear doesn't reduce intended

---

[327] *An introduction to monitoring, control and surveillance systems for capture fisheries*, accessed 28 September 2015, http://www.fao.org/docrep/003/v4250e/V4250E08.htm

[328] Large, P.A., Graham, N.G., Hareide, N.-R., et al. (2009) Lost and abandoned nets in deep-water gillnet fisheries in the Northeast Atlantic: retrieval exercises and outcomes, *ICES Journal of Marine Science: Journal Du Conseil*, Vol.66, No.2, pp.323–333

catch rates or reduce handling efficiencies these costs will be relatively small compared to the value of the catch and the costs incurred by gear conflict and navigation hazards in European fisheries. Other potential costs arise due to restricting fishing activity through spatial management and zoning schemes, and best management practices such as not setting nets in conditions where the risk of gear loss is high. These measures may result in vessels having to fish other areas or simply fish for longer in order to land their desired catch, the costs of which will be context dependent.

Mapping and reporting navigation hazards will mainly incur administration and communication costs to the organising body but will also deliver additional benefits in providing much improved understanding on the scale, nature and distribution of the problem.

Potential for Action

Requirements for gear marking and use of GPS on all fishing vessels can be set at a European or Member State level. This is discussed further in Section 3.5. GPS in particular has potential to reduce the amount of nets lost, where not already used. Fitting transponders to gear is likely to be a more costly solution and less applicable to all types of gear. However, where applicable this can be encouraged through best practice guidance, and communicated with the help of trade associations. Spatial management and zoning schemes already exist in some areas and can complement measures used to preserve areas of special importance such as European Marine Sites. Some mapping and reporting of navigation hazards is also currently undertaken but fishers would benefit from a central system that integrates with ship navigation technology to make sharing of information easier.

Contribution towards Circular Economy Package Target and OSPAR Action

Gear conflict is often reported in surveys of fishers as a key reason for gear loss and so it is thought to affect a large number of fishers. Estimates of gillnet losses are presented in Section 4.2, derived from the FANTARED 2 project in which the main cause of loss in each fishery was predominantly due to gear conflict. Further research is required to estimate losses in other fisheries, which could also potentially be large. Nonetheless, if the losses were prevented in the fisheries studied it would equate to a 20% reduction of the figure presented for the lower bound of debris from fishing and aquaculture (consisting of studied gillnet losses, dolly rope, and an assumed 7% intentional dumping of other waste).

Fishing nets and long lines are items commonly caught in gear conflict and were shown to be key items in the MCS 2014 beach survey in Section 4.5.2; in which fishing nets and fishing line accounted for 72% of fishing gear items found on an item-count basis, and synthetic rope, string and cord (which could be from degraded fishing nets and other gear) were key items in both the beach survey and benthic trawl surveys explored in Section 4.5. Furthermore, as explored in Section 4.6, gear conflict is very costly and gillnets are particularly harmful when lost due to the effects of ghost fishing.

Measures to reduce gear conflict and navigational hazards therefore provide an opportunity to make a significant reduction in the amount of material lost and prevent a great deal of cost caused by this particularly harmful debris. It also has advantages in monitoring and reporting the impact of measures upon litter levels which could be recorded using surveys of fishers to determine incidents of gear conflict and navigation hazards and the associated losses.

Measures to reduce gear conflict and navigation hazards are unlikely to lead to significant reductions in debris from aquaculture as this pathway largely relates to fishing activity.

4.9.2 Removing the Financial Incentive to Dump Waste at Sea

Description

Reuse, recycling and disposal

Whilst there are some applications for ALDFG in reuse and recycling, the majority will be disposed of. Inadequate waste facilities can be a barrier to responsible waste management and so lead to an increase in the incidence of dumping behaviour. Port reception facilities for waste are covered in detail in Section 2.3. Where the material is recycled, it can be used to offset other waste disposal costs.

Market-based instruments for waste management

Several market-based instruments can be employed to encourage good waste management. Port authorities that use an indirect, or 'no special fee', cost recovery system for the port reception facilities ensure that waste can be delivered at no additional cost to the user. This prevents disposal costs becoming an incentive to dump waste at sea. Similarly, advanced disposal fees added to goods at point of sale or import can be used to finance disposal or recycling operations, making it effectively 'free' (or rather prepaid) when the item becomes waste. Deposit refund schemes go further by adding a positive incentive to return the gear at end-of-life. They can be particularly effective for low value items that may otherwise be lost, littered or irresponsibly managed due to the low value to the owner of the waste.

For more expensive items the incentive already exists to retrieve them when lost, but a deposit refund scheme could be used to incentivise recycling of end-of-life nets and pots that may otherwise be burnt, dumped or irresponsibly managed due to high disposal costs and the associated hassle in managing this waste. Most studies concentrate on the effect of deposit refund schemes upon recycling rates but they have also been shown to have a marked effect upon litter.[329]

Measures to employ extended producer responsibility may also be effective in encouraging responsible waste management. Manufacturer buy-back schemes could alleviate pressures on the fishers of the inconvenience and cost associated with waste

[329] Lynn Levitt, and Gloria Leventhal (1986) *Litter Reduction - How Effective is the New York State Bottle Bill*, July 1986

management and may influence product design by linking the manufacturer to the product's end-of-life.

Fishing nets can be bought, sold, combined with different gear, and repaired extensively throughout the product life. It would therefore be difficult to return the exact same product for a deposit refund or extended producer responsibility scheme, but an equal volume or weight of fishing net could be accepted instead to achieve the intended effect on losses and marine debris.

Case Study Results

The Nofir project was established in 2008 to collect and recycle discarded fishing gear in Norway. The quantities handled have grown steadily and reached 4,886 tonnes in 2014. The organisation reports that:[330]

> *The waste management companies experienced difficulties with discarded equipment, especially the nets that might be up till 1100 meters long, 300 meters deep and impossible to handle without the right equipment. This created high disposal costs and provided waste owners with an incentive to dispose their waste in less environmentally manners. Nets being lit fire to or dumped were well known crimes executed along the coast daily.*

Waste fishing and aquaculture gear is collected in Norway then sent to a factory in Lithuania for dismantling before being recycled in EU and Asian facilities depending on the material type. Nets are received free of charge or even paid for in some cases. The fractions containing nylon or metals have a positive market value to the company and the gear collected is mostly composed of nylon. This operation has been operating at a profit for the last two years (€430,000 before tax in 2014), although it is reliant upon the cheap labour market in Lithuania.[331] Both profitable and non-profitable items are accepted to distinguish the organisation from its competitors who refuse certain wastes, and because the environmental benefits are recognised by the company's owners. The organisation is receiving increasing quantities from small suppliers who would otherwise have difficulty disposing of waste correctly. Nofir can offer considerable savings to such operators as a large 20 T net would cost around €5,600 to landfill and another €1,400 to transport.[332]

The Nofir organisation received EU funding under the Eco-Innovation programme to expand its operations into Member States, calling the project EUfir. After three years EUfir aims to recycle 18,000 tonnes, diverting 6,300 tonnes of plastic waste from the sea

---

[330] Nofir *Learn More - Nofir - Bringing value to marine waste*, accessed 27 July 2015, http://nofir.no/learn-more/#/about-us
[331] *Nofir AS - Bodø - Se Regnskap, Roller og mer*, accessed 27 July 2015, http://www.proff.no/selskap/nofir-as/bod%C3%B8/avfallsbehandling-og-gjenvinning/Z0IAV7GS/
[332] Personal communication with Øistein Aleksandersen, CEO of Nofir

and 8,100 tonnes from landfill.[333] Expanding the project to EU countries has been harder than expected due to low tonnages and high transport costs. Norway has a very large fishing and fish farming industry and so lots of waste is generated in a relatively small area. The industry is more sparsely distributed in the EU, making collection costs higher per tonne. The company also found that there was more competition to recycle the gear in the EU and that the alternative disposal route was cheaper than in Norway where landfill costs in the region of 280 €/T.

In Iceland fishing gear is included in the legislation for an advanced disposal fee under the Icelandic Recycling Fund (IRF). However, this system is not currently employed as the Federation of Icelandic Fishing Vessel Owners (LÍÚ) now manages this waste in place of the advanced disposal fee and the government is satisfied with the results. Discussion with a stakeholder at the IRF has indicated that the LÍÚ gains from taking responsibility for this waste management as they can operate the system more cheaply than via the government's advanced disposal fee.[334]

Deck hands clean and separate materials - a task they are proficient at as they undertake this activity in normal operations of gear maintenance. The vessel owners keep the money generated by recycling, and a higher value is gained for well-prepared materials, which incentivises high quality outputs. Most of the waste has a negative value in Iceland and so it is transported to Europe to be processed, with the exception of paper and plastic. There is an open market for recycling companies to compete for the material.

The average cost to vessel owners, including transportation, is around 68 €/T which is similar to the price of the previous disposal method through landfill but with the added benefits of an organised waste management system, environmental credentials for the fishing and aquaculture industry, and use of recycling. [335]

In both case studies there has been a significant increase in the amount of gear recycled but the impact upon ALDFG is not known.

An American project called Fishing for Energy collected 1,100 tonnes of end-of-life gear and retrieved 250 tonnes of marine debris between 2008 and 2014.[336] The material was sent to an energy from waste (EFW) facility, which would be a viable option in the European context where recycling is not possible or life-cycle analysis showed it to be a preferential treatment route. The initiative is operated by a partnership of Schnitzer Steel Industries Inc. (which extracts the metal from the waste for recycling), Covanta Corporation (which operates the EFW facility), and the environmental organisations the

---

[333] *A European System For Collecting And Recycling Discarded Equipment From The Fishing And Fish Farming Industry | ECOWEB - Your Gateway to European Eco-Innovations.*, accessed 27 July 2015, http://www.ecoweb.info/1099_1985_a-european-system-collecting-recycling-discarded-equipment-fishing-fish-farming-industry

[334] Personal communication with Gudlaugur Sverrisson, Operational Manager, Icelandic Recycling Fund

[335] Personal communication with Gudlaugur Sverrisson, Operational Manager, Icelandic Recycling Fund

[336] Fishing for Energy (2014) *Fishing for Energy Fact Sheet*, June 2014

National Fish and Wildlife Foundation (NFWF), the National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program. A similar partnership approach may be adopted incorporating plastic producers and gear manufacturers for their producer responsibility, plastics recyclers, fishing and aquaculture associations, and others from the fish industry value chain such as buyers, distributers and supermarkets.

Bord Iascaigh Mhara (Irish Sea Fisheries Board) also piloted a proof of concept scheme to recycle end-of-life nylon gear into pellets which was then manufactured into a reservoir liner made of 75% of the recycled fishing gear plastic and 25% other recyclables.[337]

Other initiatives retrieve ghost nets from the marine environment and recycle the plastic. Examples include the Healthy Seas initiative, which turns marine plastics into thread for carpet tiles and textiles. Although these initiatives target lost nets rather than end-of-life nets they can help developing a recycling market for these items that could potentially grow to encompass end-of-life gear.

Specific Costs and Benefits and the Stakeholders Affected

The operators who already dispose of their waste in a responsible manner will benefit through increased fairness of the system. If waste management costs are reduced or removed through recycling programmes like EUfir, then those who manage their waste responsibly will no longer be penalised by high disposal costs. If all are made to pay for waste management (whether they make use of it or not) through schemes such as an advanced disposal fee or a deposit-refund then at least those who continue to dump will not benefit from avoiding the costs of waste management. In addition, as recycling and responsible waste management becomes increasingly common, leading to higher tonnages captured, the costs will likely be lower, resulting in a cost-saving to vessels. The largest increase in costs will be borne by those operators currently dumping waste at sea.

The Nofir project operates a profitable gear recycling operation in Norway but the same could not be achieved when operations expanded into other European countries. As with all waste management such operations could be stimulated by strong environmental legislation and effective enforcement. The gear recycling programme jointly operated by the Icelandic government and the Icelandic Fishing Vessel Owners (LÍÚ) is administrated by a relatively small team, and other costs of waste preparation and transportation are thought to be less than the advanced disposal fee system that was originally proposed. It must be noted, however, that the fishing industries in Iceland and Norway are very large and unit costs would likely be higher elsewhere in the EU, where the industry is less concentrated.

---

[337] *Irish Marine Pilot Scheme Finds Use For Recycled Fishing Nets*, accessed 1 October 2015, http://www.centriforce.com/en/news/irish-marine-pilot-scheme-findsuse-recycled-fishing-nets/

Costs for market-based instruments will depend on the level of administration required. Advanced disposal fees and deposit refund / manufacturer buy back schemes could in theory be coordinated by a small administrative team, as is the case for non-fishing waste managed by Icelandic Recycling Fund.

Potential for Action

Recycling operations tend to be implemented at a national level, although schemes such as EUfir can be supported to act across large areas of the EU. Recycling targets could potentially be set for Member States based on the amount of fishing and aquaculture gear sold and tonnages collected for recycling. This would have the added benefit of furthering understanding of the amount of ALDFG using the data captured. Similarly, market-based instruments for waste management tend to be implemented on a Member State level and have been used to tackle other litter items such as deposit refund schemes for beverage containers.

An advanced disposal fee could be applied to fishing and aquaculture products and would remove the incentive to dump at sea that is created by disposal costs. One advantage of such a scheme is that it would be fairer for individual vessels as no vessel would avoid disposal costs by dumping their waste. The system could be employed at Member State level and run alongside port reception facilities for other waste streams.

Contribution towards Circular Economy Package Target and OSPAR Action

Measures that encourage responsible waste management aim to reduce the amount of material accidentally lost or intentionally dumped in the marine environment. The relative importance of different sources and pathways of ALDFG are not well understood and are likely to vary on a regional scale. However, dumping of waste is seen to be a major contributor to marine debris and the cost of waste management is known to be a key reason for dumping waste at sea.[338] The potential impact of these measures may therefore be considerable.

Although very crude, the figures used in Section 4.2 suggest that if 7% of waste is intentionally dumped it would equate to around 3,700 tonnes per annum, compared to roughly 950 tonnes of operational losses studied in the literature (selected gillnet fisheries and dolly rope losses). Without further data the figures are purely illustrative but nevertheless dumping could contribute a significant amount of debris into the marine environment from the fishing and aquaculture industries each year. Measures that address dumping behaviour may therefore make a considerable contribution towards the Circular Economy Package Target and OSPAR Action.

---

[338] European Commission (2015) *Ex-Post evaluation of Directive 2000/59/EC on port reception facilities for ship-generated waste and cargo residues*, 2015, http://ec.europa.eu/transport/modes/maritime/studies/doc/2015-ex-post-evaluation-of-dir-2000-59-ec.pdf

There are likely to be some challenges to overcome in creating a functioning recycling and disposal market for end-of-life gear, such as the cost of transportation in areas where the fishing and aquaculture industries are more sparsely distributed. However, these can be overcome by providing storage for waste until full truckloads can be transported, as done by the EUfir recycling project. Furthermore, as the increasing tonnages are captured the waste management industry will respond to demand with the infrastructure needed. Alongside reducing litter caused by dumping at sea, the recycled tonnage can be counted towards the environmental performance of Member States.

Both fishing and aquaculture industries deal with difficult waste streams that may lead to dumping behaviour. Measures to remove the financial incentive to dump waste at sea can therefore act equally upon both industries.

4.9.3 Shifting Consumption Away from Harmful Products

Description

Manufacturers of products used in the fishing and aquaculture industries are predominantly competing on price, performance, durability and ease of use of their products. Currently the environmental costs of using or losing these products are not reflected in the price. Environmental choice can be incentivised in consumer behaviour by internalising some of these costs in the price of the product. The environmental impact of the product will then be incorporated into the purchase choice made by consumers. This can be an effective alternative to an outright ban on certain products, and can be accomplished by adding a tax onto the cost of the product. The tax can be set to a level that reflects the environmental cost of the product or simply set at a level that will affect consumer behaviour in the manner desired.

Where appropriate, governments may choose to ban particularly harmful products or mandate certain mitigating design features. For example polystyrene floats and buoys are known to partially break apart during their lifetime but this can be prevented by sealing them in a protective cover. National and local regulations on fishing and aquaculture gear are already commonplace in most countries and could be adapted to support this measure.

Dolly rope is used to protect nets from wear and tear as they come into contact with the ocean floor and consists of twisted rope made from plastic threads. As trawl nets are dragged over the bottom of the ocean pieces of dolly rope tear off and are lost into the environment. In the past dolly rope was made from natural materials but is now manufactured from plastic due to the cost and durability advantages that it provides. It is estimated that European fishermen use an average of 100 tonnes of dolly rope each year and that 15 – 25% of this is lost when the strands are torn off by the ocean floor. [339] This equates to 15 to 25 tonnes of plastic a year. Although this accounts for less than 1% by

[339] *DollyRopeFree*, accessed 27 July 2015, http://www.dollyropefree.com/

weight of the debris presented in Section 4.2, on an item-count basis the numbers are extremely large, contributing to the high prevalence of plastic string found in beach litter surveys such as the MCS Beachwatch presented in Section 4.5.2. Efforts to find an alternative are underway but are likely to struggle to compete with the current products on price and durability. For these reasons dolly rope is a strong candidate for environmental taxation in order to incentivise environmental consumer behaviour and product innovation. Such a tax could be applied to plastic dolly rope in order to incentivise use of environmentally acceptable alternatives such as products made from natural materials or innovative products that do not create marine debris. An outright ban of plastic dolly rope would achieve the same effect and ensure no plastic debris is lost from this product.

Case Study Results

There are no examples of environmental taxes used in this way for fishing and aquaculture products but several countries have implemented such taxes for single-use plastic bags with impressive results. For example, in the Republic of Ireland the annual use of such bags decreased by more than 90%from an estimated 328 bags per capita to 21 bags per capita.[340]

Specific Costs and Benefits and the Stakeholders Affected

Initially, some of the costs are borne by the manufactures of the products that are taxed or banned as, if the measure is successful, it will lead to a decrease in sales of that product. However, for every product affected there will be a corresponding increase in sales of the more environmentally friendly (and therefore untaxed/not banned) alternative. Manufacturers can therefore either change their product design or lose out to those who do. The switch in products used is likely to involve a switch in materials from synthetic to natural materials, with a resulting impact in revenue for materials manufacturers. If the alternative products are more expensive then there may be also be a cost for consumers, although this is only because current product prices do not incorporate the environmental cost. In the case of dolly rope there may be an increase in cost for the consumer as the alternatives will likely use more expensive materials and be less durable. However, the measure will also incentivise innovation in this area which can offset some of these issues.

Bans of many materials and products are currently in place across Europe, with costs largely relating to education and enforcement. Costs may therefore be low to medium for this type of measure. An environmental tax will incur some administrative overhead but will require little enforcement and will create a new revenue stream from the taxes collected. The net cost is therefore likely to be very low.

---

[340] *Plastic Bags - Department of the Environment, Community & Local Government*, accessed 27 July 2015, http://www.environ.ie/en/Environment/Waste/PlasticBags/

Potential for Action

Measures could be implemented by Member States, and the need for such measures could be mandated at a European level specifying the products to which they must apply.

Contribution towards Circular Economy Package Target and OSPAR Action

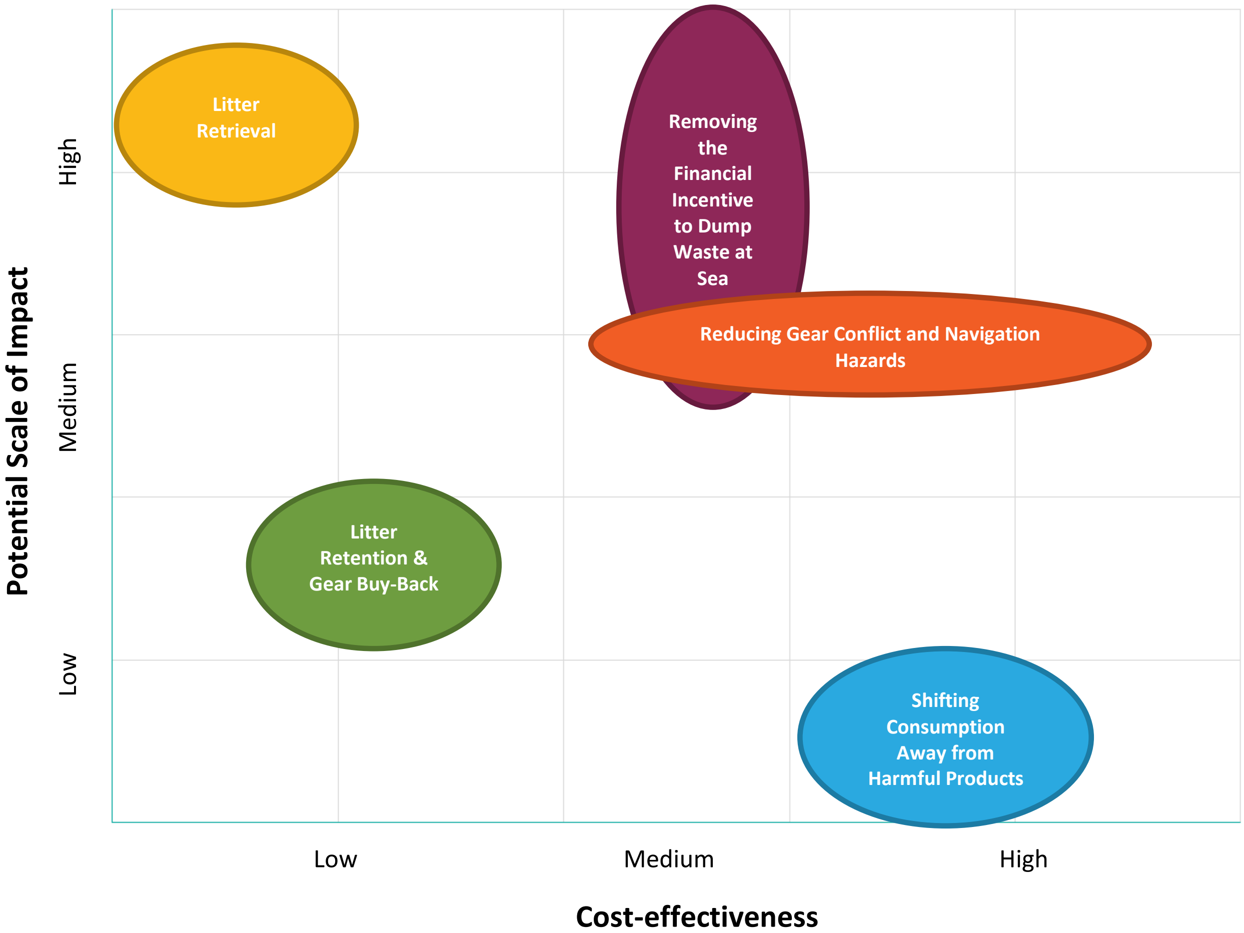
As explained above, it is estimated that 15 to 25 tonnes of plastic marine debris could be prevented annually by finding an alternative to current dolly rope design. On a per item basis, plastic string and cord of diameter less than 1cm accounted for 35% of items identified as fishing litter in the MCS beach survey results presented in Section 4.5.2, and a significant proportion of this waste could originate from dolly rope. In addition, dolly rope is known to be ingested and to cause entanglement and so has particularly high impacts when lost.

A ban or an appropriate level of environmental taxation will have an immediate and measurable impact and can be applied equally well to fishing and aquaculture. In the case of dolly rope the weight of material lost is relatively low but as the debris consists of small fragments of plastic thread its losses are much greater when viewed on an item count basis. For these reasons it would appear that such measures provide one of the most cost-effective interventions analysed.

4.10 Summary of Litter Reduction Strategies

A summary of the cost-effectiveness and potential scale of impact of each of the groups of measures is represented in Figure 35 based on the findings in this report. Cost-effectiveness will need to be judged on an individual basis but it is unlikely that litter removal projects will be able to compete with litter prevention on a large scale in terms of the amount of debris that can be reduced and especially in terms of the harm caused by the debris. Litter removal will, however, be necessary to reduce the stock of litter in the marine environment and can be made more effective by targeting litter hotspots or sensitive areas where the potential harm caused is greatest. Although further work is needed to determine how targets are set and the monitoring methods used there is no reason to delay any efforts for litter reduction. Indeed, time is of the essence to significantly reduce marine debris and minimise the harm caused in future years.

Figure 35. Summary of Findings on Litter Reduction Measures



Note: 'Removing the Financial Incentive to Dump Waste at Sea' spans a large area of potential scale of impact as it is not clear how much debris is dumped at sea, but it is likely to be a medium to large amount. 'Reducing Gear Conflict and Navigation Hazards' spans a large area of cost-effectiveness as this covers measures of varying cost-effectiveness, but they are generally of a medium to high level.

Potential measures that stand out in terms of ease of implementation, suitability for action by the European Commission and Member States, and potential impact for litter reduction are:

1) Reduce losses of equipment from interference with other fishing gear (gear conflict) and other navigation hazards:
   - Identify local hotspots for gear conflict. For each hotspot consider zoning controls. Work with fisheries and trade associations to promote and implement zoning restrictions, demonstrating the benefits to fishers to gain support for the system.
   - Mandate all vessels to carry GPS to facilitate location logging of lost gear for later retrieval.
   - Mandate reporting of gear loss and facilitate sharing of this information to reduce gear conflict. The data will also help to fill the knowledge gap of

quantities lost. Mapping and reporting navigation hazards through the same system will also help to reduce issues of gear conflict.

2) Reduce dumping at sea:

- Use market-based instruments such as advanced disposal fees, deposit refund schemes and manufacturer buy-back schemes to reduce litter and raise recycling rates.
- Remove financial disincentives to bringing waste ashore including marine litter found at sea (litter retention). Port reception facilities play an important role and can be complemented with national recycling and disposal systems for items that require special processing such as nets and gear made from composite materials.

3) Shift consumption away from harmful products:

- Reduce the use of plastic components of fishing gear that are designed to be lost or break apart during their use, e.g. plastic dolly rope, and polystyrene floats and buoys not sealed in a protective cover. This could be achieved with an outright ban on sale and use of such items, or an environmental tax that will make alternative products cost-competitive (and overcome the convenience factor).

4) Support litter removal programmes to reduce the stock of litter in the ocean in the most cost-effective manner, for example targeting litter hotspots or supporting fishers in litter retention programmes.

The participation and support of the fishing and aquaculture industries will be crucial to success of any litter reduction measure. Any action that can demonstrate the benefits to industry and make it clear where compliance and participation will provide direct cost-savings is likely to be more readily accepted.

5.0 Introduction to Task 2

This study collates and analyses all of the available data and literature in order to scope out the issue of cosmetics microplastics relative to the overall issue of plastics in the marine environment. It also looks at whether industry are addressing it—through stakeholder engagement—and what action can be taken at an EU level to reduce the problem.

This is achieved through the following and under the terms of reference for this study;

Section 6.0 addresses **Task 2.1** which states;

> *"Estimate the proportion and quantity of microplastics in the marine environment which are present as a result of the use of such materials in cosmetic products. To the extent possible, a specific quantification exercise should be carried out"*

This is split into the following sub-sections;

- **Section 6.1** looks at how we define the microplastics in cosmetics for the purpose of this study;
- **Section 6.2** looks at where and how microplastics are used in cosmetics;
- **Section 6.3** looks at the evidence base for the development of an estimate of the amount of microplastics in the ocean. It also looks at the annual flow of plastics into the ocean;
- **Section 6.4** looks at how waste water treatment processes affect the amount of primary microplastics that could enter the marine environment;
- **Section 6.5** looks at the evidence available for estimates of the amount of microplastics that enter the marine environment that can be attributed to cosmetics; and
- **Section 6.6** brings the previous sections together to give an overall estimate of the contribution of cosmetics to (micro)plastic pollution.

Section 7.0 addresses **Task 2.2** which states;

> *"Map the coverage and credibility of existing commitments from the major industry players to phase-out microplastics in their products. To the extent possible, a detailed analysis of the proportion of the market which will have phased out microplastics across their product range in the medium term (e.g. between 2015 and 2020) should be provided, as well as of the impact such measures could have on upstream plastic producers and converters."*

This is split into the following sub-sections;

- **Section 7.1** identifies the major industry players in the cosmetics market;
- **Section 7.2** looks at the commitments to phase-out microplastics both public and gathered as part of this study and maps this against the overall market to create a timeline for industry phase out from 2012 to 2020, with estimates of the proportion of the market (by value) which will have phased out through those years;

- **Section 7.3** looks at the alternatives available and whether they are creditable;
- **Section 7.4** looks at the upstream impacts for plastic producers/convertors; and
- **Section 7.5** Summarises this task with recommendations.

Section 8.0 addresses **Task 2.3** which states;

> *"Analyse the existing legal instruments which are relevant for the inclusion of microplastics in cosmetics, and their discharge into the water supply (notably the Cosmetic Products Regulation ((EC) No 1223/2009), the REACH Regulation ((EC) No 1907/2006) and the Urban Wastewater Treatment Directive (91/271/EEC)), in order to provide an initial list of options and considerations for achieving a ban on microplastics in cosmetics."*

This is split into the following sub-sections;

- **Section 8.1** looks at existing and proposed bans across the world;
- **Section 8.2** lists and analyses the initial options available in the EU for a ban; and
- **Section 8.3** provides the recommendations and conclusions for this task.

Stakeholders were engaged throughout this study, including several external presentations outlined in Appendix A.7.0, which culminated in a stakeholder meeting shortly after the draft final report was issued. Discussion from this meeting can be found in Appendix A.5.3 and written comment supplied to the project for consideration can be found in Appendix A.5.2 along with responses. Tables summarising the Terms of Reference and the work undertaken are presented in Appendix A.6.0.

6.0 Task 2.1: Microplastics in Cosmetic Products

6.1 Definition of Microplastics

Terminology and definitions in respect of microplastics have not been universally and consistently applied across the current literature base. This is not only confusing but makes comparison and aggregation of results difficult and time consuming. Thus, we find that this is one of the important issues that must be addressed for all future research.

The definition of microplastics can vary greatly between literature sources. The prefix 'micro' technically refers to a millionth of a given unit. One millionth of a meter is equal to 0.001 mm. However, common definitions put microplastics anywhere in the size range of 0 – 5 mm in diameter. In 2013 the JRC[341], on behalf of the Technical Subgroup on Marine Litter, produced guidance on how to monitor plastics in the marine environment which suggested two size classes for microplastics: <1mm and 1 – 5 mmm. It also applied a terminology (as shown in Table 17) that will be adopted in this report.

The size ranges were chosen by the JRC based upon the ability of researchers to detect these sizes of plastics using different sampling techniques in different environments. For example, 25 mm is considered the minimum size required to visually identify floating plastic debris and 5 mm is considered the minimum in visual beach inspection. While there is no minimum for small microplastics, this is usually limited by the sampling and identification equipment used to detect and sort these small particles from other organic and inorganic matter. A smaller size category of < 100 nanometres (0.0001 mm), termed 'nanoplastic', was identified by the Scientific and Technical Advisory Panel[342] in 2011, although little has been done to sample this size, and its effects on the marine environment are relatively unknown at present.

Table 17 - Marine Plastic Debris Size Definitions

Size Class (in largest dimension)	Term
> 25 mm	macroplastic
5 – 25 mm	mesoplastic
1 – 5 mm	Large microplastic
< 1mm	Small microplastic

[341] JRC (2013) Guidance on Monitoring of Marine Litter in European Seas, Report for European Commission, 2013

[342] STAP/GEF (2011) Marine Debris as a Global Environmental Problem: Introducing a Solutions Based Framework Focused on Plastic

6.1.1 Definition of Microplastics in Cosmetics

Microplastics are often found in personal care and cosmetic products (PCCPs) and are predominantly used as an exfoliating agent to remove dead skin—although their use may go beyond this to provide functions such as viscosity regulation, emulsification, film forming, binding, acting as a bulking agent, and in the case of oral care - tooth polishing.[343] Terminology for such ingredients can include 'microbeads', 'microplastic beads', 'nanobeads', 'micro-powders' and 'scrubbers'. 'Microbead' is the term most often used by the cosmetics industry, consumers and the media although this usually refers to its function as an exfoliant. This distinction and its implications are discussed further on in this section.

For the purposes of this study, however, the term PCCP microplastics will be used henceforth as a more descriptive term. Under this term, we look to arrive at a common definition for use within this study.

The following definition comes from Cosmetics Europe, and we have confirmed with industry that the majority of manufacturers also use this definition in order to measure their progress against their respective reduction targets:

> *"Plastic microbeads designate synthetic non-biodegradable solid plastic particles >1µm and < 5mm in size used to exfoliate or cleanse in rinse-off cosmetic products."*

This definition limits the scope to products that are designed to 'rinse-off' after use and includes shower gels, facial cleansers and exfoliators that will be washed off with water and therefore are highly likely to enter the waste water treatment system. Cosmetics Europe does not define the term '*non-biodegradable*'; however, the Nordic Eco Label for cosmetic products[344] attempts to do so with its definition, which states:

> *"Microplastics are defined as undissolvable plastic particles of less than 1mm size and not biodegradable according to OEC[D] 301 A-F."*

---

[343] Leslie, H., and et al. (2014) Review of Microplastics in Cosmetics, Report for Dutch Ministry of Infrastructure and the Environment, July 2014

[344] Nordic Ecolabelling (2014) Nordic Ecolabelling of Cosmetic products: Version 2.9 12 October 2010 – 30 June 2016, October 2014

This refers to the OECD testing standard[345] adopted in 1992 for the screening of chemicals for ready biodegradability in an aerobic aqueous medium. The relevance of biodegradability testing standards is discussed further in Section 8.0.

Leslie *et al*[346] propose the following set of properties, which are common to other sources of marine plastic litter:

- Synthetic polymers and/or copolymers (plastics);
- Solid phase materials (particulates, not liquids);
- Insoluble in water;
- Non-degradable; and
- Small size (maximum 5 mm, no lower size limit is defined).

The following definitions have been used by the US state of Illinois (along with other US states) in a state bill[347] imposing a ban on the manufacture and sale of PCCP microplastics, effective as of 2018 and 2019 respectively:

> ***"Plastic"*** means a synthetic material made from linking monomers through a chemical reaction to create an organic polymer chain that can be molded or extruded at high heat into various solid forms retaining their defined shapes during life cycle and after disposal.
>
> ***"Synthetic plastic microbead"*** means any intentionally added non-biodegradable solid plastic particle measuring less than 5 millimetres in size and used to exfoliate or cleanse in a rinse-off product.

The Illinois definition of synthetic plastic microbead is also cited by Gouin et al[348] as consistent with data collected by Cosmetics Europe on the use of PCCP microplastics within Europe and therefore compatible with Cosmetics Europe's definition.

The definition from Leslie *et al*, may initially seem similar to that of Illinois', however, there are subtle differences which have a large effect on what may be included. The term 'microbead' itself is one with which the public are familiar, but which also has the potential to restrict the scope to the spherical shaped plastic particles which are easy to visually identify and are used specifically for the purpose of exfoliation. The ability of the particle to retain its shape throughout its life is also key to the Illinois definition and is subtly different from defining it as 'solid phase'. Many types of polyethylene waxes used in PCCPs can be defined as solid or semi-solid compounds and may be softer due to

---

[345] OECD(1992) Test No. 301: Ready Biodegradability, Paris: Organisation for Economic Co-operation and Development

[346] Leslie, H., and et al. (2014) Review of Microplastics in Cosmetics, Report for Dutch Ministry of Infrastructure and the Environment, July 2014

[347] Illinois (2014) Illinois State Bill 2727 amending the Environmental Protection Act, June 2014, http://www.ilga.gov/legislation/publicacts/fulltext.asp?Name=098-0638

[348] Gouin et al (2015) Use of Micro-Plastic Beads in Cosmetic Products in Europe and Their Estimated Emissions to the North Sea Environment, SOFW Journal, No.03-2015

having smaller chain lengths; therefore, they may not retain their shape but would still be persistent in the marine environment under Leslie's definition[349].

Although both definitions specify that the material should be non-biodegradable, neither propose any test standards that can be used to define the process of degradation in the marine environment. Leslie suggests that no material can last indefinitely and that therefore a material is non-biodegradable if it does not decompose at a measurable rate.

For this study, the Leslie definition will be adopted for PCCP microplastics as it is less limiting. It should, however, be noted that both cosmetics industry data and other estimates of PCCP microplastics from secondary sources are almost exclusively narrower in scope and conform to the Illinois definition. The implications of this are discussed in more detail in Section 6.5.

6.2 Uses of Microplastics in Cosmetics

The earliest reference to plastics being used as an ingredient in cosmetics is from a patent filed in the US in 1959[350]. This patent sought to address issues with existing fillers for powdered make-up such as skin irritation and poor dye receptiveness by using polyolefins[351] such as Polyethylene (PE). The patent suggests that "finely divided or high pulverized" polypropylene can be used as a substitute for talc to "exhibit very desirable cosmetic properties…[such as]…colour characteristics, lack of irritation [and] good adhesion". The concentration of polyethylene is recommended to be between 20 and 90 per cent of the final product but this can vary based on the type of product it is used in and pulverised to smaller than 44 µm (0.044mm) in size. A typical ingredient list for a face powder is seen in Table 18. The patent also stipulates that the Polyethylene should be highly crystalline which implies a solid material i.e. non-water soluble.

Table 18 – Example Ingredients for Face Powders

Ingredient	Weight %
Chalk	8
Kaolin	6
Polyethylene	72
Titanium Dioxide	6
Zinc Oxide	2
Zinc Stearate	6

Source: Milton Blaustein (1965)

[349] Leslie, H. (2015) Plastic in Cosmetics. Are we Polluting the Environment Through our Personal Care?, Report for UNEP, 2015
[350] Milton Blaustein (1965) *Cosmetic Powder Compositions Containing Polyethylene*
[351] A polyolefin is any of a class of polymers produced by polymerising a simple olefin as a monomer.

There is also evidence[352] that Modified Terephthalate Polymers such as Polyethylene terephthalate (PET) are used in concentrations close to 100% in the form of powders and flakes in 'leave-on' products such as lipsticks and eye shadows as bulking and viscosity increasing agents.

The earliest reference to plastics being used as a form of *abrasive compound* in skin cleaning products is found in a US patent from 1972[353]. The patent states that although the concept of including abrasive particles within a liquid cleaner was not new at the time, the commonly used materials aluminium oxide and volcanic ash were found to be uneven in surface shape with a crystalline structure and sharp edges which could cause excessive wear to containers and dispensers—an important issue for industrial and commercial users who have reusable dispensing equipment—along with the associated skin irritation.

Some inorganic microbeads of the type used at the time have a high enough density that they can cause problems with product consistency and clog drains. The patent identified five criteria for the selection of the appropriate polymer material:

- Skin safety (inertness);
- Compatibility with other product ingredients;
- Low abrasiveness;
- Density; and
- Cost.

Polyethylene (PE), polypropylene (PP), and polystyrene (PS) were identified as the most suitable materials on the basis of these criteria. Their density is such that they will easily wash away from skin and hard surfaces and they are not hard enough to cause abrasive wear to dispensing equipment.

One of the critical factors for performance also identified by the patent is the size of the microplastics. It is stated that below 74 µm (0.074 mm) in diameter they are too small to be effective skin cleaners. Optimum performance is said to be between 177 and 74 µm (0.177 - 0.074 mm) although sizes up to 420 µm (0.42 mm) are also acceptable. The common expectation of these particles is that they are uniformly spherical in shape; however, through microscope analysis Fendall *et al* found that this is not always the case. [354]

The Fendell *et al* study analysed four products available on the New Zealand market, the results of which are presented below. Figure 36 shows the various forms in which microplastics were found in facial scrubs. In most cases, the regular spherical

---

[352] Cosmetics Ingredient Review (2012) Safety Assessment of Modified Terephthalate Polymers as Used in Cosmetics, December 2012
[353] Willis J. Beach, and Sugar Beet Products Company Skin Cleaner, Michigan
[354] Fendall, L.S., and Sewell, M.A. (2009) Contributing to marine pollution by washing your face: Microplastics in facial cleansers, Marine Pollution Bulletin, Vol.58, No.8, pp.1225–1228

microplastics were interspersed with irregular granules and sometimes thread-like fragments.

The findings of the analysis shown in Figure 36 are summarised by Fendall as follows:

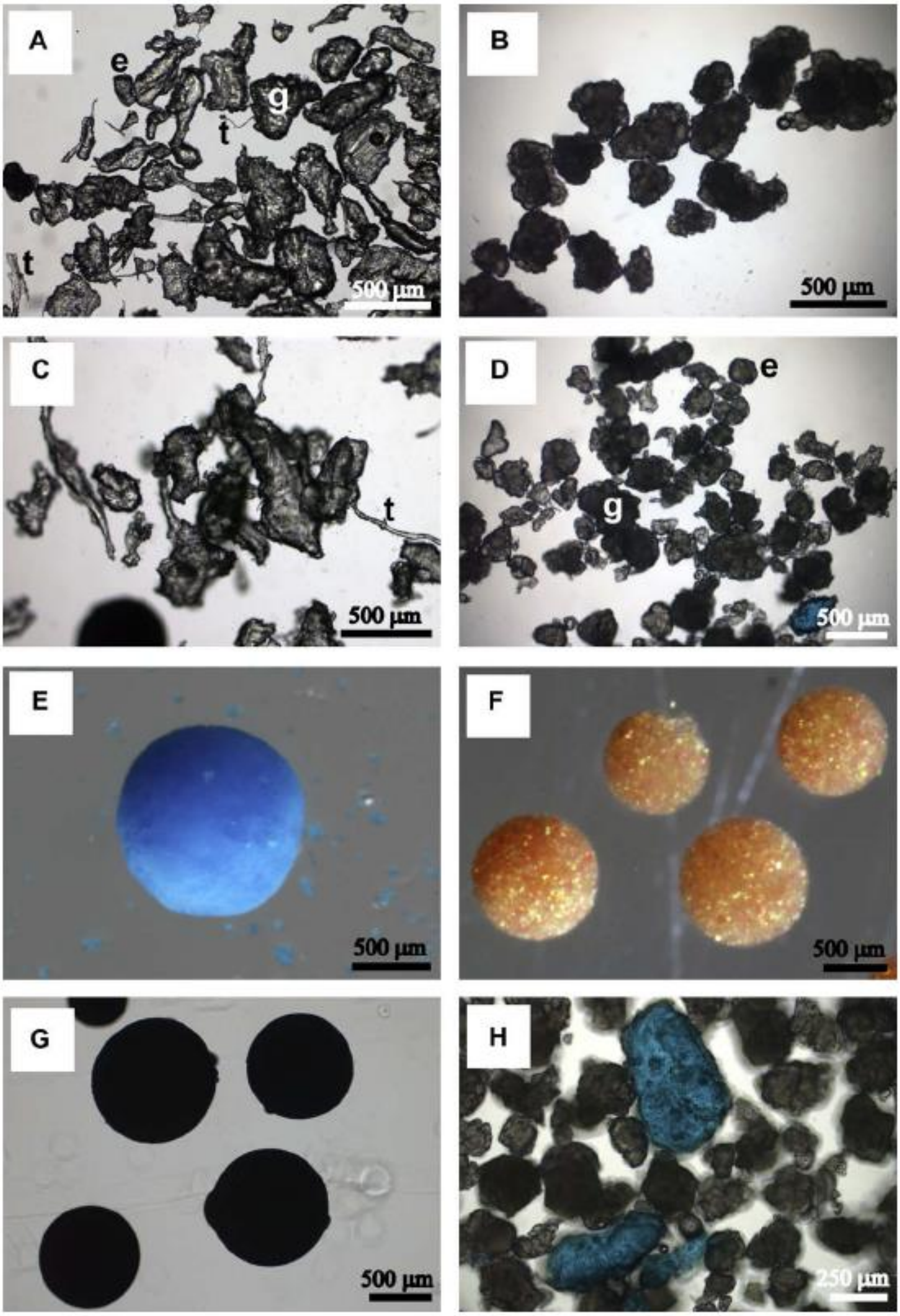
- ***Brand A*** — variable irregular shapes that include granular particles (g), ellipses (e), and threads (t).
- ***Brand B*** — uniform and granular in shape.
- ***Brand C*** — variable irregular shapes that are rounded or thread-like (t).
- ***Brand D*** — uniform and elliptical (e) or slightly granular (g) in shape.
- ***Box E*** — Blue coloured material from brand A. Product labelling refers to these as ‘‘pore cleansing power beads” that contain lactic acid to ‘‘help open clogged pores”.
- ***Box F*** — Orange coloured material from brand B.
- ***Box G*** — Blue coloured material from brand C.
- ***Box H*** — Blue coloured material from brand D.

The range of sizes was found to be between 4.1µm and 1,075µm for solid particles that are not designed to burst; far above and below the size range deemed to be effective in the original patent. The median size range of between 200 and 375µm is fairly consistent with the original patent size range.

Further to the use of microplastics within facial scrubs and exfoliators, they have also been found in toothpastes. The Netherlands National Institute for Public Health and the Environment[355] found that microplastics in toothpastes were up to one hundred times smaller than those found in scrubs. Direct measurement of products found that over 90% of plastic particles were less than 10 µm in size with a median range of 2.3–5 µm and accounted for between 2 and 4 per cent of the overall product by weight—on the lower end of the range of between 3 and 15 per cent specified as a composition density of the skin cleaners in the US patent, although the application of microplastics in toothpastes is beyond the scope of the patent.

[355] Verschoor, A., and et al. (2015) Size and amount of microplastics in toothpastes, Report for National Institute for Public Health and the Environment (Netherlands), 2015

Figure 36 – PCCP Microplastics Sampled Direct from Product



Source: Fendall et al (2009

Table 19 – Microplastic Content from Analysed PCCPs

Product	% by weight	Particle Size µm	Plastic Type	Sample Size	Country and Ref
Toothpaste	2 — 4	2 — 5	PE	3	Netherlands (2015)[356]
Anti-Callus Scrub	0.6	>200	PE	1	Germany (2014)[357]
Facial Scrub	2 — 7.5	>200	PE	3	
Shower Gel	0.45 — 3	>300	PE	2	
Toothpaste	0.26	>100	PE	1	
Toothpaste	0.1 — 0.4	40 — 800	PE	3	Denmark (2014)[358]
Facial Scrub	0.4 — 10.5	40 — 800	PE	6	
Facial Scrub	0.94 — 4.2	-	PE	3	USA (2013)[359]
Bubble Bath	0.44	50	PET	1	Netherlands (2012)[360]
Facial Scrub	10.6	100 — 1000	PE	1	
Facial Scrub	-	4.1 — 1,075	PE	4	New Zealand (2009)[361]
Facial Scrub	1.6 — 3	100 — 200	PE	3	New Zealand (1996)[362]
Hand Cleaner	0.2 — 6.9	100 — 1000	PE	3	

---

[356] Verschoor, A., and et al. (2015) Size and amount of microplastics in toothpastes, Report for National Institute for Public Health and the Environment (Netherlands), 2015

[357] Hintersteiner, I., Himmelsbach, M., and Buchberger, W.W. (2014) Characterization and quantitation of polyolefin microplastics in personal-care products using high-temperature gel-permeation chromatography, *Analytical and Bioanalytical Chemistry*, Vol.407, No.4, pp.1253–1259

[358] Jakob Strand (2014) Contents of polyethylene microplastic in some selected personal care products in Denmark, Aarhus University, 24 September 2014

[359] 5 Gyres (2013) Microplastics in consumer products and in the marine environment: Position Paper, 2013

[360] Leslie, H. (2012) Microplastic in Noordzee zwevend stof en cosmetica, Report for North Sea Foundation, 2012

[361] Fendall, L.S., and Sewell, M.A. (2009) Contributing to marine pollution by washing your face: Microplastics in facial cleansers, Marine Pollution Bulletin, Vol.58, No.8, pp.1225–1228

[362] Gregory, M.R. (1996) Plastic 'scrubbers' in hand cleansers: a further (and minor) source for marine pollution identified, *Marine Pollution Bulletin*, Vol.32, No.12, pp.867–871

Table 19 shows a summary of the studies found which have attempted to analyse products bought from their respective markets for microplastic content. These studies are not representative of the scale of the market for microplastic containing PCCPs, as in all cases the products were specifically chosen as they were known to contain microplastics—and are almost contain PE. The seven studies are ordered from newest to oldest. There have been 34 samples take—24 of these in the last five years and 21 come from products obtained within the EU. All of the microplastics in the products analysed except for the bubble bath—whose function was aesthetic—and the toothpaste—who function is to polish teeth—provided the function of exfoliation by abrasive action. No studies have yet been conducted into cosmetics that incorporate micro or nano plastics for other functions in leave-on products such as sun creams and face powders. This suggests there is a significant gap in understanding at present, with the definite need for research to be conducted in this area. The difficulty of separating much finer plastics below 1 µm may be one of the barriers to studying these other potential sources in greater depth. They are also 'less obvious' from a consumer point of view in application when compared to larger exfoliating microplastics.

Many of the major raw material plastic processors provide specific products to the cosmetics industry. Dupont produce Gotalene[363] aimed at the cosmetic exfoliating market producing PE particles ranging in size from 200 to 630 µm. Dow chemical produce a produce called Sunspheres[364] aimed at the sunscreen market. These are styrene/acrylates copolymer hollow spheres of between 300 and 350 nano meters (0.0003 mm) in dimeter. The small size range means that they would fall outside of the definition by Cosmetics Europe as their minimum size is 1 µm (0.001 mm). These spheres are used for increased ultraviolet light resistance and are designed to remain on the skin after application. The recommended concentration of between 1 and 5 percent means that each sunscreen product may contain 10 to 100 trillion particles. The scale of the use of these 'nano-plastics' in the cosmetics industry is not well understood at present—due, in part, to the lack of data from the cosmetics industry caused by the low size limit cut-off that fails to recognise these as potential plastic emissions.

Polytetrafluoroethylene (PTFE) is also sold[365] in powder form for use in face powders, blushes, mascara, eye shadow, make-up bases, sunscreens, foundations, shaving gels, creams and lotions in sizes of 5 – 13 µm. Although these are larger than the minimum size specified by Cosmetics Europe, the applications are largely for 'leave-on' cosmetic applications that fall outside of this definition.

Table 20 shows the results of a random sample of the UK PCCP market conducted by Fauna and Flora International for the Beat the Microbead campaign. The current

[363] http://www2.dupont.com/Cosmetics_Packaging_Resins/en_US/assets/downloads/Gotalene_Exfoliating_Powders_for_Personal_Care_Products042009.pdf

[364] http://www.dow.com/assets/attachments/business/pcare/sunspheres/sunspheres_powder/tds/sunspheres_powder.pdf

[365] http://www.mpipersonalcare.com/ProductDetail.aspx?id=251

database includes 214 plastic containing PCCPs, 91% of which contain PE. This shows that although PE is the predominant material there are also other sin regular use, certainly in the UK.

Table 20 – UK Plastic Containing PCCPs

Material	Plastic containing products currently in Fauna and Flora database
Polyethylene (PE)	91%
Polypropylene (PP)	1%
Polyethylene terephthalate (PET)	2%
Polymethyl methacrylate (PMMA)	1%
Nylon	5%

Source: Fauna and Flora International

In summary, the appearance, shape and size of microplastics in cosmetics can vary significantly even within the same product. They have many potential uses and it is unclear through the literature whether one use is more prevalent than another. Much of the recent attention focuses upon exfoliating 'microbeads' in products that will be rinsed off after use, however the use of PE and PET in products that are designed to be left on the skin has also been highlighted as a major potential microplastic source. As part of this study, the extent to which the literature reflects the current usage of microplastics in cosmetics is investigated.

6.3 Estimating the Proportion and Quantity of Marine Microplastics from Cosmetics

In order to quantify the proportion of microplastics that come from PCCPs—as part of task 2.1 in the terms of reference for this study— one must first investigate the wider issue of current (and past) plastic stocks in the marine environment. This is often undertaken by direct sampling of the water column or sediments to identify the concentrations of plastics present.

Recent work into this field has identified a significant gap between what has been found and what is expected to flow into the oceans. Most results from direct sampling do not match what one might expect given estimates made of emissions of (micro) plastics. This disconnect suggest that there is a major sink for microplastics that is as yet unfound.

6.3.1 Estimating the Stocks of Microplastics

From reviewing studies that have sampled plastics in the marine environment—either as the main purpose of the study or during sampling for other reasons such as for marine biota—there appear to be three main methods of sampling microplastics (and larger plastics) in the marine environment that can help to establish estimates of the overall stock:

1) Sampling of surface waters by dragging a net behind a boat both in the oceans and in estuaries;
2) Direct collection of sediments; and
3) Sampling of biota for signs of ingestion.

These methods were also discussed in a recent global assessment by GESAMP[366] which emphasised the emergent nature of sampling and analysis of microplastics and the importance of this research in marine litter science. However the GESAMP assessment also highlighted how the design and implementation of sampling plans can have a significant effect on the end result of a study and its reliability in terms of representativeness.

These methods will be discussed along with the evidence base that has been built up from studies which have employed these methods. This will lead to the current state of understanding regarding the fate and stock of microplastics in the marine environment.

---

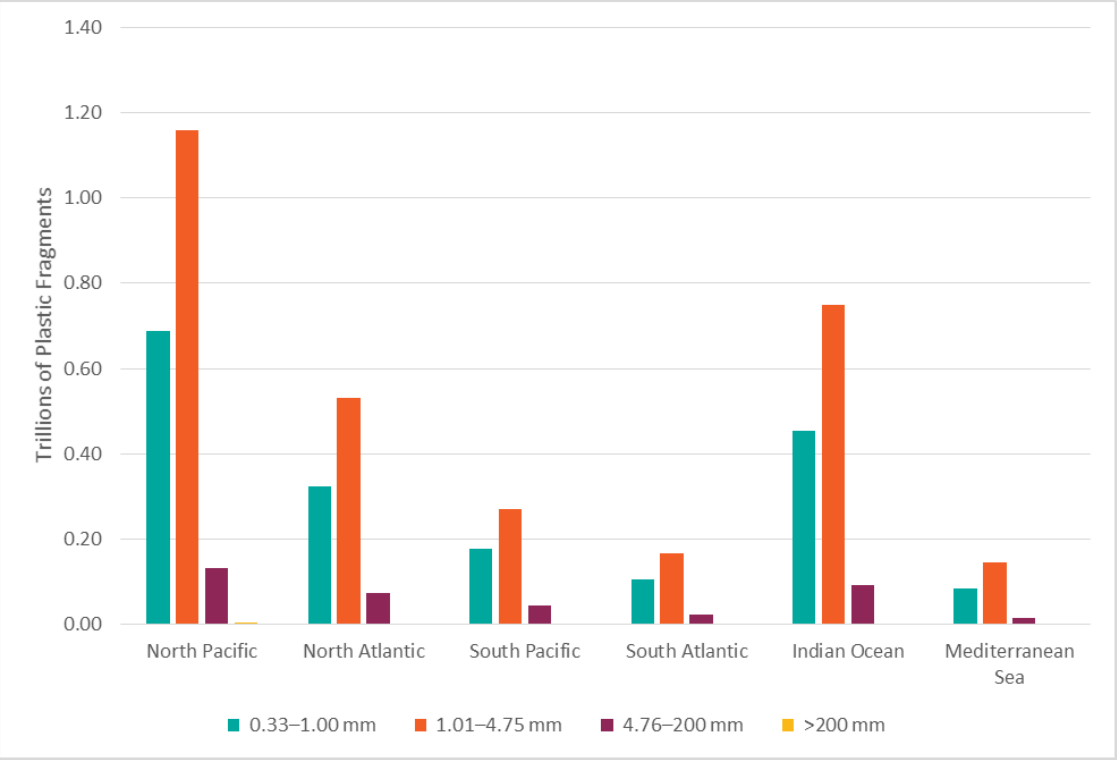
[366] GESAMP (2015) Sources, Fates and Effects of Microplastics in the Marine Environment: A Global Assessment, 2015, http://www.gesamp.org/data/gesamp/files/media/Publications/Reports_and_studies_90/gallery_2230/object_2461_large.pdf

6.3.1.1 Sampling Sea Water

Sampling of sea water is usually conducted through the use of a surface-towed trawl where a net is towed by a vessel at a pre-defined depth. The size of the net opening, the length and depth of the trawl and the mesh size can all vary depending on the size and types of plastics that are being sampled. The most common net mesh size is 333µm (0.333 mm) although sometimes larger sizes are used to prevent clogging and if a large volume of water needs to be sampled.

A recent (2014) study headed by the Five Gyres Institute attempted to quantify the amount of floating plastics in the world's oceans in terms of both number and mass[367] by using surface-towed trawls to collect plastic samples. The authors categorised plastics by size from 0.33 mm to those larger than 200 mm. Two size categories of microplastic were identified: 0.33 – 1.00 mm termed as 'small microplastics' and 1.01 – 4.75 mm as 'large microplastics'—broadly in line with the definitions adopted for this report. Although the focus of this report is on the former (small microplastics), the two microplastic classifications together account for 92.4% of the global particle count.

Figure 37 - Total Particle Count of Plastic Floating in the World's Oceans



Adapted from Eriksen et al. (Five Gyres)

[367] Eriksen, M., Lebreton, L.C.M., Carson, H.S., et al. (2014) Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea, PLoS ONE, Vol.9, No.12, p.e111913

As seen in Figure 37, however, there are far fewer particles in the small microplastics category when compared with the large microplastic category in all of the oceans studied. The study notes that as most small microplastics result from the breaking down of the larger items one would expect that the smallest sizes would be the most abundant, but this was not the case. This suggests that at least one of the following is occurring:

1) The process of sampling the oceans meant that particles smaller than 0.33 mm could not be captured and there may be a significant number of that size or smaller. This would certainly be the case for PCCP microplastics which, as already identified, are assumed to enter the oceans at a size not much larger than this.
2) There is a possibility that, in recent years, a significant increase in the release of larger plastic particles could have occurred which have not had time to degrade into the smaller particles.
3) There may be other sinks that remove the plastics from the ocean surface. Degradation, ingestion by organisms, or, as identified by Barnes *et al*[368], a decrease in buoyancy due to bio-fouling from various organisms which can lead to the microplastics sinking to the seabed.

The results of the study estimated that there are around ***268,000 tonnes*** of floating plastic in the world's oceans. Of this, ***35,500 tonnes*** (13.2%) is considered to be microplastic, 7,000 tonnes of which (2.6%) is categorised as 'small' microplastics (0.33 – 1 mm).

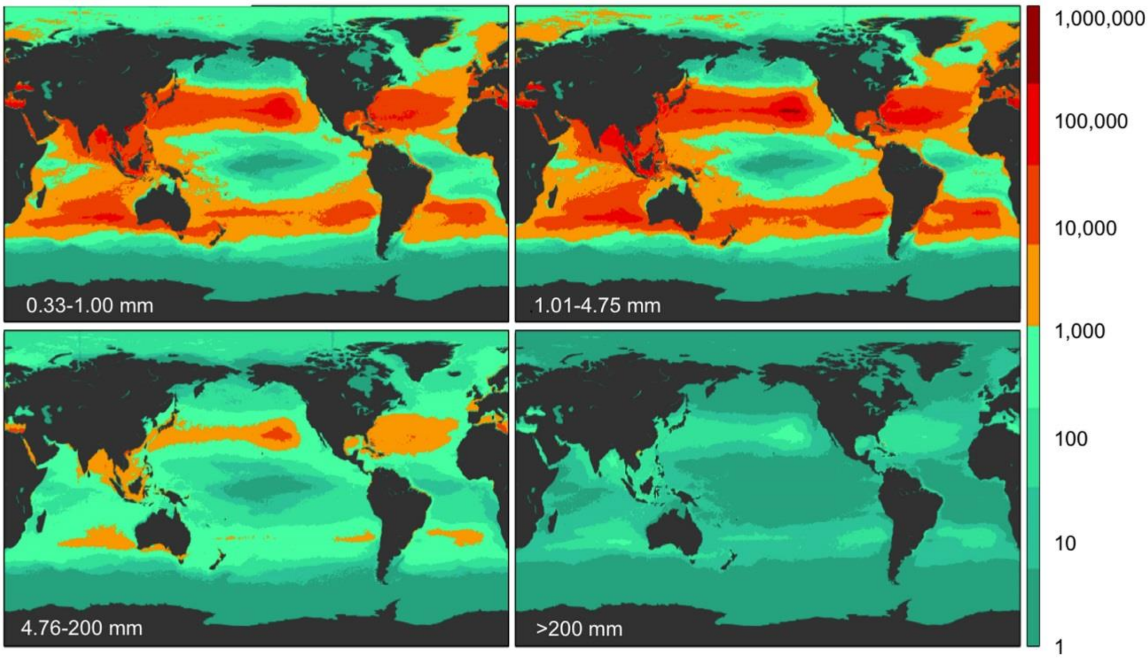
Another study, published in 2014, by Law *et al* based on twelve years' data collection by surface trawl in the North East Pacific estimated that 21,290[369] tonnes of microplastic (Categorised as 0.33 to 5mm in size) are currently floating in this area. In comparison, the Five Gyres study estimated that around 12,200 tonnes of microplastic reside in the North Pacific – the largest plastic concentration of all the oceans in the study – which is of a similar order of magnitude. Both studies found that plastics tended to accumulate in certain areas, driven by ocean currents (as seen in Figure 38) from the Five Gyres study. Law *et al* defined the 'plastic accumulation zone' in which 93% of all plastic fragments were collected: an area very similar to the high density zone (red and dark red) in the North East Pacific shown in Figure 38 which also shows the accumulation of plastic debris in the convergence zone of each of the five large subtropical gyres.

---

[368] Barnes, D.K.A., Galgani, F., Thompson, R.C., and Barlaz, M. (2009) Accumulation and fragmentation of plastic debris in global environments, Philosophical Transactions of the Royal Society B: Biological Sciences, Vol.364, No.1526, pp.1985–1998

[369] Kara Lavender Law et al (2014) Distribution of Surface Plastic Debris in the Eastern Pacific Ocean from an 11-Year Data Set, Environmental Science and Technology, Vol.48, pp.4732–4738

Figure 38 – Global Ocean Plastic Density (Predictive Model)



Source: Eriksen et al (Five Gyres)

Cózar *et al*[370] performed surface towed trawls in parts of the Atlantic and Pacific and combined the data collected with other studies including that of Law *et al*[371], bringing together data from over three thousand surface towed trawls from across the world's oceans. The trawls conducted as part of the study used nets with a mesh of 200 µm – considerably smaller than the standard size of 333 µm often used for such studies – and therefore we would expect to find a higher proportion of smaller plastic particles when compared with the previously mentioned studies. Again, this was not the case, as can be seen in Figure 39 which shows the size distribution of the captured plastic particles (blue line).

The most prevalent size of plastics found was the 1–3 mm range. Above this size, the occurrences drop sharply and below that there is also a similarly significant drop. When compared with other non-plastic particles also collected during the trawls (orange line) we find that this discrepancy in the <1 mm size range is not apparent, which suggests that – similarly to other studies on the subject – that there may be a significant sink for microplastics of this size other than the ocean surface.

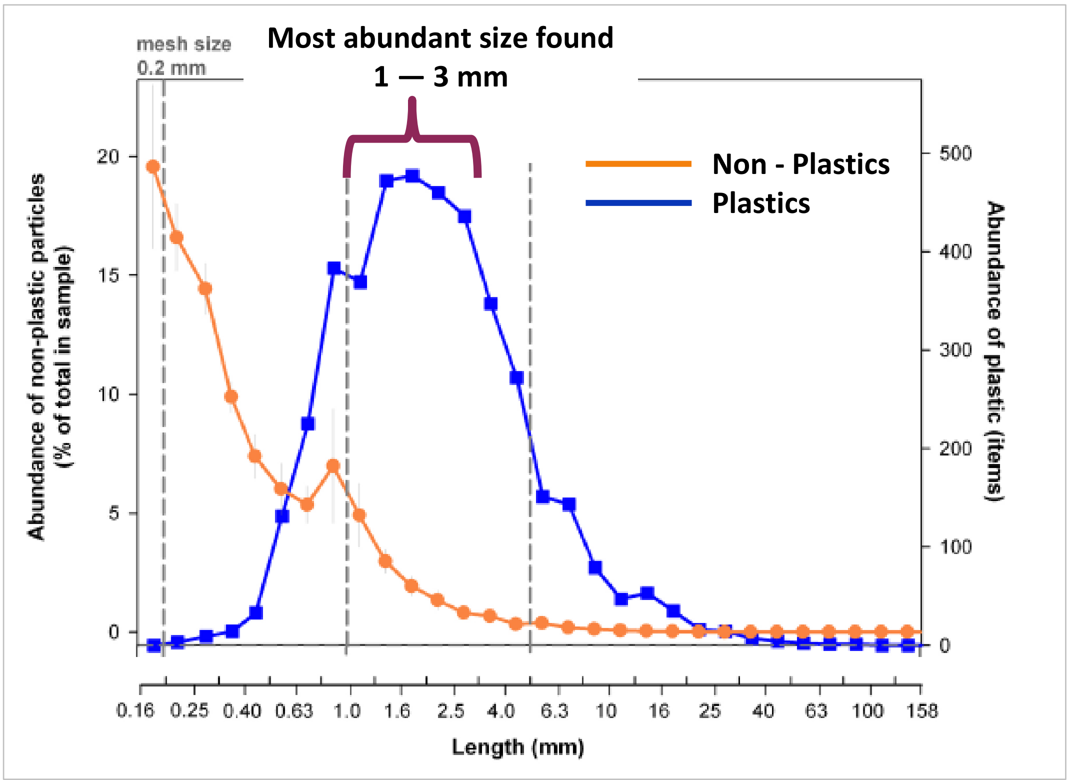
---

[370] Cozar, A., Echevarria, F., Gonzalez-Gordillo, J.I., et al. (2014) Plastic debris in the open ocean, Proceedings of the National Academy of Sciences

[371] Kara Lavender Law et al (2014) Distribution of Surface Plastic Debris in the Eastern Pacific Ocean from an 11-Year Data Set, Environmental Science and Technology, Vol.48, pp.4732–4738

The authors of the study also scaled up their sampling to create a global estimate of ***10,000–40,000 tonnes*** for all plastics. However, the authors do state that the estimate could be improved by joining up all sampling efforts particularly in the southern hemisphere and the Mediterranean where data is sparse; although these regions are unlikely to account for the magnitude of difference in the expected plastic load.

Figure 39 – Size Distribution of Captured Plastic Particles



Source: Cózar et al

Cózar *et al* estimated that their findings were one hundred fold less than would be expected. The basis for this statement was a figure gained from a 1975 study by the National Academy of Sciences (NAS)[372] which estimates 6.4 million tonnes of ***litter*** is expelled into the marine environment by marine vessels every year (at that time). Of that 6.4 million tonnes, Cózar *et al state* that 45,000 tonnes (0.7% of the total) would be plastic. The NAS study itself is often cited and in this and many other cases incorrectly interpreted. The figure of 6.4 million tonnes of litter is misquoted by Cozar as the total

[372] National Academy of Sciences (1975) Assessing Potential Ocean Pollutants: A Report of the Study Panel on Assessing Potential Ocean Pollutants to the Ocean Affairs Board, Commission on Natural Resources, National Research Council., 1975

litter expected to end up in the oceans from all sources; however, it is merely that which has been estimated to be thrown overboard from marine vessels. The figure of 45,000 tonnes of plastic quoted by Cozar appears to be arrived at based upon extrapolation from estimates of household waste composition at the time although this specific figure does not actually appear in the NAS study. Assuming that household waste composition does reflect the proportion of plastic entering the sea this would certainly be different 40 years on, especially as the discharge of litter overboard has since been restricted by the International Convention for the Prevention of Pollution from Ships (MARPOL) which entered into force in 1983. MARPOL Annex V also entered into force in 1988[373] and specifically banned plastics from being discharged from all ships and offshore platforms. Estimates for the amount of plastic entering the oceans from marine based sources are discussed in further detail in Section 6.3.2.6

This is a characteristic example of how old studies in this field are often misinterpreted or used beyond their validity to create an interesting narrative. This is largely due to the lack of more contemporary estimates that allow findings to be put in context.

There is also a lack of contemporary estimates with regard to the quantification of PCCP microplastics via sea water sampling. Very few studies have positively identified PCCP microplastics whilst undertaking sampling. One such study undertaken by the 5 Gyres Institute[374] was key to the introduction of legislation in Illinois to ban the manufacture and sale of PCCP microplastics (discussed further in Section 8.1). Although the study was undertaken in three of the fresh water Great Lakes (Superior, Huron and Erie) of North America—and therefore care must be taken in applying any conclusions to the marine environment—the findings shed new light on cities as point sources of micro plastic pollution.

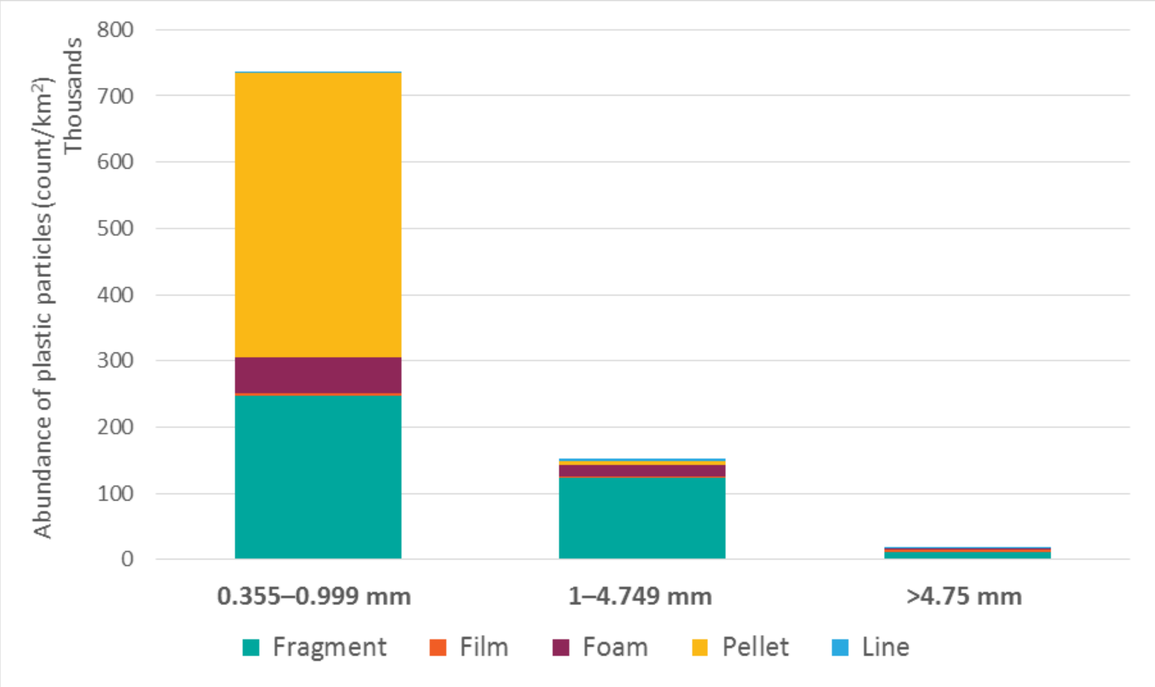
The study was conducted in various locations on the lakes with surface trawls using the sampling techniques of the 5 Gyres surveys (as Eriksen was the lead scientist on both studies). Organic and other non-plastic matter was removed after being identified using an Energy Dispersive X-ray Spectroscopy system (EDS)[375]. The results are shown in Figure 40 categorised into three size ranges and five physical shape characteristics.

[373] IMO (2012) Simplified overview of the discharge provisions of the revised MARPOL Annex V which entered into force on 1 January 2013, http://www.imo.org/OurWork/Environment/PollutionPrevention/Garbage/Documents/2014%20revision/Annex%20V%20discharge%20requirements%2007-2013.pdf

[374] Eriksen, M., Mason, S., Wilson, S., et al. (2013) Microplastic pollution in the surface waters of the Laurentian Great Lakes, Marine Pollution Bulletin, Vol.77, No.1–2, pp.177–182

[375] An Energy Dispersive X-ray Spectroscopy system (EDS) detector is used to separate the x-rays of different elements into an energy spectrum which is analysed in order to determine the abundance of different elements which is used to find the chemical composition of materials.

Figure 40 – Microplastics Found in the North American Great Lakes



Source: 5 Gyres

In the recovered samples several spherical particles coloured blue, green and purple in the size class of <1mm were suspected to emanate from PCCP sources. In order to pursue this hypothesis, PCCP products containing microplastics were analysed using the EDS system in order to compare them to the samples. It was found that they were similar in size shape and colour to those found in the lakes. Because of this, the authors point to PCCPs as being the main source of <1mm plastic—presumably in the physical category of 'pellet' (a perhaps confusing name due to pellets from plastic processors being another primary source of microplastics, albeit usually found in sizes greater than 1mm). However, it is unclear how much is directly attributable to PCCPs based on the evidence within the study.

Plastic Blasting media is one other potential primary microplastic which was discounted as a source of the microplastics found in this study. This is because the most common plastics used in this process would not be buoyant in fresh water and therefore would not be found in the surface waters of an inland lake; this may of course not always be the case in salt water.

The abundance of plastic particles was found to be greater closer to the shore lines and around cities, suggesting that cities may be a significant point source, possibly from waste water treatment plants sending their effluent out in these areas—although it is unclear whether the concentration was greatest at the point at which the waste water effluent entered the lakes. This has potentially over-inflated the count per km especially as the majority of the microplastics that were captured in two of the 21 sites were found to be at the convergence of currents and downstream from major cities. It is therefore difficult to draw any meaningful conclusions or use the results to help quantify the level of PCCP microplastic beyond that of the areas sampled.

One potentially interesting observation when comparing results with the 5 Gyres Ocean based study[376] is that in the lakes the category of <1mm microplastics is by far the most prevalent with 81% of the total number found, as seen in Figure 40. The ocean based study—which was conducted with similar equipment and sampling techniques— found that the larger 1 – 4.75 mm category was the most prevalent. Why this is the case is unclear.

Evidence of biofouling was also found in samples in the Great Lakes and is known to occur with ocean based microplastics, although to what extent this happens in either case and whether this has a large impact on buoyancy is still unknown. It is also possible that sampling near to coast lines is likely to capture more of the smaller particles before they have time to biofoul and, as indicated such a location is closest to the potential source. Out in the ocean gyres the hydraulic action of the sea may break down plastics in this size range until they are too small to be sampled.

It is clear that data available from the sampling of sea water is not currently sufficient to allow accurate estimates to be made of total plastics in the marine environment, due in part to inconsistent methodologies, but also due to the realisation that it appears that much of what is being expelled into the ocean may not end up floating on or near the ocean surface.

Table 21 shows a summary of the findings from this section. In the forthcoming sections of this report other sampling methods will be discussed in an attempt to identify and quantify the 'missing' plastics and look at more modern methods and estimates for the flow of plastics into the oceans and how they compare with estimates derived from the NAS study.

Table 21 – Global Plastic Stock Estimates (tonnes)

Study	Overall Plastics (inc. mp)	Microplastics (<5mm)
Eriksen et al	268,000	35,540
Cózar et al	10 – 40,000	-

[376] Eriksen, M., Lebreton, L.C.M., Carson, H.S., et al. (2014) Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea, PLoS ONE, Vol.9, No.12, p.e111913

6.3.1.2 Sampling Sediments

As many of the studies that have sampled sea water have pointed out there appear to be significantly fewer microplastics – especially in the sub 1 mm size range – found than would be expected.

In 2013, Cauwenberghe *et al*[377] demonstrated through direct sampling of sediments that microplastics have found their way into deep sea habitats at a depth of between 1,100 and 5,000 metres, a hitherto unexplored area of the marine environment with regard to plastic pollution. Their findings also suggest that low density polymers such as polyethylene – the most commonly reported PCCP microplastic material – could become part of this sediment even though they would normally be buoyant enough to float. Similar conclusions were arrived at by Lobelle *et al*[378] who, under laboratory conditions, submerged polyethylene in sea water and observed that after three weeks enough microbial biofilms developed to reduce the hydrophobic nature of the plastic to a point at which it became neutrally buoyant and began to sink below the surface.

Woodall *et al*[379], in the most recent deep sea sediment study available, compared their findings of the concentration of microplastics in the deep sea with the results of studies focused on the concentrations of microplastics in coastal sediments and surface water. Table 22 displays the comparative results showing that deep sea microplastics were found at 130,000 times the level of concentration found in surface waters—based on the average of five surface water studies. The level of concentration is much higher than Cauwenberghe *et al* found, due to the separation method which allowed Woodall *et al* to identify fibrous plastics. These fibres – mostly polyester and a non-plastic fibre, Rayon – were almost exclusively the only man-made particles found in the deep sea samples, with no sign of the larger particles that were described by Cauwenberghe *et al*. It is believed that these fibres could be from textiles as a result of clothes washing, and therefore they are perhaps not the 'missing' microplastics but a whole extra type of microplastic that is not often sampled.

The potential for textiles to release their fibres in washing was first studied by Browne *et al*[380]*,* who found that more than 1,900 fibres can be shed from a garment during each wash. The study also sampled beach sediments across the world and found high concentrations of plastics (0.4–6.2 fibres per 50ml) in many areas consisting of polyester (56%), acrylic (23%), polypropylene (7%), polyethylene (6%), and polyamide fibres (3%)

---

[377] Van Cauwenberghe, L., Vanreusel, A., Mees, J., and Janssen, C.R. (2013) Microplastic pollution in deep-sea sediments, Environmental Pollution, Vol.182, pp.495–499

[378] Lobelle, D., and Cunliffe, M. (2011) Early microbial biofilm formation on marine plastic debris, Marine Pollution Bulletin, Vol.62, No.1, pp.197–200

[379] Woodall, L.C., Sanchez-Vidal, A., Canals, M., et al. (2014) The deep sea is a major sink for microplastic debris, Royal Society Open Science, Vol.1, No.4, p.140317

[380] Browne, M.A., Crump, P., Niven, S.J., Teuten, E., Tonkin, A., Galloway, T., and Thompson, R. (2011) Accumulation of microplastic on shorelines worldwide: sources and sinks, Environmental Science & Technology, Vol.45, No.21, pp.9175–9179

identified by spectral analysis. Higher concentrations of microplastics were found in the beach sediments near to densely populated areas which Browne suggests is due to the effluent from waste water treatment (WWT) plants containing the fibres from clothes washing being expelled into the ocean. WWT effluent was sampled directly which confirmed the presence of the same fibres found in these sediments.

The sludge that is generated from WWT was also suspected to contain significant numbers of these fibres as, until recently, it was common practice to dispose of the sludge in coastal areas. Some of these disposal sites were also sampled which found >250% more microplastics than other sites. This is despite the fact that many of these areas, including the UK, have not practiced marine sewage sludge disposal for over a decade. This indicates the persistent nature of these plastic fibres in coastal sediments.

Table 22 – Comparative Microplastic Concentrations

Location	Pieces per 50 ml
Beach Sediment[1]	3.7
Surface Water[1]	0.00011043
Deep Sea[2]	13.4
Arctic Sea Ice[3]	0.0117

Notes:

1. Woodall et al: Average concentrations calculated from collating existing studies.
2. Woodall et al: Observed by direct observation from that study.
3. Obbard et al: Results of highest concentration of 234 particles per m^3 converted to concentration per 50 ml

Table 22 also shows another potential sink for microplastics in the form of Arctic sea ice. Although the phenomena of ice capturing suspended particles as it freezes has been suggested previously in a process known as particle enrichment[381], it was not until Obbard[382] analysed Arctic ice core samples that it was confirmed that sea ice is in fact capable of this.

---

[381] Gregory, J.M., Stott, P.A., Cresswell, D.J., Rayner, N.A., Gordon, C., and Sexton, D.M.H. (2002) Recent and future changes in Arctic sea ice simulated by the HadCM3 AOGCM, Geophysical Research Letters, Vol.29, No.24, p.2175

[382] Obbard, R.W., Sadri, S., Wong, Y.Q., Khitun, A.A., Baker, I., and Thompson, R.C. (2014) Global warming releases microplastic legacy frozen in Arctic Sea ice, Earth's Future, Vol.2, No.6, p.2014EF000240

It was found that the ice cores held between 38 and 234 particles per cubic meter, which is a substantially higher concentration than sampling of surface water has found to date. The study also highlighted that there is a growing trend for arctic ice to melt and refreeze annually with the seasons rather than remain as ice over multiple years. This could lead to up to 2 trillion cubic meters of ice melting in the next decade, which Obbard predicts could result in the release of trillions of plastic particles into the oceans.

Deep sea and coastal sediment is clearly an area that is currently under-researched in respect of plastic pollution, and there appears to be significant potential for microplastics to find their way into these areas. Currently there are no studies which have linked the plastics found in sediments with their potential source, the one exception being the large volume of fibres that have been found that can be directly attributed to clothing. It is possible that these fibres may also reside in the water column, but sampling techniques may not be capable of capturing them at present due to the commonly used net aperture (0.33 mm) being too large to capture them all—Woodall[383] found that fibres in sediments were most abundant in lengths of 2-3 mm but in diameters of less than 0.1 mm. As sediment sampling (especially in the deep sea) is in its infancy and nowhere near as established as surface water sampling it is not possible to derive estimates for the amount of microplastics that may be found there. The abundance and density of plastics in the studies conducted so far suggest it is highly likely that sediments provide the sink for the 'missing' microplastics; however, there is not enough evidence at present to quantify this issue.

---

[383] Woodall, L.C., Sanchez-Vidal, A., Canals, M., et al. (2014) The deep sea is a major sink for microplastic debris, Royal Society Open Science, Vol.1, No.4, p.140317

6.3.1.3 Sampling Biota

Marine animals have been studied for many years in order to observe the levels of plastics that have been ingested or absorbed, with plastics first found within seabirds during the 1960s[384]. Many species have since been found to ingest plastic both in the wild and in laboratory experiments. Of interest in the context of this study is the potential to study biota from the wild in order to help understand the prevalence of (micro) plastics. The following discussion provides some recent examples of how studying this area can help to provide a picture of the spatial distribution of plastics in the marine environment.

The amount of plastic ingested by the northern fulmar is one of the key indicators OSPAR uses to determine whether marine plastic is increasing or reducing over time. It states that its Ecological Quality Objective (EcoQO) to help remove the issue of litter in the marine environment is that:

> *"There should be less than 10% of northern fulmars having more than 0,1g plastic particles in the stomach samples of 50 to 100 beach-washed fulmars found from each of the 4 to 5 areas of the North Sea over a period of at least five years."*

As the fulmar forages exclusively at sea it is therefore assumed that any plastics ingested will have come from the sea via direct ingestion or via other sea creatures. They also do not regurgitate anything they ingest so the plastics will accumulate through the life of the bird[385]. The stomach contents of dead fulmars that have washed up on the shore are therefore used as an indicator for the amount of plastic litter encountered at sea.

Figure 41 shows the result of the three survey periods (conducted by Franeker *et al.*[386,387]) for the six areas which are used to indicate the prevalence of plastic in the North Sea. Broadly speaking, the areas near high population densities have a higher proportion of fulmars that have ingested plastic (i.e. The Channel and East England) when compared with the low population areas such as the Faroe Islands. However, all areas are found to have a considerably higher proportion than the ECOQO target, with very little sign that this is improving. Importantly, the ECOQO target—if and when it is ever met—does not mean that no harm will come to the fulmar as a species via the ingestion of lower levels of plastics. This harm threshold has yet to be established and the choice of the ECOQO,

---

[384] Cole, M., Lindeque, P., Halsband, C., and Galloway, T.S. (2011) Microplastics as contaminants in the marine environment: A review, Marine Pollution Bulletin, Vol.62, No.12, pp.2588–2597

[385] F. Galgani, and et al. (2010) MARINE STRATEGY FRAMEWORK DIRECTIVE Task Group 10 Report Marine litter, Report for JRC and DG ENV, April 2010

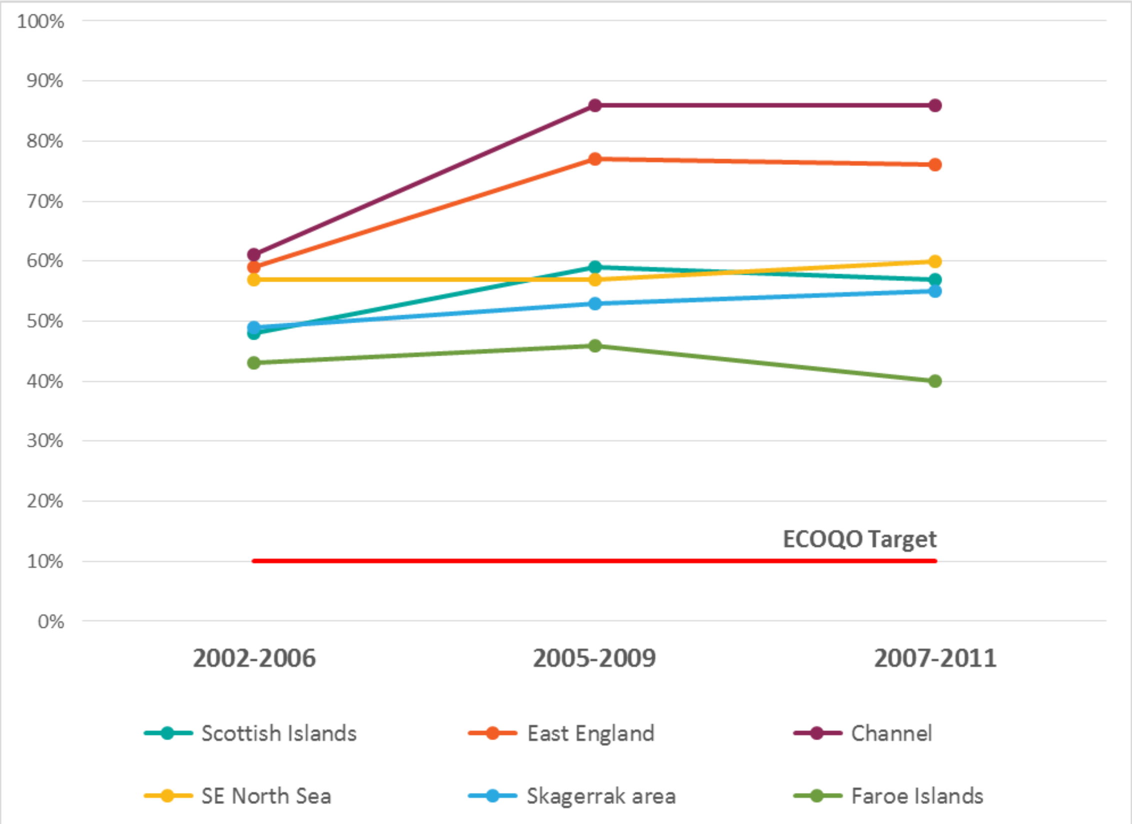
[386] van Franeker, J.A., Heubeck, M., Fairclough, K., et al. (2005) 'Save the North Sea' Fulmar Study 2002–2004: A Regional Pilot Project for the Fulmar-Litter-EcoQO in the OSPAR Area, 2005, http://www.vliz.be/imisdocs/publications/72498.pdf

[387] van Franeker, J.A., Blaize, C., Danielsen, J., et al. (2011) Monitoring plastic ingestion by the northern fulmar Fulmarus glacialis in the North Sea, Environmental Pollution (Barking, Essex: 1987), Vol.159, No.10, pp.2609–2615

although perhaps arbitrary, is meant to resemble a reference area where the levels of plastic pollution are deemed acceptable.

The study of fulmars, although useful in tracking the prevalence of marine plastics, focuses on larger sizes of >1mm. Fulmars can ingest smaller particles but this is usually through feeding on smaller marine creatures which have themselves ingested these particles whilst living amongst them in sediment of surface waters.

Figure 41 - % of Fulmars that have Ingested More than 0.1g of Plastics



Source: OSPAR

In 2013 Leslie[388] sampled five species of amphipod collected from three locations on the Dutch coastline. Microplastics in the size range 1–300µm were found in high concentrations of up to 105 particles per gram of dry matter in four out of the five amphipods, with the highest concentrations found in filter feeders.

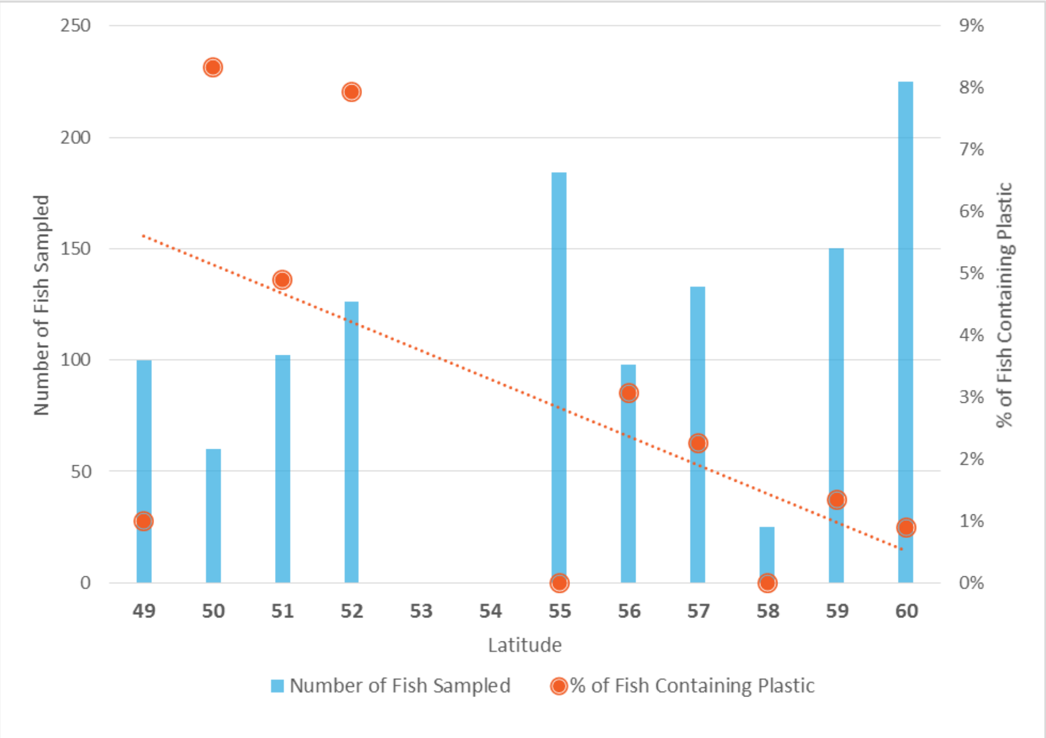
---

388 Leslie, H. (2013) Microplastic survey of the Dutch environment Novel data set of microplastics in North Sea sediments, treated wastewater effluents and marine biota, Report for RWS Noordzee, September 2013

Microplastics have also been found in zooplankton in a recent survey[389] off the coast of Canada in the North Pacific. These particles—in both fibre and fragment form—were found to be ingested in high concentrations in sizes of around 0.5mm. This is the first time that zooplankton have been studied outside of a laboratory setting and the study demonstrates how concentrations can increase further up the food chain, estimating that the salmon which feed on the zooplankton will be ingesting between 2 and 7 microplastic particles per day.

Plastics have also been found to have been ingested by North Sea fish in a study by Foekema *et al.* in 2013.[390] Similar to the study of Fulmars, the fish that had ingested the most plastic were found closer to areas of high population density and a greater number of shipping movements. Figure 42 shows the results of the study. Plastic occurrences were highest between latitudes 50°N to 52°N which covers The Channel and the Southern North Sea adjacent to the East coast of England and the coast of the Netherlands. Between latitude 55 °N and 60 °N spanning from Scotland to the Southern tip of Norway, a much reduced occurrence is observed. ,

Figure 42 – Fish Containing Plastic in the North Sea



Source: Derived from data in Foekema et al.

---

[389] Desforges, J.-P.W., Galbraith, M., and Ross, P.S. (2015) Ingestion of Microplastics by Zooplankton in the Northeast Pacific Ocean, Archives of Environmental Contamination and Toxicology, pp.1–11

[390] Foekema, E.M., De Gruijter, C., Mergia, M.T., van Franeker, J.A., Murk, A.J., and Koelmans, A.A. (2013) Plastic in North Sea Fish, Environmental Science & Technology, p.130711150255009

Through these example studies it becomes clear that the sampling of biota can be a useful indicator for the prevalence of plastic in the oceans as well as identifying the most polluted areas. The MSFD marine litter task group has recommended[391] that, along with the fulmar in the North Sea, other species are identified that will provide indicators where the fulmar is not native including species such as marine turtles, fish and even zooplankton and shellfish. The current data on fulmars and other biota does not allow any estimates to be made of absolute amounts of plastic in the ocean, however.

The sampling of biota to aid in the estimation of marine plastics may become increasingly important when more surveys of the oceans begin to give a better picture of what resides there and where the sinks for plastic are located. If reliable and accurate figures for these sinks are ever found it will potentially be at great financial cost. Repeating such studies on a regular basis may therefore be prohibitively expensive. However, the regular sampling of marine biota can be used to show a decrease (or increase) in overall marine plastics and thus be used as an indicator for policy making. This may mean that large scale ocean surveys would be unnecessary in the long term.

In the context of this study it appears that sampling of biota cannot provide the data necessary to help frame the issue for PCCP microplastics. Certainly, no studies were found to have attempted to categorise the plastics found to be ingested by source and therefore we cannot know whether any of it came specifically from PCCPs.

[391] F. Galgani, and et al. (2010) MARINE STRATEGY FRAMEWORK DIRECTIVE Task Group 10 Report Marine litter, Report for JRC and DG ENV, April 2010

6.3.2 Estimating Flows of Microplastics

According to Plastics Europe, global plastics production reached 299 million tonnes in 2013 with 57 million tonnes being produced in Europe, second only to China which produced 74 million tonnes[392]. As we find in the coming section the vast majority of this is either recycled or disposed of through residual waste treatment; only a small fraction finds its way through various paths to the marine environment, however this can still be in the order of millions of tonnes per year.

As it appears all but impossible to estimate the level of plastics pollution in the marine environment with the data and models currently drawn from direct sampling. It may, however, be more prudent to investigate a 'top down' approach to the problem by looking to current methods for estimating the annual flow of plastics from both terrestrial and marine sources into the marine environment. The following looks to the current literature base for estimates of this.

6.3.2.1 Primary Sources of Microplastic

GESAMP[393] characterise primary microplastics as particles that were originally and intentionally manufactured to be that size on the basis that potential sources will be easier to identify and mitigation measures put in place. PCCP microplastics are one such source where the intrinsic function of the product means that there is a high chance that they will end up in water bodies via waste water treatment facilities (in many cases) and eventually the oceans.

An alternate definition is proposed by a recent microplastics study for the Norwegian Environment Agency by Mepex [394] that suggests that it is of greater value to characterise primary sources as plastic "added from human society at the start of the pipe" i.e. they enter the marine environment as a microplastic. This can include unintended emissions through wear and tear of paints and clothing. In the context of this study it is believed that this approach has merit as these sources will also enter the marine environment as microplastic and therefore have the potential to have similar *immediate* impacts as those sources that were manufactured as microplastics as per the GESAMP definition. The methodology used to calculate all of these sources—both intended and unintended—is also similar, in that a top down approach is used to seek data for the

[392] Plastics Europe (2014) Plastics – the Facts 2014/2015: An analysis of European plastics production, demand and waste data, 2014

[393] GESAMP (2015) *Sources, Fates and Effects of Microplastics in the Marine Environment: A Global Assessment*, 2015, http://www.gesamp.org/data/gesamp/files/media/Publications/Reports_and_studies_90/gallery_2230/object_2461_large.pdf

[394] Mepex (2014) *Sources of microplastic pollution to the marine environment*, Report for Norwegian Environment Agency, April 2014

magnitude of the potential sources followed by applying emission factors. On that basis, this study will adopt the Norwegian definition.

The National Institute for Public Health and the Environment (RIVM) in the Netherlands was one of the first to highlight and prioritise potential sources of primary (and secondary) microplastic emissions in a report from 2014[395]. Prioritisation was assigned to sources based on the opinion of an expert panel who rated the sources due to the perceived magnitude of the emission, the achievability of reductions and the urgency due to public opinion. Although plastic packaging and any subsequent littering was seen to be the biggest priority, the following primary sources were also given high priority:

- Cosmetics (PCCP)
- Consumer Paints
- Clothing fibres
- Pellet spills
- Building site dust
- Abrasive cleaning agents
- Tyre wear

Another study from 2014, this time for the Norwegian Environment Agency by Mepex[396] highlighted further sources of interest which it attempted to quantify in the first study of its kind. On top of consumer paints identified by RIVM, Mepex also identified:

- Building paints
- Road paint
- Marine paint

Work is currently underway by RIVM to quantify the microplastic contribution from the Netherlands from detergents, paints and car tyres by engaging with industry to obtain activity data. Co-operation from industry is mixed, as many microplastic sources have not had the consumer focus that has been afforded to cosmetics in recent years. It is also understood that the Belgian government is also engaged in a similar exercise.

Whilst it is out of the scope of this study to engage with all of the industries that may contribute to microplastic pollution (PCCP microplastics aside), a review of the current level of data available has been undertaken in an attempt to show the relative magnitude of each source. This may help focus subsequent work in this area and highlight some of the significant data gaps that exist. These sources are summarised along with estimates for European emissions of microplastics (where possible) in Section 6.3.2.4 and discussed in detail in Appendix A.3.0.

[395] Verschoor, A., and et al. (2014) Quick scan and Prioritization of Microplastic Sources and Emissions, Report for National Institute for Public Health and the Environment (RIVM) (Netherlands), 2014

[396] Mepex (2014) Sources of microplastic pollution to the marine environment, Report for Norwegian Environment Agency, April 2014

6.3.2.2 Secondary Sources of Microplastic

Secondary microplastics result from where plastic has entered the ocean as a ***meso***plastic—between 5 and 25 mm—or a ***macro***plastic—larger than 25mm—and has been weathered and fragmented due to physical, biological and/or chemical processes[397] to the point where is becomes micro sized (>5mm). In keeping with the definition adopted for this report for primary microplastics, it is the size in which the plastic enters the ocean that is important.

Ultraviolet radiation from sunlight can oxidise the polymer matrix, leading to the splitting of the chemical bonds (known as bond cleavage). This can also release some of the chemical additives that are designed to increase durability whilst in use. This process is accelerated for plastic fragments on shorelines that have a greater exposure to oxygen, and ultimately leads to fragmentation from abrasion and the hydraulic action of the ocean[398]. This has been observed as a continuous process as larger pieces fragment and become smaller and smaller until the ability to detect and identify them using current methods becomes limited. Currently, the smallest size plastic particle found is 1.6µm[399] (0.0016 mm) which is considered to be ***nano***plastic in size.

6.3.2.3 Pathways to the Ocean

Although many sources of microplastic—both primary and secondary—have been identified, understanding the pathways these plastics take to reach the marine environment is important. Some emissions of microplastic, such as tyre wear, have been highlighted as a significant contributor to microplastics in the environment; however, as yet no clear pathway has been identified that allows accurate estimates to be made of how much of this ends up in the marine environment. PCCP microplastics, on the other hand, are by design typically ejected directly into household wastewater effluent and therefore reasonable assumptions can be made as to the path they take to reach the ocean. Figure 43 shows some of the possible pathways to the oceans of the sources of microplastic debris that have been identified during this study.

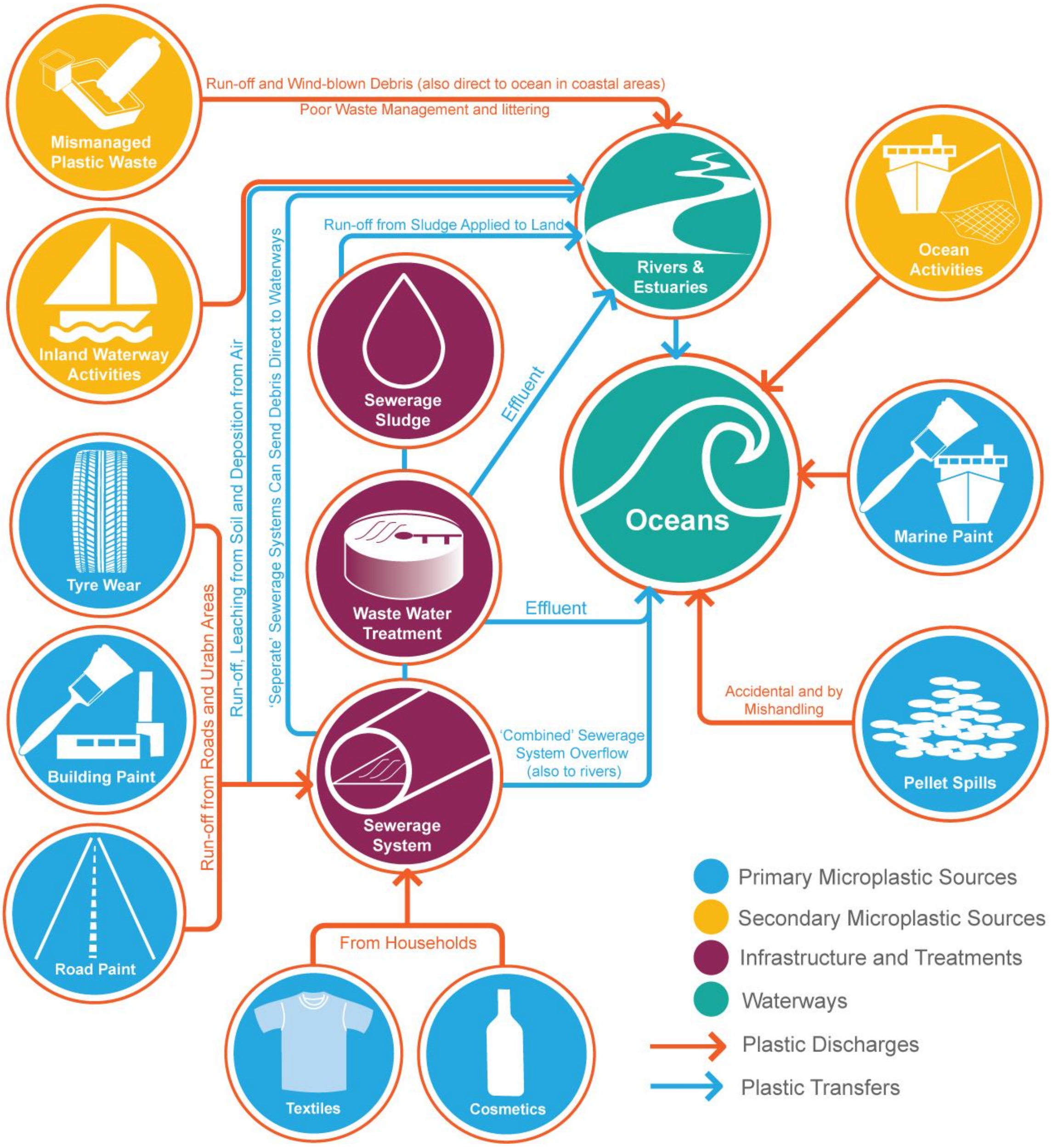
---

397 Cole, M., Lindeque, P., Halsband, C., and Galloway, T.S. (2011) Microplastics as contaminants in the marine environment: A review, Marine Pollution Bulletin, Vol.62, No.12, pp.2588–2597

398 Barnes, D.K.A., Galgani, F., Thompson, R.C., and Barlaz, M. (2009) Accumulation and fragmentation of plastic debris in global environments, Philosophical Transactions of the Royal Society B: Biological Sciences, Vol.364, No.1526, pp.1985–1998

399 F. Galgani, and et al. (2010) MARINE STRATEGY FRAMEWORK DIRECTIVE Task Group 10 Report Marine litter, Report for JRC and DG ENV, April 2010

Figure 43 – Sources and Pathways of Microplastic Debris



6.3.2.4 Primary Microplastics Estimates

A study conducted by Mepex[400] for the Norwegian environment agency (hereafter referred to as 'the Mepex study') provides the most current— and in respect of some sources, only—estimates of primary sources of microplastics. Although the study is limited in scope to Norway it still provides a useful indicator of the likely proportions of different source microplastics for Europe as a whole.

Some of the estimates are well supported with data from existing studies that have looked at these specific issues, whereas many of the estimates are a first attempt to quantify and draw attention to sources that had hitherto not been highlighted as significant sources of microplastic pollution. In many cases, the industries involved are unaware that their activities may be producing this pollution.

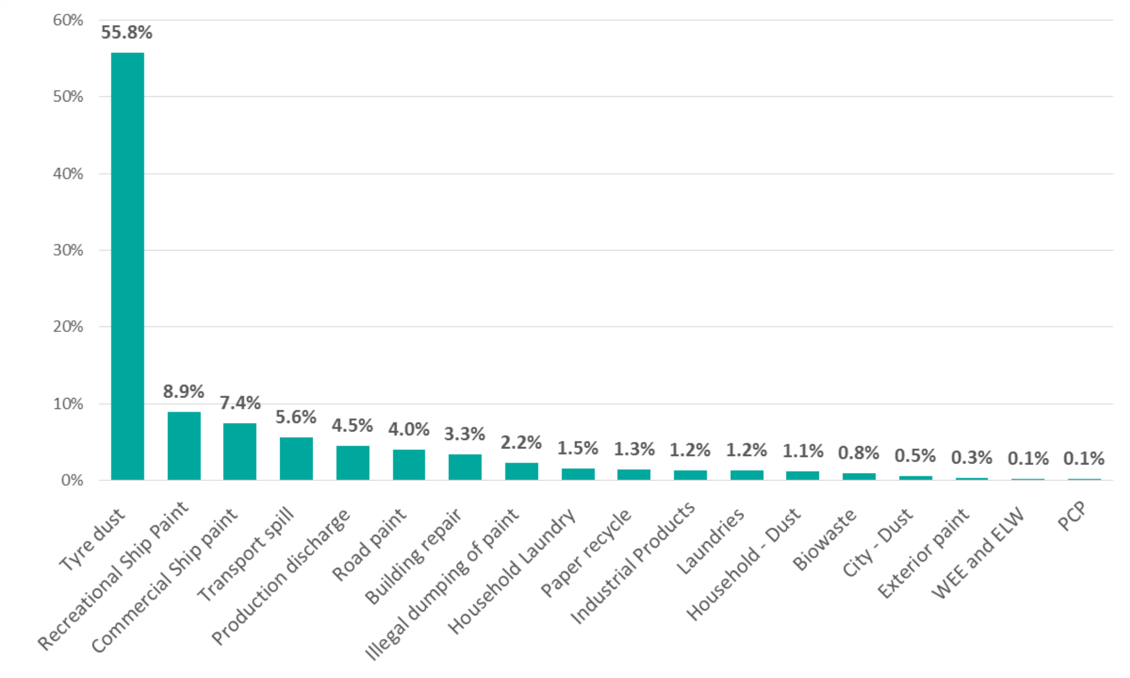
As part of this current work, the Mepex study will be reviewed and, where possible, the figures adapted and updated with additional data to encompass the whole of Europe. In many cases, however, the data available is not sufficient to provide a reasonable estimate, and in these cases attention will be drawn to the issue but no estimate will be given. However, all of the largest contributors—as identified by the Mepex study—have reasonable estimates associated with them.

As can be seen in Figure 44 the results of the Mepex study suggest that vehicle tyre wear is the most prominent source of microplastics with over 55% of the contribution to the marine environment. PCCP Microplastics are estimated to contribute 0.1% using the assumption that 90% is captured by waste water treatment plants.

---

[400] Mepex (2014) Sources of microplastic pollution to the marine environment, Report for Norwegian Environment Agency, April 2014

Figure 44 - Estimates of Primary Microplastics Proportions for Norway



Source: Mepex

Many of the categories in Figure 44 refer to different stages of the same product or service. For example, 'building repair', 'illegal dumping of paint' and 'exterior paint' all refer to the practice of painting and maintaining buildings; 'transport spill' and 'production discharge' refer to different stages of the production and transport process that may lead to plastic pellet spills. Whilst it is important to highlight where in the lifecycle these emissions occur—and therefore the pathway to the oceans—it is perhaps more important that the relevant industries see their impacts as a whole. For this reason, relevant categories will be grouped together where appropriate.

Another similar study conducted by the Nova Institute[401] on behalf of the German Environment Agency (hereafter referred to as 'the Nova study') also attempted to quantify primary sources of microplastics from a German perspective. Although not as comprehensive in scope as the Mepex study it provides some useful comparison estimates in some cases.

[401] Roland Essel, and et al. (2014) Sources of microplastics relevant to marine protection, Report for Federal Environment Agency (Germany), November 2014

6.3.2.5 Primary Microplastic Estimates Summary

Table 23 shows a summary of the estimates for each microplastic source, all of which are discussed in detail in Appendix A.3.0. The figure for PCCP microplastics is discussed in detail in Section 6.5. Estimates for some of the groups identified by Mepex such as household dust generation have been excluded based on lack of information and the potentially small contribution to the overall issue. European estimates have been made for 94% of the tonnages described in the Mepex study so that useful comparisons can be made.

Figure 45 shows the estimates by their relative contributions, which can be compared with Figure 44. This is based on the mean values between the upper and lower estimates, and therefore there is potential for the relative contributions to change as shown by the error bars.

We find that the contribution of PCCP microplastics is greater than the Mepex estimate for Norway, increasing from 0.1% to around ***3—4%.*** Tyre dust is still expected to be one of the largest contributors, but with a lower proportion than estimated by Mepex. It is also one category of microplastic emission that hasn't been positively proven to behave in the same way as other microplastics when in the marine environment; a recent study by the Dutch government[402] concluded that it was not certain whether the elastomers that are part of car tyres should be considered a microplastic in the context of marine litter. Importantly, the same study also concludes that petro-based polymers such as polyethylene—one of the common microplastics used in PCCPs—should be classed as a microplastic. If, as a result of future investigation, tyre wear is not considered to be a source of marine litter, PCCP microplastics would then be contributing to around 4—6% of the total primary microplastic emissions from Europe.

Pellet spills and building paints have higher contributions than reported by Mepex partly due to aggregation of categories and partly due to marine paint estimates being significantly lower than the Mepex estimates. Textiles have been found to potentially have a much higher contribution, although there is a very wide range in the uncertainties around how many fibres are shed during washing (a difference of 3x) and the level of capture in waste water treatment (a difference of 10x).

It is important to highlight that very few of these estimates are based on reliable data and that they should be taken as an indicator of the potential magnitude of each source of pollution. The total for PCCP microplastics is the only figure that is based—in part—on industry data (as will be discussed in Section 6.5) and therefore can be considered to be the most reliable figure. The high and low estimates of PCCP microplastic as seen in

---

[402] Anja Verschoor *Towards a definition of microplastics : Considerations for the specification of physico-chemical properties*, accessed 16 November 2015, http://www.rivm.nl/en/Documents_and_publications/Scientific/Reports/2015/augustus/Towards_a_definition_of_microplastics_Considerations_for_the_specification_of_physico_chemical_properties

Table 23 are derived from the high and low estimates of microplastic being produced by the industry, but also the high and low estimates of the capture in waste water treatment (as will be discussed in Section 6.4). Table 23 also provides an overview of the issues with data quality with suggested improvements to help achieve better estimates in the future.

Figure 45 – Annual Microplastic Emissions to the Marine Environment: Estimates for Europe

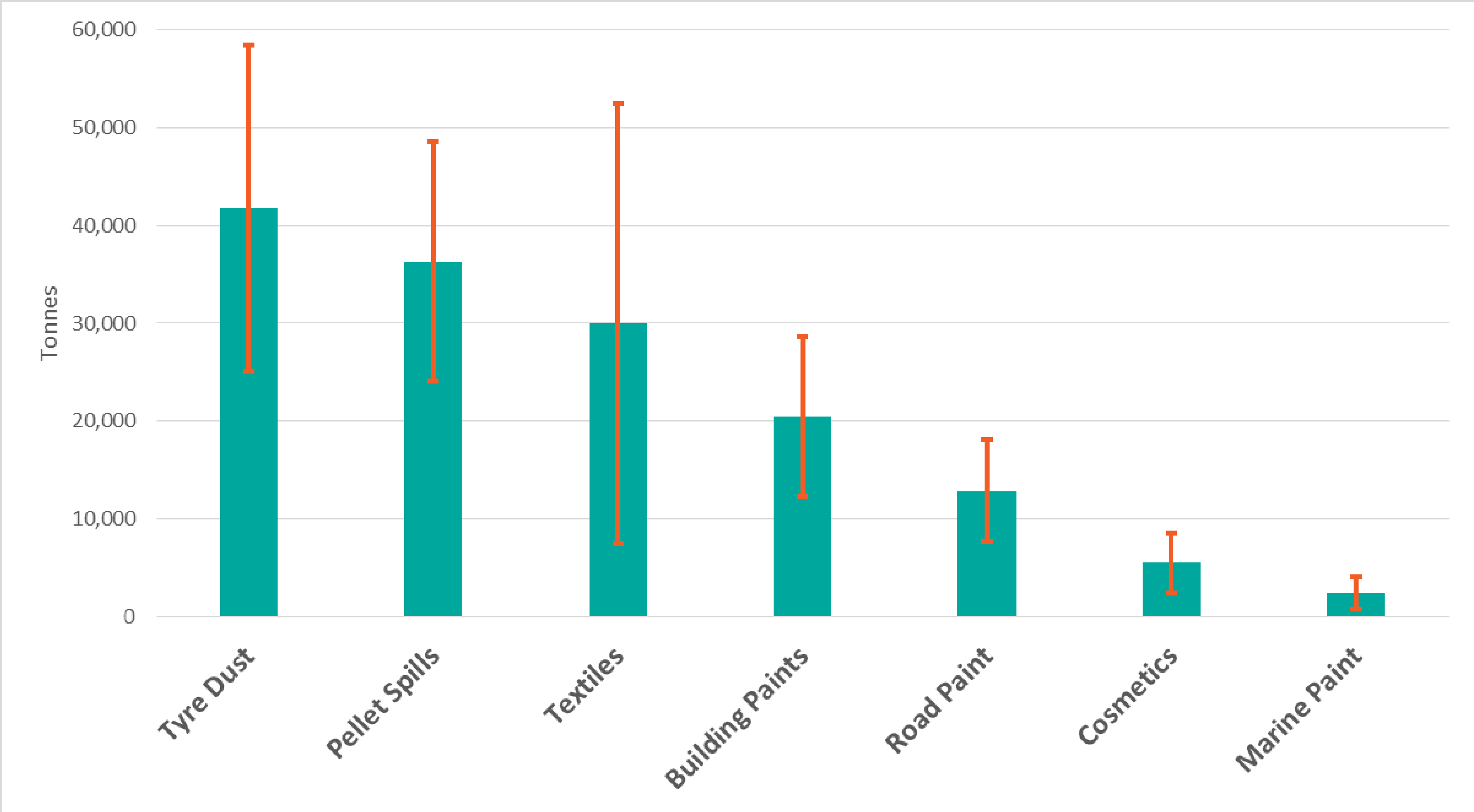


Table 23 – Summary of European Estimates of Primary Microplastic Emissions

Each data source has been evaluated against its appropriateness for time related coverage, geographical specificity and the quality of the data. Each is colour coded: Green = Reliable/representative, Yellow = Questionable, Red = Unreliable/unrepresentative. The overall conclusion on the data suitability is given by colour in the final column for each material/process.

Emission Source	Data Source	Applicability to European Scale	Year	Overall Data Reliability	Suggested Data Improvements	Upper Estimate (tonnes)	Lower Estimate (Tonnes)
Tyre Dust	Activity data for Dutch transport combined with an emission factor and particle fate analysis.	Dutch Data up-scaled to Europe	2012	Good specific data used, but scaling up from Dutch activity data may not be representative.	• Transport activity data from all EU countries. • Improved understanding of plastic content of tyre particles. • Improved understanding of the pathways to the marine environment.	58,424	25,122
Marine Paint	OECD; Paint sales estimates along with emission (to water) factors.	European Data	2002	Old emissions factor and sales figures. Little understanding of recreational market.	• Improved understanding of plastic content of paint. • Up to date sales figures. • Data on commercial vs recreation split. • Up to date emission factors.	4,056	825
Pellet Spills	One Norwegian reprocessor and OECD emission data	Mixed	Unknown	A mixture of data than is questionable in its applicability to pellet spills with nothing on a European scale	• Industry data on spills. • Data on whether initiatives .have reduced spills.	48,450	24,054
Textiles	Emission data from one small study combined with average European activity data.	European Data	2010	Upscaling from one small study and using average European activity data.	• Fibre loss from different garment types/materials. • Per country activity data. • Level of capture in WWT.	52,396	7,510

Emission Source	Data Source	Applicability to European Scale	Year	Overall Data Reliability	Suggested Data Improvements	Upper Estimate (tonnes)	Lower Estimate (Tonnes)
Building Paints	OECD; Paint sales estimates along with emission (to water) factors.	European Data	2002	Old emissions factor that may not be representative and sales figures that also may not apply specifically to this emission.	• Improved emission factors specific to the purpose. • Specific sales data. • Improved understanding of plastic content of paint particles. • Improved understanding of the pathways to the marine environment.	28,600	12,300
Road Paint	Paint sales data is assumed to equal the paint wear minus new and replacement roads.	European Data	2006	Wear rate derived from paint sales which may not be directly linked. Old sales data is also used	• Data on fate of these particles. • Improved understanding of plastic content of paint particles. • Increased understanding of whether paint sales = worn off paint. • Improved understanding of the pathways to the marine environment.	18,069	7,770
PCCP	Data from cosmetics industry via Cosmetics Europe	European Data	2012	Industry data supplied does not include all types of microplastic. Other data used to supplement is poor and incomplete.	• Annual data to monitor reduction efforts. • Expansion of scope of CE survey to include all types of microplastic. • Improved transparency of survey methods	8,627	2,461

Emission Source	Data Source	Applicability to European Scale	Year	Overall Data Reliability	Suggested Data Improvements	Upper Estimate (tonnes)	Lower Estimate (Tonnes)
Total (summary)	Very little industry derived data and emission factors have usually been developed for another purpose.	Mostly European Data	A mix of recent and older data	A mixture of data from many difference sources and timeframes means that it is difficult to apply overall conclusions and comparison of figures should be made with care.	Engaging with the industries responsible for the relevant emissions is key to understanding the issues and acquiring specific data.	**218,622**	**80,042**

6.3.2.6 Secondary Microplastic Estimates

As secondary microplastics are defined as those that have broken down from larger plastics (>25 mm) this section focuses on those larger plastics. While it is not certain that these plastics will become microplastics, it is known that over time larger plastics decay and fragment. The following estimates therefore attempt to account for the amounts of plastics flowing into the oceans that have the *potential* to become microplastics over time.

As previously identified in Section 6.3.1.1, the most commonly used estimate for the levels of plastics being transported into the marine environment comes from the 1975 National Academy of Science (NAS) study[403], which is almost certainly out of date and only attempts to identify marine sources of litter. Nevertheless, if we assume that 45,000 tonnes of plastic (as derived by Cozar[404] from the NAS study) were to have been deposited into the oceans every year since 1975 via maritime sources, we can supplement this assumption with another: as it is also estimated that 80%[405] of marine litter is derived from land based sources, together these assumptions would suggest that the total plastic entering the world's oceans every year is ***225,000 tonnes.*** (45,000/20 x100).

Of all the plastics produced only around 50% are buoyant in salt water (see Table 49 in Appendix A.4.0) which reduces the potential amount of plastic which may be found on the ocean surface to ***112,500 tonnes per year***. Lebreton *et al*[406] modelled plastic particle release scenarios which showed that 72% of maritime releases made their way to the sub-tropical gyres while the remaining 28% became 'beached'—i.e. theoretically being washed up on beaches and potentially incorporated into costal sediments. Modelling also showed up to 40% of terrestrial releases to be trapped in this way.

Therefore, this further reduces the potential tonnage of plastics that would find their way into ocean surface waters to around ***69,000 tonnes per year*** (72% of marine sources and 60% of land sources). If this has been happening at a consistent rate since 1975 (40 years)—and assuming this level has remained constant even while global plastics production has increased six fold[407] and that marine sources may have been reduced

[403] National Academy of Sciences (1975) *Assessing Potential Ocean Pollutants: A Report of the Study Panel on Assessing Potential Ocean Pollutants to the Ocean Affairs Board, Commission on Natural Resources, National Research Council.*, 1975

[404] Cozar, A., Echevarria, F., Gonzalez-Gordillo, J.I., et al. (2014) Plastic debris in the open ocean, *Proceedings of the National Academy of Sciences*

[405] There are various sources for this figure, but with little substantiation. This is discussed in detail in the 'Marine Based Sources' section.

[406] Lebreton, L.C.-M., Greer, S.D., and Borrero, J.C. (2012) Numerical modelling of floating debris in the world's oceans, Marine Pollution Bulletin, Vol.64, No.3, pp.653–661

[407] Plastics Europe (2014) Plastics – the Facts 2014/2015: An analysis of European plastics production, demand and waste data, 2014

substantially since then due to MARPOL—we would expect to find around ***2.75 million tonnes of plastics in the world's oceans***. Even considering the potential inaccuracies of these figures and the crudeness of the calculation, there appears to be a fairly significant discrepancy between what one may expect to find in ocean surface waters compared with what has actually been found to date; as identified in Section 6.3.1.1, the highest estimate for the plastics residing in surface waters is currently 268,000 tonnes.

The following sections will look to more up to date sources of data and modelling to ascertain whether this discrepancy is still found in more contemporary sources.

Land Based Sources

Jambeck *et al*[408] recently attempted to quantify land based sources of plastic that flow into the marine environment after highlighting the dearth of rigorous estimates available in the last 40 years and questioning the widely used assumption that 80% of marine litter comes from terrestrial sources, calling the claim "not well substantiated". The study sought to estimate the flow of plastic waste into the oceans by calculating how much is generated the population within 50km of the coastline of coastal countries and modelling the flow based on how much is expected to be mismanaged[409]. Out of the 275 million tonnes of plastic waste generated in 192 coastal countries in 2010 they estimated that ***4.8 to 12.7 million tonnes entered the ocean***. This is based on low, medium and high estimates of the percentage of mismanaged waste that ends up in the ocean of 15, 25 and 40 per cent respectively.

Of particular interest in the context of this study is that the plastic marine debris has been estimated for individual countries. A global ranking puts China at the top of the plastic polluters with an estimate of between 1.3 and 3.5 million tonnes of plastic debris entering the ocean per year. This is a function of population size (in close proximity to coastal areas) along with high mismanagement of waste. The authors note that sixteen of the top twenty are middle-income countries where waste management may not be keeping pace with economic growth.

If all non-landlocked EU countries are considered collectively they would rank eighteenth on the global list with between ***54,000 and 145,000 tonnes annually***. The UK contributes the most to this total due to the highest coastal population (defined as the population living within 50 km of the coast) as seen in Figure 46.

These inputs have been estimated for the year 2010; however, in order that comparisons can be made with the stock estimates the cumulative total should be calculated. This was achieved by taking the (low, medium and high) estimates for 2010 and dividing them by the plastics production for that year, and shows that the plastics

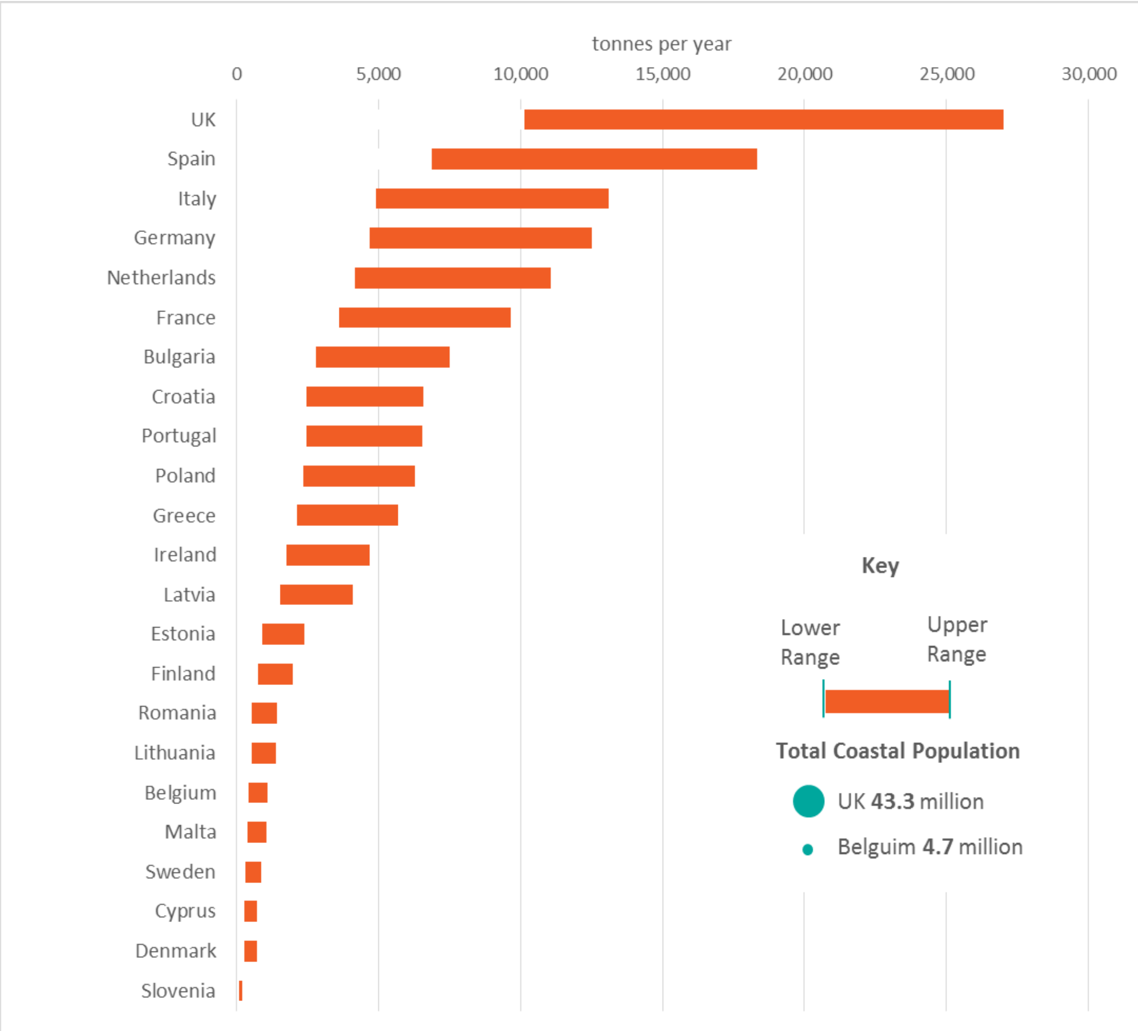
---

[408] Jambeck, J.R., Geyer, R., Wilcox, C., et al. (2015) Plastic waste inputs from land into the ocean, Science, Vol.347, No.6223, pp.768–771

[409] Per Capita waste generation rates were taken from the World Bank for the year 2005 and applied to populations for 2010 therefore the estimations are likely to be on the conservative side.

ending up as marine debris account for between 1.8% and 4.7% of the global production of plastics for that year. If this is assumed to be constant, and plastic production figures are used all the way back to 1980 and up until 2013 we can estimate the total cumulative plastics from terrestrial sources as somewhere between ***100 and 265 million tonnes.***

Figure 46 – Contribution to Plastic Marine Debris of EU Countries



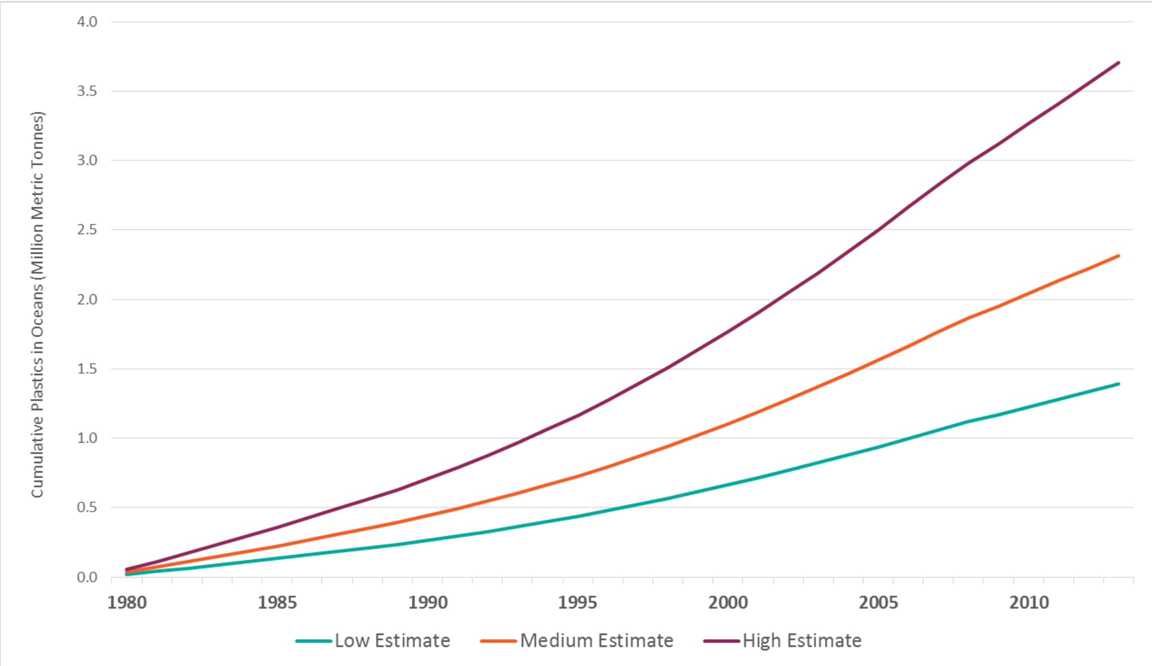
Source: Derived from Jambeck

It is possible that this may even be a conservative estimate, owing to the fact that waste management has improved vastly in the last 30 years and therefore there is a possibility that a higher proportion of plastic may have ended up being mismanaged in the past. The estimate also only takes into account secondary plastics—i.e. plastics that are not directly expelled into the ocean by design -and not primary sources such as the PCCP microplastic.

The estimate does, however, frame the magnitude of the issue as being in the order of millions of tonnes on an annual basis: *one thousand times* the magnitude found by sampling the surface waters of global oceans even without taking into account marine based sources of plastic. By contrast, the Cozar[410] assertion that the 'missing' plastics in the oceans are *one hundred times* greater than the estimates of floating plastics, now appears to have significantly underestimated the amount of plastic unaccounted for.

From a European perspective, if the same exercise is undertaken for EU countries we find that plastic marine debris accounts for between 0.1% and 0.25% of plastic production for 2010—lower than the global average due to better waste management practices and a high proportion of the world's plastics production—which equates to ***between 1.4 and 3.7 million tonnes*** of cumulative marine plastics between 1980 and 2013 as seen in Figure 47.

Figure 47 – EU Cumulative Estimates of Marine Plastics 1980 - 2013



Source: Derived from Jambeck and annual European plastics manufacture data

There have been few other attempts to quantify the flow of plastics from secondary sources; however, the reviewed literature does include some estimates that will be discussed.

---

[410] Cozar, A., Echevarria, F., Gonzalez-Gordillo, J.I., et al. (2014) Plastic debris in the open ocean, Proceedings of the National Academy of Sciences

The German Nova[411] study cites a figure from a 2006 UNEP[412] report as a means to estimate the amount of plastic entering the seas. The UNEP report states that:

> *"The total input of marine litter into the oceans was estimated at approximately 6.4 million tonnes per year, of which nearly 5.6 million tonnes came from merchant shipping".*

The literature source for these figures is not cited by UNEP; however, it is notable that the 6.4 million tonnes is the same figure as the one from the 1975 National Academy of Science study[413] which was previously shown to be potentially unreliable and certainly out of date. The Nova report interprets this figure to represent purely *plastic* litter rather than *litter* as a whole and based on plastic production figures estimates that 6% of global plastics production ends up in the oceans. This is higher than the global upper limit of 4.7% calculated from the Jambeck study and considerably higher than the 0.25% estimate for the EU.

Marine Based Sources

As already identified, one of the most widely used estimates for the proportion of marine debris coming from land is 80%, the validity of the source and data behind which was already called into question by Jambeck[414].

The origin of this figure is hard to discern; Faris *et al*[415] has often been cited, however, there is no specific mention in this conference paper regarding the source or derivation of this figure. It is also twenty years out of date. Another source which is also widely quoted—including in a paper by Greenpeace[416] via an overview provided to the UN by Sheavley[417]— is from an even earlier paper by GESAMP[418]. This paper does not directly state any assumptions about the proportion of marine debris, but only says that it is not "easy to compare, on present information, the amount of debris originating from land

---

[411] Roland Essel, and et al. (2014) Sources of microplastics relevant to marine protection, Report for Federal Environment Agency (Germany), November 2014

[412] Kristina M. Gjerde (2006) Ecosystems and Biodiversity in Deep Waters and High Seas UNEP Regional Seas Report and Studies No. 178, Report for UNEP, 2006

[413] National Academy of Sciences (1975) Assessing Potential Ocean Pollutants: A Report of the Study Panel on Assessing Potential Ocean Pollutants to the Ocean Affairs Board, Commission on Natural Resources, National Research Council., 1975

[414] Jambeck, J.R., Geyer, R., Wilcox, C., et al. (2015) Plastic waste inputs from land into the ocean, Science, Vol.347, No.6223, pp.768–771

[415] Faris, J., and Hart, K. (1994) Seas of Debris: A Summary of the Third International Conference on Marine Debris: A Summary of the Third International Conference on Marine Debris

[416] Allsopp, M., Walters, A., Santillo, D., and Johnston, P. (2006) Plastic Debris in the World's Oceans, Report for Greenpeace, 2006

[417] Sheavly, S.B. (2005) Marine Debris – an Overview of a Critical Issue for Our Oceans, Sixth Meeting of the UN Open-ended Informal Consultative Process on Oceans and the Law of the Sea, 2005, http://www.un.org/depts/los/consultative_process/documents/6_sheavly.pdf

[418] GESAMP(1991) The State of the Marine Environment, Oxford: Blackwell Scientific Publications

with that arising from fishing and shipping" (paragraph 55). There are statements that reflect total marine *pollution*, of which debris is a part, but this also includes pollution derived from the atmosphere. Therefore, there appears to be no substantiated source for this figure and certainly not one from within the last 20 years.

There is also evidence to suggest—at least on a local scale—that some marine based activities lead to a greater proportion of marine debris; for example, a study in Chile that found most litter came from marine sources in the form of Styrofoam from mussel farms.[419]

Unlike the estimates made for land-based sources, there are no recent top-down estimates available for the different sea-based activities. There is certainly no data available which specifically focuses on plastic. However, there have been many attempts to categorise the sources of marine litter that is found washed up on beaches. These surveys often occur through the use of volunteers during beach clean-ups, so the results can vary hugely based on the quality and accuracy of the recording. There is a fine balance to be struck between using a high number of categories that help to classify marine litter in the most accurate way possible and recognising that it is easier for volunteers to work with fewer categories. This problem is exacerbated when conducting such surveys on a global scale with many different languages.

A survey conducted for the USEPA[420]as part of the *National Marine Debris Monitoring Program* analysed marine debris washed up on US beaches and categorised it by source. It found that on a *per item* basis 49% was considered to come from land-based sources, with 18% from ocean-based sources. A further 33% was considered to be general debris that could have come from either source. Interestingly, most of the general category was made up from plastic, with the majority being plastic bags and beverage bottles. Because the study looked at total numbers of items rather than mass, it is difficult to draw conclusions from this that can be scaled up. For example, the largest ocean-based source was rope greater than a metre in length, which had 13,000 occurrences. From land-based sources drinking straws were the most prevalent with 65,000 occurrences. Obviously a metre long length of rope would weigh the same as many hundreds of drinking straws. This does suggest that even though only 18% of items were ocean-based, this proportion could be much higher by weight.

One of the most comprehensive global data sets available for beach debris counts comes from the Ocean Conservancy, who every year use around 600,000 volunteers worldwide to count and categorise what they find[421]. The full dataset is available for 2012 and

---

[419] Hinojosa, I.A., and Thiel, M. (2009) Floating marine debris in fjords, gulfs and channels of southern Chile, Marine Pollution Bulletin, Vol.58, No.3, pp.341–350

[420] Ocean Conservancy, and Sheavley (2007) National Marine Debris Monitoring Program - Final Program Report, Data Analysis and Summary, 2007

[421] Ocean Conservancy (2012) The Ocean Trash Index - Results of the International Coastal Cleanup (ICC), 2012, http://www.oceanconservancy.org/our-work/marine-debris/2012-icc-data-pdf.pdf

allocates 43 different materials/items into five source categories as shown in Table 7. Unlike the USEPA survey where most of the plastic packaging material was classified neither as land nor ocean based—as both could be a possible source—the 'shoreline & Recreational Activities' primarily comprises this sort of (mostly plastic) material.

One of the main issues with the approach of aggregating together the total items collected from all beach cleaning exercises worldwide is that by doing so an artificial weighting is created. Out of the 90 countries in the survey three (USA, Canada and the Philippines) account for around 60% of the items collected and therefore these countries have a greater influence over the final result and prevent a full and accurate global picture from being built. Also of concern is that there is little in the way of standardisation, and the same number of items may have come from one kilometre of beach or 100 kilometres. The latter would suggest that debris is lower but this nuance is lost in the aggregated dataset. Similarly, if one volunteer collects the same amount as ten volunteers, this would again suggest that more debris is available to collect in the former case than in the latter.

Table 24 – Estimates for Marine Litter Sources from ICC Beach Cleanups

Source	Global				EU
	Count	Proportion by Item	Proportion by Item (weighted)	Proportion by Mass (weighted)	Proportion by Mass (weighted)
Shoreline & Recreational Activities	7,250,257	65%	73%	59%	47%
Ocean/Waterway Activities	**1,003,737**	**9%**	**10.6%**	**23%**	**32%**
Smoking-Related Activities	2,475,996	22%	12%	2%	7%
Dumping Activities	242,461	2%	3%	14%	13%
Medical/Personal Hygiene	225,828	2%	1%	1%	1%
Total	11,198,279	100%	100%	100%	100%

As part of the dataset, the Ocean Conservancy has also collected data on the number of volunteers, the amount of litter collected (in pounds) and the length of beach the litter was collected along. This means that for each country a figure for *pounds collected per person per mile (ppppm)* can be derived. These figures show, for example, that the USA has a concentration of 0.002 ppppm whilst Germany has a concentration of 2.6 ppppm. This can be used as a weighting for each country (removing outliers with over 100pppm) and therefore help to find a truer picture of marine debris sources on a world scale. The results of this are shown in Table 7 (under the column labelled 'Proportion by Item (weighted)') which shows that, in particular, occurrences of marine debris from smoking related activities were unduly influenced by those countries with the highest participation rate.

Although data on a per item basis is useful for making policy decisions that help to kerb littering behaviours—as each item found is potentially an individual act of littering—it is less useful when attempting to estimate the mass of marine litter in the ocean. As already discussed there may be considerable disparities between the relative mass and number of items. Therefore, an attempt has been made to highlight the level to which this disparity may be evident by further classifying each item of marine debris by its relative weight.

Table 25 shows examples of debris categories along with a factor applied. These factors are perhaps conservative—as a plastic bag may weigh in the order of grams and fishing nets in kilograms—however, the results shown in Table 7 (in the column labelled 'Proportion by Mass (weighted)') give an indication of how applying factors such as these will affect the relative proportions. Both ocean and dumping activities have increased their proportions substantially as they contain much heavier items overall. Increasing the 'heavy' items to a factor of 100, for example, means that both categories would occupy around a quarter of the total each. It is therefore unwise to apply proportions derived from item numbers to figures that are based on mass.

Finally, it is also notable that this dataset includes countries from around the world and is not, therefore, necessarily representative of the EU. By conducting the same analysis of the data to provide proportions by mass using European countries only, we find that there are significant differences. The final column in Table 7 shows that both Oceans/Waterways Activities and smoking activities are proportionally much higher than for the rest of the world. This finding aligns well with the EU land based sources calculated from Jambeck *et al*[422], for which it was also found that the EU had a lower rate of mismanaged waste when compared to the rest of the world. This may lead to other activities accounting for a higher overall proportion as a result.

[422] Jambeck, J.R., Geyer, R., Wilcox, C., et al. (2015) Plastic waste inputs from land into the ocean, Science, Vol.347, No.6223, pp.768–771

Table 25 – Example Item to Mass Conversion Factors for Materials

Description	Factor	Example
Very Light	1	Plastic Bags
Light	10	Beverage Cans
Medium	20	Buoys
Heavy	50	Fishing Nets

The results of this exercise show that, by weight, ocean based marine debris may count for considerably more than many studies using unit counts would suggest. It is difficult to make strong estimates without more knowledge of the types of debris found during the Ocean Conservancy survey. If individual objects were weighed during clean-up, or a representative sample taken that would allow more accurate weights to be assigned to each category, then a more improved picture could be developed. With the potential that not all of the ocean/waterway activity category can be assigned to purely ocean based sources and considering that relative mass estimates may be underestimated, a range of ***between 20 and 40% for Europe*** will be used as an estimate of the proportion of marine debris from marine sources. A lower range of between ***10 and 30% for global estimates*** will be used, which accounts for the higher proportion of land based sources found in the global dataset.

Riverine Studies

Using similar methods to the ones used to estimate the total stocks of surface water marine plastics it is also possible to generate estimates of the annual flow of plastics into the oceans by sampling rivers for plastics using static nets instead of moving trawls. It is possible to capture both primary and secondary microplastics, although in many cases the size of the nets used is >3mm and therefore most microplastics are not captured. However, there is potential for an amount of double counting when combining estimates of primary sources of microplastics and the results of riverine studies

This approach has its limitations, especially when sampling of a single river is used to scale up for a global estimate, as varying catchment areas, varying populations close to the river basins, tidal estuaries, currents and weather at or around the time of sampling can all affect the level and size of plastics captured. The following is an overview of some of the studies in the emerging field of riverine plastic sampling, from which the total transportation of plastics can be estimated.

One such study was conducted in the Danube by Lechner *et al*[423] who estimated that 1,533 tonnes of plastics flowed through the Danube into the Black sea every day. The study used static drift nets that could capture plastics in the size range of 0.5 – 50 mm. It was noted that therefore this estimate would be on the low side for plastic debris as a whole as the drift nets could not capture particles smaller than 0.5 mm or anything larger than 50 mm that would be floating on the surface just above the net frame.

With the Danube annual average discharge estimated to be 202 km^3/yr[424], 1,533 tonnes equates to a plastic flow rate of 7.5 tonnes per km^3 per year. As previously identified by the 5 Gyres study, 75% of plastic debris by weight is larger than 200 mm. If the same is true for rivers, this would suggest that plastic debris flowing through the Danube could be as much as 30 tonnes per km^3 per year (7.5*4). With global river discharge estimated to be 37,288 km^3/yr[425] the total plastics flowing from rivers to the ocean could be around ***1.1 million tonnes per year***. This may be overestimating for sparsely populated areas with larger rivers such as the Amazon but possibly underestimating for countries such as China with large populations near rivers and coastal areas.

The results of the Danube study—which was originally intended to sample fish larvae—sparked a further study by the Austrian Environment Agency (Umweltbundesamt) to improve on the methodology for sampling in rivers and to discover the overall contribution of riverine plastics by Austria. This was undertaken by designing stationary drift nets that captured plastics where the Danube enters Austria from Germany and where it leaves for Slovakia, the theory being that Austria's contribution to the litter being transported down the Danube could then be calculated.

Austria is unique in that 96% of its surface runoff becomes part of the Danube and 7.7 million people inhabit the basin (92% of the population). Because of this, and because of the fact that Austria is completely landlocked, it is therefore possible to assume that 92% of the plastics that end up in the marine environment from Austria are transported via the Danube. The study is yet to be fully published at the time of writing; however, initial results estimated that 40 tonnes[426] of plastic are carried down the Danube from Austria each year. Sampling was conducted at various depths and points across the cross section of the river to obtain a clearer picture of what was being transported. Mesh sizes of 500µm and 250 µm were used to capture the plastics, which could mean that many of the primary sources of microplastic are missing from these results. This is a typical

---

[423] Lechner, A., Keckeis, H., Lumesberger-Loisl, F., et al. (2014) The Danube so colourful: A potpourri of plastic litter outnumbers fish larvae in Europe's second largest river, Environmental Pollution, Vol.188, pp.177–181

[424] Aiguo Dai, and Kevin E. Trenberth (2002) Estimates of Freshwater Discharge from Continents: Latitudinal and Seasonal Variations, Journal of Hydrometrology, Vol.3, pp.660–687

[425] ibid

[426] Karl Kienzl, and Deputy Managing Director, Environment Agency Austria (2015) Plastics in the Environment Activities in Austria, paper given at Brussels, 5 November 2015

limitation of net based sampling due to the potential for fouling if smaller apertures are used.

To put Austria's annual plastic river discharge of 40 tonnes in perspective, this would equal 5 grams of plastic per person in Austria (around 2,500 tonnes in total for the EU). This appears to be a very small amount when compared with some of the source estimates for primary microplastics discussed in Section 6.3.2.4; for example, tyre wear alone may account for around 1kg of microplastic per person per year. Assuming primary microplastics were not well captured by the study, this figure still seems remarkably low.

Another study from California[427] estimated that, after a period of wet weather, during one single day over 5,000 tonnes of plastic were estimated to have flowed through the Los Angeles River—the equivalent of over 14,000 t/km^3/y (based on an average daily flowrate for the river of 354,592 m^3). A similar wet period yielded 750 t/km^3/y and a dry period 330 t/km^3/y—significantly less but still around 50 to 100 times the amount estimated to flow through the Danube. The aim of the study was to draw attention to sub 5 mm sized plastics as Californian state law determines that "debris of human origin" is regulated at sizes of 5 mm and above. It is unclear how much, if any, macro-plastic debris was captured as anything above 4.75 mm was aggregated together. The largest sized aperture of the collection devices used was 0.46 metres, although no indication was given as to whether any significantly large pieces were captured. Even the lowest estimate of plastic flow from the Californian example would suggest a global flow of 50 million tonnes per year—around 15% of the global production of plastic—which would seem to be unrealistic.

A recently published study[428] for the European Commission looked to monitor the litter being transported down four European rivers (the Rhine, Dalålven, Po and Danube) to assess amounts discharged into the sea. Values for the total plastics transported down three of the four rivers are shown in Table 26. This is set against the annual average discharges, which shows a large disparity in the density of plastic being transported between different rivers, with the Rhine appearing to be transporting relatively little for its size. The results for the Danube are also three times smaller than estimated from Lechner *et al*[429]. The equipment used should also have collected more plastics as the aperture in the water sampler was 500mm at its smallest dimension—larger than that maximum sampling size of 50mm for Lechner. Similarly, for microplastics sampling a

[427] Moore, C.J., Lattin, G.L., and Zellers, A.F. (2011) Quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California, Journal of Integrated Coastal Zone Management, Vol.11, No.1, pp.65–73

[428] Tweehuysen, G., Peterlin, M., Van der Meulen, M., Van der Wal, M., and Sherrington, C. (2014) Identification and Assessment of Riverine Input of (Marine) Litter. Second Progress Report for the European Commission DG Environment under Framework Contract No ENV.D.2/FRA/2012/0025, 2014

[429] Lechner, A., Keckeis, H., Lumesberger-Loisl, F., et al. (2014) The Danube so colourful: A potpourri of plastic litter outnumbers fish larvae in Europe's second largest river, Environmental Pollution, Vol.188, pp.177–181

mesh size of 333µm was used compared with Lechner's 500 µm. Scaled up to a global level using the average of Tweehuysen *et al*, the total amount transported in global rivers would be around 75,500 tonnes. When compared with even the lowest global estimate for mismanaged coastal based sources from Jambeck *et al*[430] of 4.8 million tonnes, this seems low.

There are many factors at play which influence how much riverine plastic will be transported every year, however. A study using a similar methodology to Jambeck but for inland sources from rivers has yet to be carried out—i.e. mapping populations within river basins and estimating mismanaged waste to create top down estimates.

Early studies have shown the variability of the results of riverine studies, even between those conducted on the same river (and even within the same study on the same river but at different times). Despite these difficulties, as riverine sources of plastic will be a considerable source of marine plastics some estimate as to the magnitude will therefore be made.

The above estimates give a global figure of anywhere between 75,000 and 1.1 million tonnes. Adjusting this to Europe is troublesome due to the complexity of analysing exactly where river basins lie and the fact that many of them cross borders. An estimate will be made relative to the land based sources from Jambeck, which estimated (at the mid-point) 8 million tonnes of plastic per year globally. The riverine estimates represent between 1 – 14% of this. Applying this to the estimate for land based sources (54,000 – 145,000 tonnes) results in an ***estimate of riverine plastic sources of between 500 and 20,000 tonnes***. The scaled up European estimate (2,500 tonnes) from the Environment Agency Austria fits in the lower end of this scale.

Table 26 - Tweehuysen et al Riverine Study Results

River	Plastic Transported per year (tonnes)	Annual Discharge (km^3/yr)	Tonnes transported per km^3 per year
Rhine	30	75	0.4
Danube	500	202	2.5
Po	120	55	2.2
Total	650	332	1.95

Notes:
Annual discharge rates taken from Dai et al[431]

[430] Jambeck, J.R., Geyer, R., Wilcox, C., et al. (2015) Plastic waste inputs from land into the ocean, Science, Vol.347, No.6223, pp.768–771

[431] Aiguo Dai, and Kevin E. Trenberth (2002) Estimates of Freshwater Discharge from Continents: Latitudinal and Seasonal Variations, Journal of Hydrometrology, Vol.3, pp.660–687

6.3.2.7 Secondary Microplastics Estimates Summary

The overall estimates for potential secondary microplastic flows are shown in Table 27. These are the plastics that may break down into microplastics but do not enter the marine environment as such. This combines the three approaches that are capable of deriving tonnage figures on a European and global scale:

- The land based sources account for the mismanaged waste in coastal areas based on a top down approach.
- The riverine studies have provided an estimate for mismanaged waste that comes from inland sources and is subsequently transported to the ocean via rivers; this uses a bottom-up approach.
- Marine sources of plastic litter estimates are derived by taking beach sampling data to arrive at a relative proportion that is applied to the land based sources; this uses a bottom up approach.

Table 27 – Summary of Secondary Plastic Flow Estimates

Plastic Source	Approach	Study Basis	Global Estimate (tonnes per yr)	EU Estimate (tonnes per yr)
Land (Coastal)	Global mismanaged plastic waste (coastal).	Jambeck *et al* (2015)	4.8 – 12.7 million	54,300 – 145,000
Land (Inland)	Riverine plastic sampling data scaled up by using global river discharge.	Lechner *et al* (2014), Tweehuysen et al (2015)	0.075 – 1.1 million	500 – 20,000
Marine	Beach Survey data used to derive the proportions of marine litter sources.	Ocean Conservancy (2012)	0.541 – 5.9 million[2]	13,700 – 110,000[1]
Total			**5.42 – 19.7 million**	**68,500 – 275,000**

Notes-

1. European marine sources are estimated to account for 20–40% of total input; this is therefore proportional to the sum of the coastal and inland figures.
2. Global marine sources are estimated to account for 10–30% of total input; this is therefore proportional to the sum of the coastal and inland figures.

6.3.3 Summary of Microplastics Estimates

In order to attempt to identify the proportion, and quantity, of microplastics in the marine environment that can be attributed to cosmetics products, the literature base has been thoroughly reviewed. This includes all recent scientific studies that seek to quantify level of plastics in the marine environment. Global estimates for the stocks of plastics currently in the marine environment have only very recently been available due to the time consuming nature of the direct sampling of ocean gyres. However, these are still limited to surface waters and show that there is a clear gap between the amounts one would expect to find, based on the influx of plastics to the marine environment, and what has actually been found.

Sediment sampling studies, both in coastal areas and in the deep sea have identified that a large sink for these plastics may exist. However, most of the microplastics that have been found in these areas are fibrous in nature and therefore are thought to be attributable—at least in part— to the washing of textiles. Whether the low proportion of particulate type microplastics found in sediments is due to these particles (which would include PCCP microplastics) currently residing in a part of the marine environment as yet unstudied, (i.e. their absence from sediments) or whether the sheer number of fibres from clothing is on a scale greater than initial studies into the field have estimated is unknown. What the estimates of the flow of plastics into the ocean on an annual basis do suggest is that more PCCP microplastics should have been found than have currently been detected. This study estimates that this differential could be up to a thousand fold, which is considerably higher than some other recent estimates.

Because of the difficulty in estimating the overall stocks of plastics (and microplastics) in the marine environment it is therefore impossible within current understanding to determine how much of these can be attributed to cosmetics. Instead, the approach taken was to seek to define the annual proportional contribution of microplastics to the marine environment from PCCP microplastics relative to other sources.

Table 28 shows the results of this approach. The total annual European plastic discharge is estimated to range from 148,500 to 494,000 tonnes per year. One of the key findings is that a significant proportion of this is expected to be attributable to primary microplastics i.e. plastics that enter the marine environment as a microplastic (<5mm). Studies from Norway, the Netherlands and Germany have recently highlighted potential primary sources of microplastic that have not been recognised as a potential contributor to marine litter—at least not on the scale that this report finds—until recently. Textiles, paint and car tyres may all be significant microplastic sources that require further investigation as to their magnitude beyond the first order estimates presented in this report.

Plastics that enter the marine environment have the potential to become secondary microplastics, but may not immediately do so. Although it is expected that all plastics in the macro (>25mm) and meso (5—25mm) sizes will eventually degrade to microplastic sizes local conditions will have a large effect on this process.

Table 28 – Summary of Annual European Plastic Discharge

Microplastic Type	Annual Europe Ocean Discharge (t)
Primary	80,000 — 219,000[1]
Secondary (Potential)[2]	68,500 — 275,000
Total	148,500 — 494,000

Note:

1. Figures rounded to three significant figures from ***Table 23***
2. Secondary plastics is an estimate of plastics larger than microplastics (>5mm). These are plastics that enter the marine environment with the *potential* to become microplastics.

Potential secondary sources of microplastics have been found to come largely from mismanagement of waste in coastal areas from the work conducted by Jambeck.[432] This work, the first of its kind, is very theoretical and would benefit from more localised studies into just how much waste is mismanaged in reality. The second largest secondary plastic contributor was found to be from marine sources. We find that this source may be larger than the 20%/80% sea/land split that is often quoted and may be as high as 40% but, again, there are a large number of assumptions that have been made to arrive at this figure. Beach litter studies are the primary source of data for this estimate and we find that the outcomes of these surveys can vary hugely depending on how the litter is categorised. Further assumptions are also required to translate the results from unit numbers to tonnages. These data inadequacies and layered assumptions mean that estimates for the contribution from marine sources are highly speculative, however it is hoped that by highlighting these issues that there may be potential for further surveys and studies of this kind to be mindful of the ways in which the data they can provide may be used for wider purposes.

Finally, riverine data, whilst potentially introducing an element of double counting due to the chance of detecting primary microplastics is the final 'piece in the puzzle' in understanding the flows of potential secondary plastics. Early studies of the kind from California and Austria vary wildly in their estimates because of the variability in the volumes of plastics that are transported both from day to day and within different parts of a river. This, coupled with the fact that each river will have very different catchment characteristics and population levels means it is very difficult to create a meaningful

[432] Jambeck, J.R., Geyer, R., Wilcox, C., et al. (2015) Plastic waste inputs from land into the ocean, Science, Vol.347, No.6223, pp.768–771

European average without studying every river basin in Europe. Nonetheless some of the more recent studies with improved capture methodologies and specific aims to quantify the flow of riverine plastic have made estimates that are not too dissimilar from each other and therefore an order of magnitude can be derived.

With these first order estimates of primary and secondary plastics flowing into the marine environment from Europe, we have a baseline for which to compare the flow of PCCP microplastics. The following sections will attempt to quantify the PCCP microplastic flows and provide an estimate for the overall contribution to the marine plastic problem from a European perspective.

6.4 Capture of Microplastics in Wastewater Treatment

Although it has been identified that PCCP microplastics will almost certainly end up in sewerage systems and consequently waste water treatment (WWT) plants, until recently little was known about the proportion likely to be captured during the purification process. However, a number of recent studies have now been conducted, particularly in countries bordering the Baltic Sea.

Leslie *et al*[433] conducted the first of these in 2012, in which—from limited sampling—it was found that around 90% of the plastic particles that were suspected to enter the WWT plant were captured during either primary or secondary sludge stages. The samples were taken at the same time daily, and therefore it is difficult to accurately apply the findings to determine an overall removal efficiency.

A follow up study by Leslie[434] in 2013 attempted to build on the previous findings by sampling multiple WWT plants in the Netherlands. The collected samples were mixed with a salt solution which allowed the microplastics to float to the surface for microscopy analysis into two size categories: 0 – 300µm and > 300µm. Interestingly, the results show that in one of the plants the use of a membrane bioreactor (MBR) as a tertiary filtration process—with a mesh of 0.7µm—did not reduce the number of particles in the effluent: the mean number of particles per litre of effluent was 51 with this process compared to 48 without.

As seen in Figure 48, the Netherlands has the highest percentage of tertiary treatment in the EU (99%) and as seen in Figure 49 all of the sludge generated is incinerated. Therefore, one would expect the Netherlands to be one of the lowest emitters of PCCP microplastics to the environment in the whole of the EU. Despite this, there still appears to be a significant amount not being captured by the WWT process even where the highest standards of filtration are applied.

Similarly, a 2015 study from the New York State Attorney General's Office[435] found that out of 34 WWT plants sampled in New York State, 25 were releasing PCCP microplastics in their effluent. Of the nine that did not, six incorporated some form of tertiary advanced filtration process. The presence of PCCP microplastics in particular could only be confirmed by positively identifying perfectly spherical microplastics through a microscope. Although it is known that PCCP microplastics can be spherical or irregular, it is difficult to differentiate the irregular shapes from other sources. For this reason, it is

---

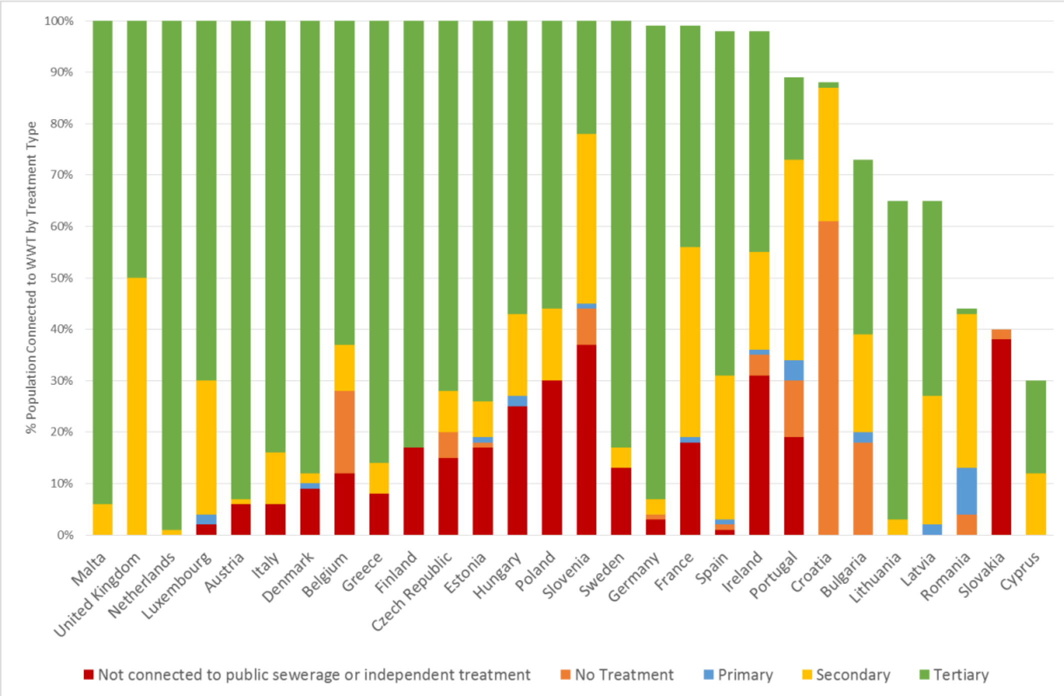
[433] Leslie, H., and et al. (2012) Verkennende studie naar lozing van microplastics door rwzi's (Pilot study on emissions of microplastics from wastewater treatment plants), H2O, No.14/15, pp.45–47

[434] Leslie, H. (2013) Microplastic survey of the Dutch environment Novel data set of microplastics in North Sea sediments, treated wastewater effluents and marine biota, Report for RWS Noordzee, September 2013

[435] Nalbone, J. (2015) Discharging Microbeads to Our Waters: An Examination of Wastewater Treatment Plants in New York, Report for The Environmental Protection Bureau of the New York State Attorney General's Office, April 2015

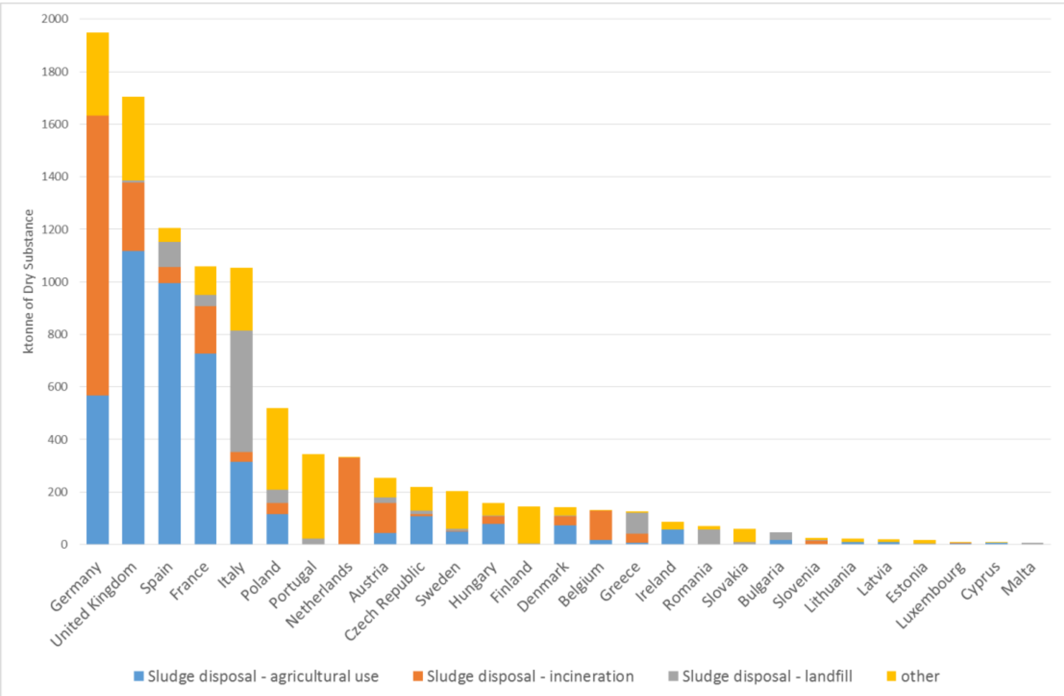
possible that PCCP microplastics may have passed through the other nine plants without being identified as such.

Figure 48 - Percentage of EU Population Connected to WWT (2011)



Source: Eurostat and OECD

Figure 49 – Sewage Sludge Disposal Routes in k-tonnes (EU-27)



Source: Eurostat

A recent study from Russia has sought to increase the understanding of plastic particle capture in WWT based on data collected during a 24 hour period from a St Petersburg WWT plant[436]. An experiment was designed to capture non-organic particles and fibres from samples of both the influent and effluent using a mesh of 200 µm in order to identify whether a difference occurs. The study does not differentiate the findings by the size of the captured particle, only the shape; however, in all cases the results suggest that around 95% (by number count) of the plastics suspected to enter the WWT plant are captured during the process. The captured plastics would be suspended in sewage sludge, which is most often then applied to agricultural land as a source of fertiliser. The results from this study should, however, be taken with caution as they come from one WWT plant over a period of 24 hours. It is unclear how representative this would be across Europe.

In 2014 the Swedish Environmental Research Institute conducted two studies, in Sweden[437] and Norway[438], looking at WWT plants in each country using a similar method to the one used during the Russian study. Norway conducted sampling in one WWT plant: two samples from influent and two from effluent. The retention efficiency was found to be between 97% and 99% for particles ≥300 µm, and 87–97 % for particles ≥20 µm. This is for both synthetic and non-synthetic particles; non-synthetic particles were almost exclusively textile fibres such as cotton, which the Swedish study suggests are retained in WWT to a larger extent than synthetic particles. Although the reasons for this are not suggested in either report, cotton is negatively buoyant and therefore is far more likely to sink into the sludge during the sedimentation process (compared with positively buoyant polyethylene).

The Swedish study took three samples from three WWT plants sized between 12,000 to 750,000 population equivalents[439] (pe), finding a retention rate of 70 – 100% for all types of particle. The study also found that passing the waste water through a sand filter made no difference to the retention rate. However, a membrane bioreactor (MBR) increased the capture of smaller sized particles by 90% (over WWT plants that did not have this technology). Of particular interest are different findings between plants when the data was normalised to the size of the plant. This revealed that the amount of microplastics

[436] Baltic Marine Environment Protection Commission (HELCOM) (2014) Synthetic microfibers and particles at a municipal waste water treatment plant, Report for BASE Project - Implementation of the Baltic Sea Action Plan in Russia, 2014

[437] Magnusson, K., and Wahlberg, C. (2014) Mikroskopiska skräppartiklar i vatten från avloppsreningsverk (Microscopic particles of debris in the water from sewage treatment), Report for IVL Svenska Miljöinstitutet, August 2014

[438] Magnusson, K. (2014) Mikroskräp i avloppsvatten från tre norska avloppsreningsverk (Micro Debris in wastewater from three Norwegian sewage treatment), Report for IVL Svenska Miljöinstitutet, December 2014

[439] WWT pants are sized based on the population they serve. Population equivalents are based on the Biochemical Oxygen Demand (BOD) in the household wastewater produced by one person.

moving through the plants per hour can vary by up to 15 times between plants, although the variation in capture rate was not as great.

Another study[440] from Germany further demonstrates the variability between WWT plants. With 12 plants studied, particles were found in concentrations of between 86 and 714 per m^3 of effluent and fibres between 98 and 1479 per m^3 of effluent. The upper and lower ends of these observations were all from different plants, showing that there is not even consistency in the proportion of particles and fibres captured in the same plants.

The biggest issue with taking the results of these studies and applying them across Europe—besides the low number of samples and the variability of results—is that they invariably do not seek to categorise the source of the microplastics that are captured. This is important, as different sources tend to use different materials which are likely to behave differently in WWT. The density, and thus the buoyancy of the material, appears to be a key variable affecting the likelihood of the particle being captured. This is to say, if ~90% of the overall number of micro particles are captured this does not necessarily mean that 90% of *all types* of particle are captured. In the case of PCCP microplastics, which are primarily made from positively buoyant polyethylene and—as seen in Section 6.3.2.4— are a relatively small source of microplastic pollution, it is possible that significantly fewer particles are captured compared with other (more dense) sources.

An industry sponsored thesis from Ghent University[441] looked at the practical and theoretical side of microplastic retention in a WWT in Flanders. In this study the influent, effluent and the sludge were sampled and analysed. It was found that 65% of the particles exiting the plant, and 24% of the fibres, were captured in sludge. One significant observation is that that when comparing the particle counts in the influent with that of the effluent and sludge, it was found that there were a greater number coming out of the plant than going in. This was attributed to the processes in the plant causing fragmentation of the particles, and this theory is backed up by the fact that the average particle size was found to be smaller in the effluent than in the influent.

A theoretical approach was also taken to establish the size of particles most likely to settle during the sedimentation process. This was based on the principal of laminar flow which most WWT plants are designed to obtain, the key variables in this being the flow rate through the plant, the density, and the size of the particles. More dense, larger particles are more likely to settle during times of low flow. Equations were formed for both Polystyrene and PVC with a density of 1,050 and 1,380 kg/m^3 respectively.

---

[440] Mintenig, S., and et al. (2014) Mikroplastik in ausgewählten Kläranlagen des Oldenburgisch-Ostfriesischen Wasserverbandes (OOWV) in Niedersachsen (Microplastic in selected sewage treatment plants in the Oldenburgisch- Ostfriesischen Water Association (OOWV) in Lower Saxony), Report for Oldenburgisch- Ostfriesischer water (OOWV), October 2014
[441] Wout Van Echelpoel (2014) Microplastics in a biological wastewater treatment plant and the surrounding freshwater environment in Flanders: Quantitative assessment, dissertation submitted at University of Ghent, 6 June 2014

Table 29 shows how the density of the material affects the likelihood of settling based on the maximum and minimum flow rates observed at the plant under study. In this case PVC particles will settle in sizes three time smaller than polystyrene. This also shows that the capture rate will be highly variable depending on the flow through the plant and therefore highlights the difficulty in applying a blanket retention figure. It is clear from this that the less dense polyethylene particles will settle in fewer number and in larger sizes than other more dense plastics and therefore WWT is unlikely to capture them in the same proportions.

Table 29 – Critical Particle Diameter for Settling in WWT

	Polystyrene (1,050 kg/m^3)	PVC (1,380 kg/m^3)
Max Flow	59.5 µm	21.6 µm
Min Flow	37.1 µm	13.5 µm

Source: Wout Van Echelpoel (2014)

Using this approach the thesis calculated an overall retention proportion of 27.6% assuming that the particles entering the WWT arrived in the same proportions as are manufactured on a global scale (see Table 49 in the Appendix A.4.0 for these proportions). This is unlikely to be the case, as the materials that make up the primary microplastics entering a WWT are likely to be in very different proportions. There are also other issues with the theoretical approach such as the occurrence of biofouling which increases the density of the particles and therefore its likelihood of settling. The addition of flocculant during sedimentation as a clarifying agent is also suggested by some sources[442] to increase the likelihood of settling. However, flocculant is used to separate solid materials that are *dissolved* in the wastewater to make it less turbid (cloudy), and as plastics are hydrophobic—and in the case of polyethylene, buoyant—flocculant is unlikely to have an effect[443].

With the majority of captured plastics ending up as part of sewage sludge it is also important to understand where this sludge will end up when it is disposed of. As seen in Figure 49, based on data from Eurostat[444], Germany, the UK, Spain, France and Italy are the largest producers of sludge in the EU. Application to agricultural land is the single largest disposal route in the EU at 44%; this is followed by incineration at 24% and landfilling at 9%. This means that at least 53% of the sludge—as the 'other' category includes composting applications—will be introduced to the land and therefore could

[442] Gouin et al (2015) Use of Micro-Plastic Beads in Cosmetic Products in Europe and Their Estimated Emissions to the North Sea Environment, SOFW Journal, No.03-2015
[443] Cheryl Hogue (2013) Microplastic Beads Pollute Great Lakes, Chemical and Engineering News
[444] The most recent years' data possible was used for each countries from between 2009-11 depending on availability. EU-27 only as Croatia have not reported any figures.

enter waterways through surface run-off. The extent to which this may happen has not been the subject of research at this time, but to assume that all microplastics captured by WWT via sludge will not find their way into the ocean is to potentially underestimate their contribution to marine pollution. It does appear that there is significant potential for plastic build up in agricultural lands, and this may require further exploration.

The final issue that can affect the numbers of microplastics that reach the marine environment is the type of water and sewerage transfer system installed. There are two types of water dealt with by sewerage systems: foul water from toilets, sinks, showers and any other household appliances that expels water effluent, and surface water that falls onto built up areas from rainfall. The main difference is whether these two systems are separate or combined. With a separate system the two effluents are kept separate with the foul water sent via the sewer to a WWT plant and the surface run-off sent mostly directly to the nearest water body. Combined systems will send both effluents to a WWT plant in dry weather, but occasionally in periods of prolonged wet weather the system cannot cope with the extra water and therefore to prevent flooding of the WWT plant or homes it overflows directly to the receiving water. Due to increasing population density and the added expense of treating more water the combined sewer system is usually not the choice for new installations, but there is still a legacy of combined sewers, especially in older European cities.

Separate sewers do have their own issues as contaminants—such as microplastics—will be washed directly into water bodies rather than through WWT. There is also the potential that household foul water will be misconnected to surface water, thereby contaminating it with raw sewage. Current data on the split of these systems within different countries is not available, although a source from 1989[445] suggests that Europe could have anywhere between 14% (Sweden) and 90% (Netherlands) combined sewers. Other sources for individual cities suggest the ratio is 50:50[446]. This is of relevance to those microplastics whose pathway to the ocean is via surface water run-off. If 50% of the available plastics go to separate sewers then that entire proportion will be assumed to end up in the ocean. The other 50% will be assumed to go to a WWT treatment plant, at which point the capture rate of the plant will come into force and the remaining plastics will be transported to the ocean.

Based on the available studies it is unclear whether PCCP microplastics will be captured at the same levels as other denser microplastics. Most studies find that around 90% of the microplastics that enter the WWT plant are captured, although even this is very variable from plant to plant. The data in Figure 48 shows that 63% of the EU population are connected to tertiary waste water treatment. If, in the best case, 90% of microplastics are captured in these facilities, 57% of all microplastics that are emitted

[445] J. B. Ellis (1988) Urban Discharges and Receiving Water Quality Impacts, 1988
[446] http://ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2013/06/Indicator-9-WasteWater_BRISTOL.pdf

into sewerage systems in the EU can be expected to be captured. Not all tertiary facilities will be able to provide such a high capture rate and leaching from sludge placed on land may also be a significant issue. On this basis, a worst case lower estimate of 0% capture will be used to demonstrate the full range of the possible emissions based on the current data available.

Because of this uncertainty, any microplastics that are thought to enter the sewerage system will be given a capture rate range of ***0 – 57%***.

6.5 Estimates for the Tonnage of PCCP Microplastics Entering the Marine Environment

Due to the difficulty in identifying the source of any captured microplastics during sampling, whether from surface waters or sediments, it is almost impossible to estimate the level of PCCP microplastic prevalence in the marine environment through direct measurement and observation. Most surface water studies also do not have the capacity to capture particles smaller than 0.3 mm, meaning they could potentially miss a large proportion of the PCCP microplastics present in the ocean. The biggest obstacle facing such estimations is that no study has yet proven where all the plastics— including microplastics—go once entering the marine environment. No conclusive mass flow model has been developed to fully take account of the flows from terrestrial and marine sources to the different sinks discussed in this report. We therefore look to cosmetics market for data regarding their use of microplastics to develop a top-down estimate of the flow of PCCP microplastics into the marine environment.

6.5.1 The Global Cosmetics Market

In order to frame the issue of PCCP microplastics it is important to look at market considerations, both from a European and global perspective.

The size and nature of the global cosmetics market is difficult to estimate as there are many ‘emerging markets’ such as those in Africa and South America for which strong industry derived data is less comprehensive.

In Europe, Cosmetics Europe provides cosmetic product sales data on an annual basis by country. It also estimates the sales of other key global markets such as the USA and Japan. Various other sources of sales data has been found that allow the creation of a global picture of the industry, which is summarised in Table 30. Europe is currently the largest market with €72 billion worth of sales in 2013. This is followed by Asia (excl. China and Japan) with €61 billion worth of sales. If China and Japan were added to this the Asian market total would be in excess of €100 billion, and the largest market in the world.

Table 30 - Global Cosmetics Market

Region/Country	2012 Retail Market (Billion €)	Market Share
Europe[1]	72	23%
Asia (excl. Japan and China)	61	19%
USA[1]	47	15%
Brazil[2]	38	12%
Japan[2]	26	8%
China[2]	14	4%
Russia[2]	9	3%
Africa[2]	7	2%
Other	45	14%
Total[2]	**319**	**100%**

Notes:

1. Based on Cosmetics Europe data from 2013[447]
2. Roland Berger Strategy Consultants 2012[448]
3. Euromonitor via Reed Exhibitions[449] USD to Euro conversion rates taken from *www.ukforex.co.uk* for @ 0.753 USD-EUR for 2013

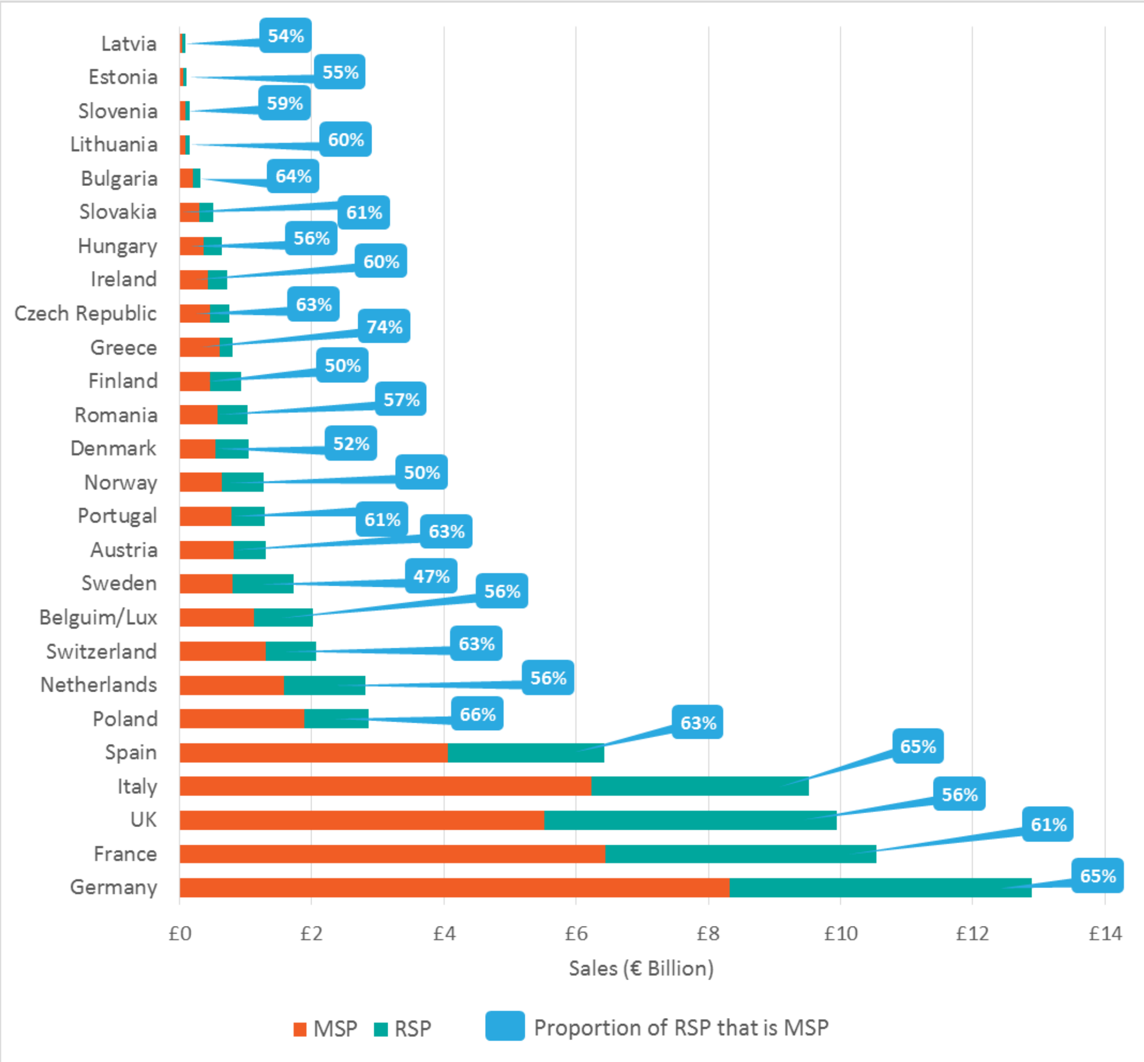
6.5.2 The European Cosmetics Market

Figure 50 shows the makeup of the European market by Retail Selling Price (RSP)—the price which the consumer pays for the product—compared with the Manufacturers Selling Price (MSP)—the price that the manufacturer sells to the retailer. This provides insight into the countries that place the greatest price mark up on products in retail as a

[447] Cosmetics Europe (2014) Market Performances 2013- European Cosmetic, Toiletry & Perfumery Data, 2014
[448] Roland Berger Strategy Consultants (2013) Beauty and personal care market in Africa: one billion people to care for!, 2013
[449] Reed Exhibitions (2014) Russian Perfumery & Cosmetics Market 2014, 2014

result of sales taxes and retailer profit margins. The average MSP is 61% of the RSP; Greece is the highest with 74% (therefore has the lowest retail mark-up) and Sweden the lowest with 47%. Germany, France, the UK, Italy and Spain are the largest markets in Europe with 68% of the overall European market, although they account for slightly less of the population (EU28 + Switzerland and Norway) at 64%.

Figure 50 - European Cosmetics Sales by Country



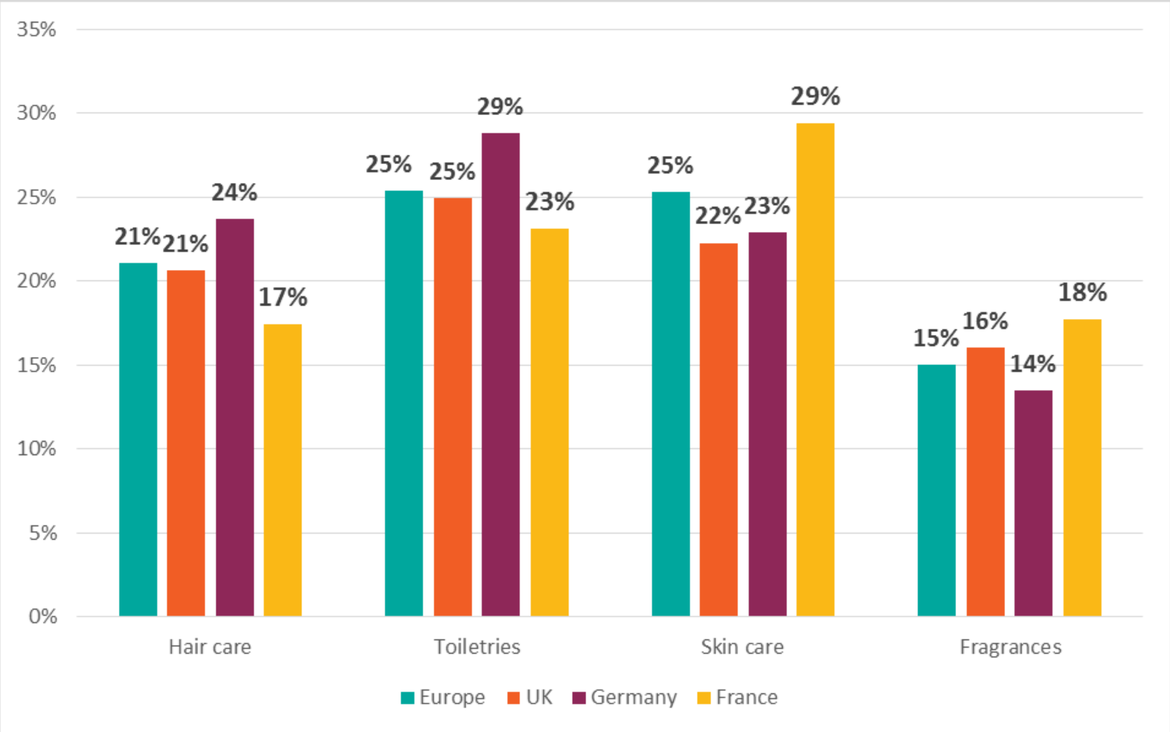
Source: Cosmetics Europe

Cosmetics Europe also provide an estimate of the market share (by retail sales price) in Europe by product category with the following product types;

- Hair Care
- Toiletries
- Skin Care
- Fragrances
- Decoratives/Colour Cosmetics

Figure 51 shows the market share for each of the five product categories for Europe[450] and its top three largest markets; Germany, France and the UK. The product category proportions are very similar between the UK and the European average. This is important as there is a lack of data availability for Europe, whereas the UK—via The Cosmetic, Toiletry & Perfumery Association (CTPA); the UK's cosmetic industry trade body—has data for product sales within each of these product categories. This is key to understanding which products which would potentially include microplastics. The full list of products can be found in Appendix A.4.0. This list is also used to calculate the overall market potential for microplastic containing PCCPs using the UK data as a proxy for Europe as a whole; this is discussed in Section 6.5.5.

Figure 51 – Cosmetics Product Category Market Share in 2013 by RSP in Europe and the UK.



Source: Cosmetics Europe

It is true to say, however, that market value (especially retail value) may not be representative of the number of product sold. Indeed, this is evidenced in Figure 52 which shows that, for the UK[451] (UK data is from The Cosmetic, Toiletry & Perfumery Association (CTPA); the UK's cosmetic industry trade body), toiletries have a much higher

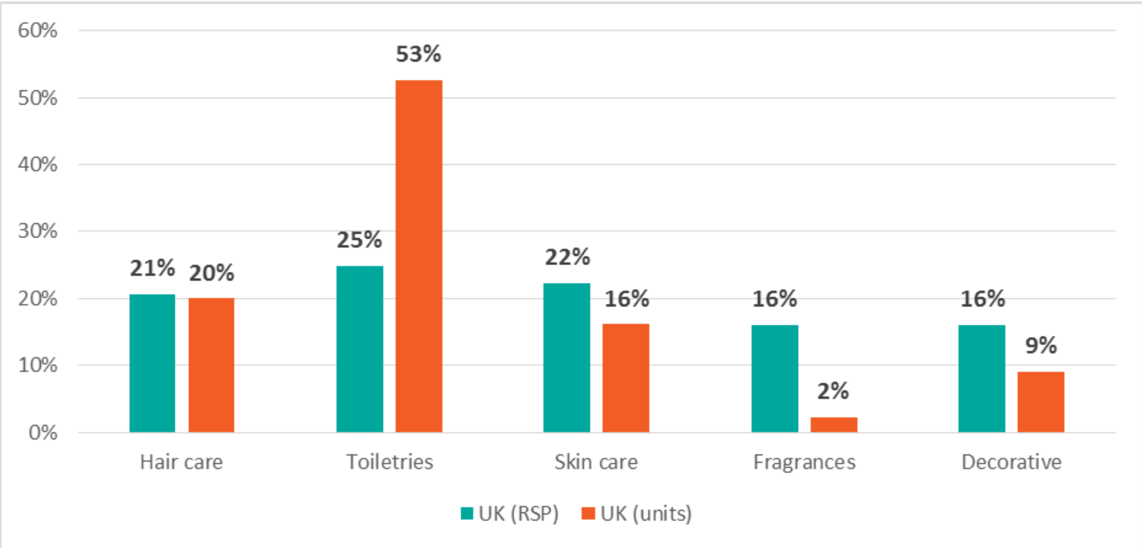
---

[450] Cosmetics Europe (2014) *Market Performances 2013- European Cosmetic, Toiletry & Perfumery Data*, 2014

[451] CTPA (2014) CTPA Annual Report 2014, 2014

proportion of the market by unit sales. This shows these products to be high volume, low cost. This is in stark contrast to Fragrances and Decorative products which command a much higher value for each unit sold. This distinction is also taken into account in Section 6.5.5 where unit sales are used to determine the overall market for microplastic containing PCCPs rather than RSP as this provides a truer picture of the amount of product and therefore the amount of microplastics being sold in Europe.

Figure 52 - Cosmetics Product Category Market Share in 2013 by Unit Sales the UK.



Source: CTPA

6.5.3 Current Evidence for Estimates

There have been various attempts over the last five years to estimate the quantity of microplastics being used in cosmetics products within Europe and the US. In common with approaches to the overall estimations of plastics flowing into the marine environment, estimating the possible flows of PCCP microplastics is currently the preferred method of understanding the magnitude of the issue for the purposes of this study. As the literature review in Section 6.3 has shown, it is currently not possible to identify—with any degree of accuracy—the source of microplastics that are found in the marine environment. It is therefore, very difficult to quantify the issue of PCCP microplastics on this basis.

The following section reviews all of the attempts that have been made to estimate the use of PCCP microplastics based on sales and usage data. As so few studies have been conducted in this field, estimates from countries outside of Europe have also been sought in order to help provide more evidence and greater context with which to understand the issue.

In a study focusing on the risks to marine life from the absorption of chemicals by microplastics Gouin *et al*[452] (working on behalf of Unilever) estimated (based on Euromonitor consumption data) that in 2009 each US citizen used 2.4 mg per day of polyethylene (PE) microplastics in the liquid soaps and shower gels are used. This estimate was based on the assumptions summarised in Figure 53.

Figure 53 - Gouin et al (2011) PCCP Microplastic Estimate Assumptions

- Indications from the Euromonitor data suggest that ***15% of the market*** is made up of companies that use PE microplastics in their liquid soaps;
- Of those companies ***10%*** of *all* their products contain PE microplastics; and
- Of those products that contain PE microplastics,—based on the original US patent[1]—each product contains ***10%*** PE (by volume).

If the figure of 2.4 mg per day is applied on a European level, with a population of 504 million[453] in the EU this would equate to 442 tonnes of PCCP polyethylene microplastics being used per year.

[452] Gouin et al (2011) A Thermodynamic Approach for Assessing the Environmental Exposure of Chemicals Absorbed to Microplastic, Environmental Science & Technology, No.45, pp.1466–1472
[453] Eurostat for 2012, EU 28

Another more recent study, by the Nova Institute[454], and focused on Germany, used many of the same assumptions from Gouin *et al* (2011). The report used German sales data from 2002 taken from a study by Tolls et al.[455] This data allowed estimates to go further than Gouin et al (2011) to include production quantities for more than just liquid soaps. The main assumptions that were used to generate the estimates are shown in Figure 54.

Figure 54 – Nova Institute PCCP Microplastic Estimate Assumptions

Assumption 1: In Germany, 15% of companies which manufacture cosmetics in the product group ' liquid soaps, bath and shower gels' use microparticles in 10% of their products, with an average content of 10%. This assumption is in line with the approach taken by Gouin et al. (2011).

Assumption 2*:* The category 'Skin-care and sun protection' has an average plastic content of 2.4%. This is based on direct samples of product from various studies.

Assumption 3: The production volume of liquid soaps, bath and shower gels has remained constant at 175,000 tonnes since 2002. Shower gels and liquid soaps potentially containing microplastics account for around 100,000 tonnes of these. The remaining 75,000 tonnes of bath gels contain no microparticles. This assumption is based on a study by Tolls et al. (2009) and was confirmed by representatives of the IKW.

Assumption 1 is identical to the ones used by Gouin et al. (2011). It is difficult to verify whether 15% of cosmetics manufacturers use microplastics without analysing the data directly, although in has been clear during engagement with the industry through the course of this study that all of the 'top' manufacturers were using microplastics in 2011. The estimate that 10% of the products that those companies sell contain microplastics is the author's (Gouin) own estimate and not based upon any data, and the product plastic content assumption of 10% is based upon the patent from 1972 which states that: [456]

> *"It has been found that skin cleaning compositions of the liquid, lotion, semi-solid cream, and cream types are provided utilizing between about 3 and 15 percent of the finely divided plastic resin particles therein."*

[454] Roland Essel, and et al. (2014) Sources of microplastics relevant to marine protection, Report for Federal Environment Agency (Germany), November 2014
[455] Tolls, J., Berger, H., Klenk, A., et al. (2009) Environmental safety aspects of personal care products—A European perspective, Environmental Toxicology and Chemistry, Vol.28, No.12, pp.2485–2489
[456] Willis J. Beach, and Sugar Beet Products Company Skin Cleaner, Michigan

Several more recent studies have directly analysed the plastic content of retailing products. In 2012 Leslie[457] analysed one facial scrub to find that just over ten per cent of the product by weight was comprised of PE plastic. Analysis of a child's bubble bath soap found considerably less plastic (<0.1%), although its inclusion appears to be for aesthetic purposes to provide a glittering appearance. More recently an overview study by Leslie[458] on behalf of UNEP stated that some cosmetics could contain up to 90% plastic. The source of this statement is from the Cosmetics Ingredient Review[459] which specifically relates to the use of Modified Terephthalate Polymers although it is unclear where this precise figure (90%) was derived from in that paper. However, the Cosmetics Ingredient Review paper does state—from cosmetics industry survey data— that the use of these polymers goes beyond that of rinse-off products. Table 31 shows the examples of the concentration and forms in which Polyethylene terephthalate (PET) can be found in 'leave-on' cosmetics. 394 leave-on products were reported to contain PET, but what proportion of the market (for each product group) these account for is not reported so it is difficult to draw any specific conclusions about PET's prevalence in the cosmetics industry.

Table 31 – PET found in 'Leave-on' Cosmetics Products

Product Type	Concentration of PET	Form of PET
Eye Shadow	46.3%	Flake
Face Powders	99.6%	Powder
Body Sprays	0.3%	Not stated
Mascara	0.05%	Fibre
Nail Extenders	0.6%, 14%	Gel, Powder
Body Lotions	0.005%	Powder
Lipsticks	0.12%	Flake

Source: Cosmetics Ingredient Review

---

457 Leslie, H. (2012) Microplastic in Noordzee zwevend stof en cosmetica, Report for North Sea Foundation, 2012

458 Leslie, H. (2015) *Plastic in Cosmetics. Are we Polluting the Environment Through our Personal Care?*, Report for UNEP, 2015

459 Cosmetics Ingredient Review (2012) *Safety Assessment of Modified Terephthalate Polymers as Used in Cosmetics*, December 2012

The 5 Gyres Institute[460] sampled three facial scrub products and found microplastic concentrations to be between 0.94% and 4.2%. Similar concentrations were found by Gregory *et al*[461] in a 1996 sampling of New Zealand hand cleaners and facial scrubs, with a mean concentration of 2.95% over six products. In a Berkeley university thesis[462] nine facial scrubs were sampled to find a plastic mass of between 0.08 and 0.1 grams per millilitre of product. The products were chosen based on the author's research into the most popular brands. Assuming that the density of the product is similar to water—an assumption also used by Gouin[463]—then this would mean that the plastic concentration would be between 8—10%.

Similarly, DuPont manufacture a range of 'exfoliating micropowders' called Gotalene, aimed at the cosmetics market. Made from polyethylene this product is available in sizes ranging from 200 to 630 µm and is recommended for use in concentrations of between 3—10%. Choosing 10% therefore seems like an appropriate assumption to use for exfoliating microplastics in liquid soaps and shower gels in the absence of a large scale market survey.

Assumption 2 in Figure 54 reduces the plastic concentration to 2.4% for the category 'skin care and sun protection'. The justification for this is based on the 5 Gyres and Gregory studies highlighted above by taking an average over all the products sampled. However, it is unclear whether the products sampled within these studies should be classed as 'liquid soap' or 'skin care' or even 'cleansers for body care'. The Nova study does not provide a description of the distinction, nor does the source of the data (Tolls[464]), so it seems potentially inappropriate to apply a different concentration figure to this category alone especially in light of the concentrations of plastic found to be used in leave on products of anywhere between 20 — 80% for PE[465] and close to 100% for PET[466].

---

460 5 Gyres (2013) Microplastics in consumer products and in the marine environment: Position Paper, 2013

461 Gregory, M.R. (1996) Plastic 'scrubbers' in hand cleansers: a further (and minor) source for marine pollution identified, Marine Pollution Bulletin, Vol.32, No.12, pp.867–871

462 Michelle Chang (2013) Microplastics in Facial Exfoliating Cleansers., dissertation submitted at Berkeley University, 2013

463 Gouin et al (2015) Use of Micro-Plastic Beads in Cosmetic Products in Europe and Their Estimated Emissions to the North Sea Environment, SOFW Journal, No.03-2015

464 Tolls, J., Berger, H., Klenk, A., et al. (2009) Environmental safety aspects of personal care products—A European perspective, Environmental Toxicology and Chemistry, Vol.28, No.12, pp.2485–2489

465 Milton Blaustein (1965) *Cosmetic Powder Compositions Containing Polyethylene*

466 Cosmetics Ingredient Review (2012) *Safety Assessment of Modified Terephthalate Polymers as Used in Cosmetics*, December 2012

The datasheet for Dow Chemical's 'Sunspheres'[467] suggests that the concentration of microplastics in sunscreens could be between one and five per cent. The suggested product formulations in the same datasheet all show a concentration of five per cent to achieve the optimum effectiveness—in this case a 50% increase in UV protection—which would suggest that this would be the concentration that would be used most often. This concentration is also double that of the assumption used by the Nova study, although the study does highlight the potential arbitrary nature of applying a concentration factor across all product ranges based on, to large extent, guesswork.

Assumption 3 in Figure 54 includes the assumption that bath gels do not contain any microplastics, which the ingredients review by Tolls et al agrees with, although as identified by Leslie[468] there may be certain niche bath products which use them in very low concentrations for aesthetic purposes.

The list of product categories considered by the Nova study to include PE microplastics are detailed in Figure 55 along with the tonnage estimates for Germany. As data availability for PCCP microplastics is sparse, the study limited its estimates to Polyethylene. Although it acknowledges the use of other plastics including polypropylene (PP), polyamide (PA), ethylene-vinylacetate copolymers (EVA), polyurethane (PUR), Polyethylene terephthalate (PET) and acrylonitrile copolymers with ethyl acrylate or other acrylates (ANM); there is a distinct lack of research to allow a quantification exercise to be performed with these materials.

One notable exception in this list of products is make-up products which as demonstrated in Table 31 from evidence by the Cosmetics Ingredient Review[469] may also contain microplastics, possibly in much high levels than rinse off products— close to 100%.

[467] Datasheet can be downloaded at: http://www.dow.com/assets/attachments/business/pcare/sunspheres/sunspheres_powder/tds/sunspheres_powder.pdf

[468] Leslie, H. (2012) Microplastic in Noordzee zwevend stof en cosmetica, Report for North Sea Foundation, 2012

[469] Cosmetics Ingredient Review (2012) *Safety Assessment of Modified Terephthalate Polymers as Used in Cosmetics*, December 2012

Figure 55 – Nova Institute Annual Polyethylene PCCP Microplastic Consumption Estimates for Germany

Product	Production Quantity (tonnes)	Polyethylene Microplastic Content (tonnes)
Shower gels, liquid soaps	100,000	150
Cleansers for body care	118,000	177
Skin-care and sun protection	109,000	39
Dental hygiene products	65,000	98
Other body-care articles	21,000	32
Total	**488,000**	**495**

Source: Essel et al. (Nova Institute).

A more recent study—also conducted by Gouin[470]—focused on specifically quantifying plastic PCCP microplastics using data both from Cosmetics Europe—which was gathered from its members—and Euromonitor activity data for each country. Cosmetics Europe surveyed its members, which include many of the largest manufacturers of cosmetics worldwide, and concluded that 4,360 tonnes of microplastics were sold within ***rinse-off liquid soaps and facial cleansers and toothpastes*** in Europe in 2012. The survey was based on the Cosmetics Europe definition, which most of its members have adopted, and all data and derived estimates from the survey are based upon this definition:[471]

> *"Plastic microbeads designate synthetic non-biodegradable solid plastic particles >1µm and < 5mm in size used to exfoliate or cleanse in rinse-off cosmetic products."*

This definition also has its limitations and has the potential to exclude certain types of microplastic that may appear in cosmetics such as;

- Biodegradable polymers (discussed further in Section 7.3.3);
- Products that are not used to exfoliate and then be rinsed off. These can include a significant number of make-up's that may contain plastic, but are washed off during skin care routines (as highlighted in Table 31); and
- Plastic particles smaller than 1µm—often referred to as nanoplastics.

---

[470] Gouin et al (2015) Use of Micro-Plastic Beads in Cosmetic Products in Europe and Their Estimated Emissions to the North Sea Environment, SOFW Journal, No.03-2015
[471] Personal communication with Gerald Renner, Cosmetics Europe.

These limitations to the Cosmetics Europe definition—and subsequently the data that has been gained from the industry under it—must be borne in mind when considering the use estimates that can be derived from it.

The date presented by Gouin of the extent to which microplastics are used within liquid soaps and toothpastes within Europe does not allow estimates on a per country basis. Therefore, the study also deemed it necessary to look at liquid soap sales data from Euromonitor to provide a comparison between countries. To develop an estimate of microplastic consumption for each country based on liquid soap usage required several assumptions to be applied to the data, which are summarised in Figure 56.

Assumption 1 is based on Gouin's assertion that most liquid soaps are a water based formula. This is consistent with the product formulations identified by Tolls et al[472], which found that ~80% of these products are made up from water.

Assumption 2 estimates that 6% of all liquid soaps contain microplastics. This is four times higher than Gouin's 2011 assumption (15% x 10%) and was derived by maintaining assumption 3 (10% plastic concentration) and finding a figure that allowed the overall European total to come close to the Cosmetics Europe survey result of 4,360 tonnes. By this method any numbers could replace those used in assumptions 2 and 3 so long as they equal 0.6% (10% x 6%). This is on the basis that the Cosmetics Europe survey provides the best and most accurate estimate of microplastic use to date.

Figure 56 – Gouin et al (2015) PCCP Microplastic Estimate Assumptions

Assumption 1: One litre of liquid soap is equal to one kilogram, i.e. it has the same density as water.

Assumption 2: 6% of all liquid soaps contain microplastics.

Assumption 3: Of those products that contain microplastics there is ***maximum*** inclusion level of 10% PE microplastic. Importantly, the study uses 10% as an ***average*** rather than a maximum to calculate its estimates.

In conversation with Cosmetics Europe it became clear that the full dataset was not made available to Gouin during this study as much of the company specific information is considered commercially sensitive. The study suggests that the scope only includes liquid soaps and facial cleaners; however, Cosmetics Europe confirmed that the study

[472] Tolls, J., Berger, H., Klenk, A., et al. (2009) Environmental safety aspects of personal care products—A European perspective, Environmental Toxicology and Chemistry, Vol.28, No.12, pp.2485–2489

also included oral care products in the form of toothpastes, and that these formed 10% of the 4,360 tonnes.[473]

The table which estimates the usage of PCCP microplastics in European countries which was used in the Gouin study was therefore recreated by using the lower figure of 3,924 tonnes to exclude toothpastes (this can be found in Table 23 in Appendix A.4.0). When compared with Gouin's (2011) data for the US, the per person volume of liquid soaps used annually is much larger in the EU than in the US—albeit using data from 2012—and therefore each European citizen uses 21 mg of plastic microbeads per day. This shows that overall country use is greatest for Spain. This is followed by the UK, Germany and France, which combined account for 67% of the total EU usage. Spain also has the highest levels per person with 41.7mg per person per day—20 times Gouin's (2011) estimate for the US and double the EU average.

Comparing results with the Nova study (which calculated that 150 tonnes of microplastic were used in 100,000 tonnes of liquid soap) we find that Euromonitor data puts liquid soap usage at 111,000 tonnes with 638 tonnes of microplastic. As already discussed, this can be attributed to the microplastic concentration assumptions being four times greater for this study.

The Cosmetics Europe survey was also the first to investigate the types of material that were being used in these products. Although it was suspected that polyethylene was the predominant material, it has not been confirmed by data until now. Table 32 shows that 94% of the reported material use is PE. The remaining 6% is reported by Cosmetics Europe[474] to be Ethylene/octene copolymer, Nylon 11, oxidized polyethylene and Polyurethane.

Table 32 – Total PCCP Microplastics by Material Type from Rinse-off liquid soaps and facial cleansers and toothpastes

Material	Total mass per year (EU)	Proportion
Polyethylene (PE)	4,098	94%
Other materials	262	6%

Source: Cosmetics Europe

In addition to the data published by Gouin, Cosmetics Europe provided a break-down of the size ranges used in Europe, which are shown in Table 33. The results of this differ from the effective range suggested by the original 1972 patent[475] of between 74 and 420 µm. This range only accounts for 27% of the market. The largest proportion is in the

[473] Personal communication with Gerald Renner, Cosmetics Europe.
[474] Personal communication with Gerald Renner, Cosmetics Europe.
[475] Willis J. Beach, and Sugar Beet Products Company Skin Cleaner, Michigan

range of 450 – 800 µm, which is in keeping with the majority of the information obtained from the interviews with individual cosmetics companies, which suggested that most use microplastics of around 500 µm.

Table 33 – PCCP Microplastic Size Ranges in from Rinse-off liquid soaps and facial cleansers and toothpastes

Proportion	Size
> 1%	< 50 µm
27%	50 to 450 µm
57 %	450 to 800 µm
15 %	>800 µm

Source: Cosmetics Europe

The survey results are also inconsistent with the results of sampling conducted by RIVM[476] in the Netherlands, which found that over 90% of plastic particles in *toothpastes* were less than 10 µm in size with a median range of 2.3 – 5 µm.

If this sampling is representative of the toothpaste industry—and Cosmetics Europe confirms that only two companies are known to have produced toothpastes containing microplastics—then we would expect that all toothpastes that contain microplastics would therefore make up less than 1% of the market (the smallest size category seen in Table 33). However, Cosmetics Europe also claims that the survey data shows that around 10% of the microplastics in cosmetics come from toothpastes, suggesting that a significant proportion of the toothpastes contain particles larger than 50 µm—ten times the size of the particles found by RIVM. The reasons for this discrepancy are unclear but possibly as a result of the low sampling rate (two products) of the RIVM. It is not known how much the particles will differ in size between different products by the same manufacturer. Finally, an estimate was made by Mepex[477] for Norway using 4,000 tonnes (of PCCP microplastics consumed per year in Europe) as the basis. This figure was cited as coming from a source within Plastics Europe, although upon contact Plastics Europe were disinclined to confirm this figure, advising that it was not backed up by any specific data that they hold.[478] Nonetheless, the figure is in the same range as the Cosmetics Europe figure and led to an estimate for Norway of 40 tonnes of PCCP

[476] Verschoor, A., and et al. (2015) Size and amount of microplastics in toothpastes, Report for National Institute for Public Health and the Environment (Netherlands), 2015
[477] Mepex (2014) Sources of microplastic pollution to the marine environment, Report for Norwegian Environment Agency, April 2014
[478] Personal communication with Ralph Schneider, Plastics Europe.

microplastics consumed per year which compares well with the Cosmetics Europe data that estimates 41 tonnes (see Table 51).

6.5.4 European Estimate from Cosmetics Europe Data

With the Cosmetics Europe survey being limited to rinse-off products and toothpastes, the scope was therefore narrower than the Nova Institute estimates (as seen in Figure 55). In conversation with Cosmetics Europe[479], it was suggested that both *'shower gels, liquid soaps'* and *'cleansers for body care'* were covered by their survey, along with *'dental hygiene products'* in the form of toothpastes. The category of *'skin-care and sun protection'* was considered to consist of 'leave-on' products which are designed to be rubbed or smeared onto the skin and left. This was out of scope for the Cosmetics Europe survey, which focused primarily on 'rinse-off' products with the justification that they are the most likely to be expelled directly into sewer systems. It is highly likely that even 'leave-on' products would be cleaned off at some point, however, and therefore they will remain in scope in the context of this study. The two categories that were out of scope in the Cosmetics Europe survey amount to 14% of the total estimate for Germany by Nova. Cosmetics Europe state that they believe these 'leave on' categories would constitute a small part of the overall quantities although this is currently unverified through data—these types of products are investigated further in Section 6.5.6 which will lead to a full European estimate.

Cosmetics Europe also confirm that their members—all of which were surveyed—account for 90% of the cosmetics market. To achieve a full European estimate the remaining market must be added on.

Based upon the discussion provided in Section 6.5.3 a list of key estimate assumptions that apply to the European estimates has been developed, chosen using the best information and data currently available. These are summarised in Figure 57. The European estimate is shown in Table 34 as ***4,844 tonnes per annum***.

[479] Personal communication with Gerald Renner, Cosmetics Europe.

Figure 57 – Key European Estimate Assumptions

Assumption 1: The Cosmetics Europe survey provides the most accurate data regarding overall PCCP microplastics consumption in Europe for *rinse-off liquid soaps and facial cleansers and toothpastes*.

Assumption 2: The Cosmetics Europe survey results are only for products that fall under their definition of:

> *"Plastic microbeads designate synthetic non-biodegradable solid plastic particles >1µm and < 5mm in size used to exfoliate or cleanse in rinse-off cosmetic products."*

Assumption 3: The Cosmetics Europe survey accounts for 90% of the market.

Table 34 – Estimates of PCCP Microplastics Particles>1µm Derived from Cosmetics Europe Data

Source	Additional Proportions	Tonnes of PCCP Microplastics per annum
Cosmetics Europe Survey: Soaps		3,924
Cosmetics Europe Survey: Toothpastes		436
Rest of Market	10%	484
Total		**4,844**

Notes:

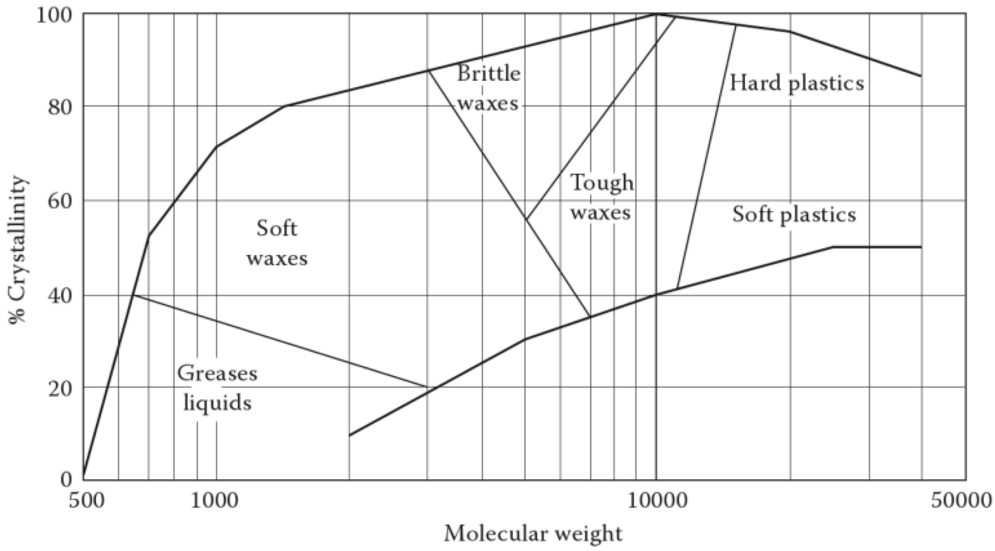
These estimates are derived from Cosmetics Europe data and are therefore limited to the products which were surveyed. Estimates for the remaining products are calculated in Section 6.5.6

6.5.5 Other Potential Forms PCCP Microplastics

As discussed in the preceding sections, much of what is thought to be microplastic marine litter refers specifically to microplastic that conforms to the Cosmetics Europe definition, primarily used for their abrasive qualities as exfoliates. However, it is known that polymers are regularly used throughout the cosmetics industry and in other industries. There is also scientific evidence to suggest that some of these polymers may also conform to the definition of marine litter (see Section 6.1 for definition) in a similar way to the polyethylene waxes in floor cleaners identified in Appendix A.3.0 (Industrial Products).

Deciding whether a PCCP polymer ingredient should be classified as marine litter largely comes down to whether it can be classified as a liquid or a solid[480]. Polymers are made from chains of atoms with the physical properties dependent upon the size and length of these chains. The length of the chain can be expressed as the molecular weight (known as the mole). As the molecular weight (chain length) increases, so do properties such as melting point and boiling temperature. Figure 58 shows how the physical properties of polyethylene change based on its crystallinity and molecular weight. Highly crystalline polymers with a high molecular weight are hard, however there is a significant 'grey area' during the transition from hard plastic to soft wax which—with a molecular weight of over 7,000— where it is possible that these other forms of polymers could be considered marine litter.

Figure 58 - Physical Properties of Polyethylene



Source: Engineering Design with Polymers and Composites[481]

Tolls *et al*[482] identified several examples of typical cosmetic product formulas. Most contained some form of Polyethylene glycol, which is often used as a binder, thickening agent or emulsifier, and is known as PEG in the International Nomenclature of Cosmetic

---

[480] Leslie, H., and et al. (2014) Review of Microplastics in Cosmetics, Report for Dutch Ministry of Infrastructure and the Environment, July 2014

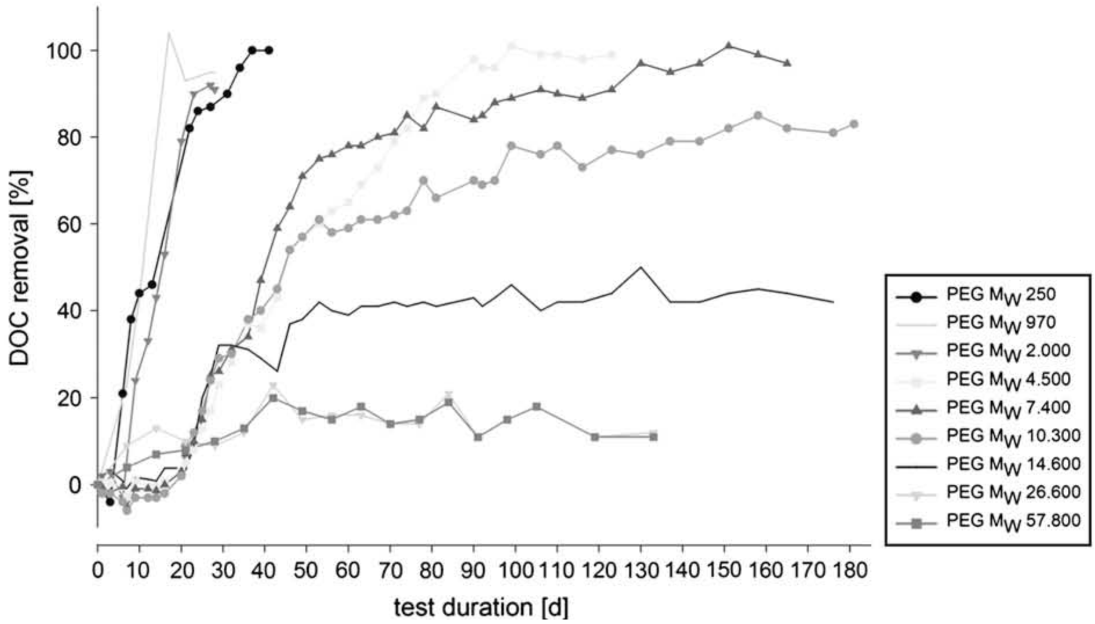
[481] James C. Gerdeen(2005) Engineering Design with Polymers and Composites, CRC Press

[482] Tolls, J., Berger, H., Klenk, A., et al. (2009) Environmental safety aspects of personal care products—A European perspective, Environmental Toxicology and Chemistry, Vol.28, No.12, pp.2485–2489

Ingredients (INCI) list followed by the molar mass number (between 2 and 240)[483], for example PEG-8. PEG may also be named based on the molecular weight of the compound. For example, PEG-8 is also known as PEG 400, with 400 representing the average molecular weight of the compound.

A recent study[484] looked into the degradability of PEG in waste water treatment (WWT), fresh water and sea water. This was carried out in a simulated environment using bacteria from each respective source. Whilst it found that all grades of PEG up to a molecular weight of 57,800 would degrade entirely in fresh water and the sludge from WWT, PEGs over 7,400 are only partially degradable. The time to degrade is also increased in seawater and for higher molecular weights as seen in Figure 59. Under 250 took around 40 days whereas 7,400 took up 170 days. This increase in persistence may be important, but it is not known whether this time spent in the marine environment will have a direct relationship to the harm caused.

Figure 59 – PEG Degradability in Artificial Seawater



Source: Bernhard et al

[483] A copy of the INCI list can be downloaded from: www.essentialwholesale.com/library/inci-names-list/

[484] Bernhard, M., Eubeler, J.P., Zok, S., and Knepper, T.P. (2008) Aerobic biodegradation of polyethylene glycols of different molecular weights in wastewater and seawater, *Water Research*, Vol.42, No.19, pp.4791–4801

PEG-240 is listed as an ingredient in the INCI list. This has an average molecular weight of 12,000 which according to Figure 59 would only degrade somewhere between 40—60% over the course of six months. This is known to be used as a viscosifier and moisturizer in hair conditioner and hair styling products.[485] PEG with a molecular weight of up to 20,000 has also been found to be produced for the cosmetics market[486] and many others[487,488,489]produce PEG 8,000 which is very much in the grey area of degradability.

The degradation tests were also carried out at 22 +/- 2^{o}C, however temperature is thought to be a major influencing factor in both speed and completeness of degradation.[490] It is unlikely that much of the ocean's temperatures will be as high as this especially below the surface. The absolute effects of this are unknown at present as there is a limited amount of research into PEG in the marine environment; much of the current knowledge is focused upon fresh water. However, PEG has been found in concentrations of between 0.5 and 68 microgram/Litre in estuarial waters.[491]

The extent to which these sorts of polymer compounds are used in cosmetics products and whether they behave in a similar fashion to plastic micro particles when in the marine environment is not well understood at present. Moreover, as highlighted by Leslie (2014[492] and 2015[493]), it is not always possible to identify whether an ingredient is solid and therefore insoluble in water purely by the INCI name. PG-N-Buteth-M, for example, is a mix of ethylene oxide and propylene oxide, where the ratio determines its water solubility. It is therefore very difficult to estimate the extent to which these (water insoluble) waxes may be used in different products without knowing where the ingredient is sourced from. Fauna and Flora International (one of the members of the Beat the Microbead campaign) provided a list[494] of ingredients that they have found in PCCPs on the UK market, but their solid or liquid state cannot be determined from their INCI name. This list includes over 70 ingredients (the full list can be found in Appendix A.4.1). It is unclear how ubiquitous these ingredients are, what concentrations they appear in and whether they can be considered marine litter at this time. Further study is

485 http://www.clariant.com/en/Solutions/Products/2013/12/09/18/29/Polyglykol-12000-S
486 http://www.sanyo-chemical.co.jp/eng/products/product-list/pdf/no02.pdf
487 http://www.dow.com/polyglycols/polyethylene/products/sentryp.htm
488 http://www.clariant.com/en/Solutions/Products/2013/12/09/18/29/Polyglykol-8000-P
489 http://personal-care.basf.com/ProductDetails?PRD=30170765
490 Kramer, R.M., Shende, V.R., Motl, N., Pace, C.N., and Scholtz, J.M. (2012) Toward a Molecular Understanding of Protein Solubility: Increased Negative Surface Charge Correlates with Increased Solubility, *Biophysical Journal*, Vol.102, No.8, pp.1907–1915
491 NielsNiels Jonkers, and Pirn de Voogt (2004) *Nonionicc surfactants in marine and estuarinee environments:a literature review*, Report for University of Amsterdam, 2004
492 Leslie, H., and et al. (2014) Review of Microplastics in Cosmetics, Report for Dutch Ministry of Infrastructure and the Environment, July 2014
493 Leslie, H. (2015) Plastic in Cosmetics. Are we Polluting the Environment Through our Personal Care?, Report for UNEP, 2015
494 Personal communication with Daniel Steadman, Fauna and Flora International

necessary to discern whether the ingredients on this list—which is by no means a complete list—should be considered as part of the marine litter issue.

From the limited evidence available it can be concluded that there is potential for microplastics to appear in many more forms within PCCPs and their ingredients; the persistence of these ingredients in the marine environment is yet to be fully understood, however. The lack of transparency within the cosmetics industry with regard to how products are labelled is also a significant barrier to unambiguous substance identification and ultimately a full understanding of the extent to which microplastics may be of concern within the cosmetics industry.

6.5.6 Expanding the Estimates to include all PCCPs

In this section the estimate in Table 34 —which is based upon the scope of the Cosmetics Europe survey—is expanded to include other potential sources of PCCP microplastics. This quantification exercise looks at the limited data available in order to show a first order estimate of the potential for these sources.

In Section 6.5.2 the five product groups of fragrances, decorative, skincare, haircare and toiletries and their relevant market shares were identified. These products groups can be broken down further to allow individual products to be identified which may contain microplastics—based upon the evidence found for this study. This gives an impression of the size of the cosmetics market that should be the focused upon. Table 50 shows the extended list of products as reported by the CTPA[495] for the UK, along with the market share for each. With the lack of itemised data on a European scale, the UK serves as a reasonable proxy to allow a sensitivity test of the data previously presented and show whether the Cosmetics Europe data is a true representation of the use of microplastics in Europe. As shown in Section 6.5.2 market share by RSP can be vastly different to the market share by unit. The RSP market share is therefore converted into a unit market share for each product (using the known values for each of the product groups).

Not all products in this list are known to contain microplastics, therefore column four of Table 50 defines which products should be considered as part of this study. The criteria for inclusion is whether one or more products has been found to contain microplastics and is included in the Beat the Microbead[496] database. This database, whilst not an exhaustive list, provides an indication of the types of products that contain microplastics and can be purchased somewhere in Europe. There are also other products that are not on the database, but may contain microplastics. Most of these are considered to be leave-on cosmetics such as sunscreens and make-ups as identified in Section 6.5.3. From this it was found that **76%** of the cosmetics market (by unit number) could conceivable contain microplastics.

Finally, of these products which may contain microplastics, only some will conform to the Cosmetics Europe definition; **36%** of the overall market. This means that **40%** of the overall market may contain microplastics, but is not covered under the Cosmetics Europe definition. The proportion of the market covered by the Cosmetics Europe manufacturer survey is potentially narrower still, as it did not cover shampoos and shaving soaps; totally 7% of the market. Therefore the survey accounted for **29%** of the market—covering most of the products in the toiletries product group—with the remaining **47%** of the microplastics containing market left unaccounted for; these are largely part of the skincare and decorative product markets.

---

[495] CTPA (2014) *CTPA Annual Report 2014*, 2014

[496] http://www.beatthemicrobead.org/

Table 35 – Potential Market for Microplastics Containing Products in the UK

Product Type	Market Share (RSP)	Market Share (Units)	Evidence of MP Inclusion?	Market Potential for MP (Units)	Conforms to Cosmetics Europe Def?	Market Potential for MP (Units) Covered by Cosmetics Europe Def.
Fragrances	**16%**	**2%**				
Fine Female Fragrance	9%	1.3%	No		No	
Fine Male Fragrance	5%	0.7%	No		No	
Mass Female Fragrance	1%	0.1%	No		No	
Mass Male Fragrance	1%	0.1%	No		No	
Colour Cosmetics (Decorative)	**16%**	**9%**				
Face	6%	3.6%	Yes	4%	No	
Lips	2%	1.3%	Yes	1%	No	
Eyes	4%	2.5%	Yes	2%	No	
Nails	3%	1.4%	Yes	1%	No	
Gift Packs	0%	0.2%	Yes	0%	No	
Skincare	**22%**	**16%**				
Prestige Skincare	6%	4.1%	Yes	4%	No	
Face Care Non-medicated	9%	6.2%	Yes	6%	No	
Face Care Medicated	1%	0.7%	Yes	1%	No	
Face Care Male	1%	0.5%	Yes	1%	No	
Hand Care	1%	0.4%	Yes	0%	No	
Body Creams & Lotions	2%	1.4%	Yes	1%	No	
Baby Care Products	0%	0.2%	No		No	
Lipsalves	1%	0.5%	Yes	0%	No	
Sun Preparations	3%	2.1%	Yes	2%	No	
Haircare	**21%**	**20%**				
Shampoo	5%	5.2%	Yes	5%	Yes	5%
Hair Colorants Inc Lightening	4%	3.5%	No		Yes	
Conditioners	3%	3.4%	No		Yes	
Hair Sprays & Setting Sprays	2%	2.0%	No		No	
Hair Creams/Waxes and Gels	1%	1.0%	No		No	
Settings Lotions and Mousses	0%	0.3%	No		No	
Home Perms	0%	0.0%	No		No	
Salons (Industry estimate)	5%	4.7%	No		No	
Toiletries	**25%**	**53%**				
Toothpaste	5%	11.4%	Yes	11%	Yes	11%
Depilatories	1%	1.3%	No		No	
Foot Preparations	0%	0.6%	No		No	
Deodorants	7%	15%	Yes	15%	No	
Shaving Soaps	1%	2.0%	Yes	2%	Yes	2%
Mouthwashes	2%	4.7%	No		Yes	
Talcum Powder	0%	0.4%	No		No	
Bath Additives	1%	2.7%	Yes	3%	Yes	3%
Shower and Body Wash	4%	8.3%	Yes	8%	Yes	8%
Liquid Soap	2%	3.9%	Yes	4%	Yes	4%
Toilet Soap	1%	2.3%	Yes	2%	Yes	2%
Total	**100%**	**100%**		**76%**		**36%**

Other than sample product formulations and a small amount of survey data from Cosmetics Ingredient Review[497] little is known about the extent to which these products may contain microplastics. These products have neither been sampled for analysis nor studied in any meaningful way and therefore it is difficult to convert this potential market share into microplastic usage figures. Data for the tonnage of product sold, along with assumptions on microplastic concentrations for each product is needed in order to estimate the amount of microplastics not accounted for by Cosmetics Europe. Tonnage data for Germany was found by the Nova Institute[498] for five product categories, two of which are useful as they fit the product categories in Table 35. Eurostat data for "Organic surface-active products and preparations for washing the skin" and the Euromonitor data reported in Gouin et al (2015)[499] for liquid soaps can be compared with this. By scaling up the German data for 'shower gels, liquid soaps' to EU levels using the relative market share for Germany (Figure 50) this figure (558,000t) can then be compared with the other two data sources (625,000 and 668,000). On this basis the scaled up Germany figure appears to be around 10-20% lower than the other figures would suggest. Data on a European level is unavailable for the product category 'skin-care and sun protection', however, this can also be scaled up from the German data to give 609,000 tonnes. If this figure is also around 10% lower than expected, the actual figure may be around 670,000 tonnes. This category can be assumed to incorporate all of the products from the 'skincare' category in Table 35 and can then be used with the market share data to derive a tonnage for each of product sub-groups—seen in Table 40.

No data is available for the other product groups in this list and in the case of the decorative products the tonnage figure for skincare will not serve as a proxy as the individual product sizes are very different—skin creams and facial scrubs being in containers of around 50—300ml[500] whereas as decorative products a far smaller with containers of around 5—50ml. Therefore the skincare data will be used as a proxy, but with a reduction factor of 10; resulting in a product tonnage of 37,811 tonnes for decorative cosmetics. Shampoo and Deodorants are sold in similar sized containers to skincare products and therefore the skincare tonnage figure will be used as a direct proxy. This process resulted in the figures in column two of Table 37. Column three shows the microplastic concentration fibres found for each product type within the literature.

---

[497] Cosmetics Ingredient Review (2012) Safety Assessment of Modified Terephthalate Polymers as Used in Cosmetics, December 2012

[498] Roland Essel, and et al. (2014) *Sources of microplastics relevant to marine protection*, Report for Federal Environment Agency (Germany), November 2014

[499] Gouin et al (2015) Use of Micro-Plastic Beads in Cosmetic Products in Europe and Their Estimated Emissions to the North Sea Environment, *SOFW Journal*, No.03-2015

[500] Author's findings from a random survey of cosmetic products available online.

Table 36 – Comparison of Production Data Sources

Product Category	Germany Production Quantity 2002 (t)	EU Production Quantity (Scaled up from Germany) (t)	Eurostat EU Production Quantity 2013 (t)	Euromonitor EU Production Quantity 2012 (t)
Shower gels, liquid soaps	100,000	558,000[1]	625,000[2]	668,000
Skin-care and sun protection	109,000	609,000[1]	-	-

Notes:

1. Germany is 18% of the European market by RSP. This figure is up-scaled to European levels based on this.
2. Eurostat Prodcom figure for 'Organic surface-active products and preparations for washing the skin; whether or not containing soap' for 2013. EU27 total for PRODQNT.

Table 37 – Microplastic Estimates for Other PCCPs

Product Type	Tonnes of Product	Microplastic Concentrations	Microplastic Total (t) 20% of Products	Microplastic Total (t) 10% of Products
Decorative	**37,811**			
Face	15,006	72%[4]	2,161	1,080
Lips	5,616	0.12%[1]	1	1
Eyes	10,412	46%[1]	964	482
Nails	6,069	14%[1]	170	85
Skincare	**670,000**			
Prestige Skincare	172,715	0.005%[1]	2	1
Face Care Non-medicated	260,176	0.005%[1]	3	1
Face Care Medicated	28,065	0.005%[1]	0.3	0.1
Face Care Male	21,870	0.005%[1]	0.2	0.1
Hand Care	17,555	0.005%[1]	0.2	0.1
Body Creams & Lotions	60,104	5%[3]	601	301
Lip salves	20,847	0.12%[1]	0	104
Sun Preparations	88,668	5%[2]	208	443
Hair Care				
Shampoo	219,141	5%[3]	2,191	1,096
Toiletries				
Deodorant	628,317	0.3%[1]	377	188
Total			**7,566**	**3,783**

Notes:

1. Cosmetics Ingredient Review (2012)
2. Dow Chemical Datasheet 'Sunspheres'
3. No data available. 5% is taken as a default value.
4. US patent: Milton Blaustein (1965) *Cosmetic Powder Compositions Containing Polyethylene*

The next stage of the calculation is to decide how much of the market for each product will contain microplastics. Data on this is non-existent and applying the assumption from Gouin (2011)[501]—and subsequently the Nova Institute[502]—of 15% of manufacturers use microplastics in 10% of their products (1.5% of overall market) seems to understate the issue. Based on the interviews held with cosmetics manufacturers where all admitted to using microplastic at some point, it is unlikely that only 15% of manufacturers are or were using microplastics. Microplastics may even be ubiquitous in some products, such as make-ups which rely on polymers as part of their core function. With this in mind, an upper and lower limit are proposed; the upper limit assumes that 20% of products contain microplastic and the lower limit assumes that 10% contain microplastics. This assumption is used across all product groups. This gives an estimate of between 3,800 and 7,500 tonnes of microplastic used in the part of the market not covered by the Cosmetics Europe survey.

It should be made clear that the data and assumptions that lead to this estimate of 'unaccounted' microplastics are very much in need of improvement to gain accurate figures for the use of microplastics in these products. This first attempt at quantification is used to draw attention to other potential sources of PCCP microplastics that have not yet seen the same level of study that the microplastics in rinse-off exfoliation products have. Further work is needed by the cosmetics industry to help understand the extent to which these other products contain microplastics and whether they should be considered marine litter.

Table 38 – Overall PCCP Microplastic Estimates

	Tonnes of PCCP Microplastics per annum used in Europe	Overall Proportion of Market (By Unit)
Cosmetics Europe Survey Estimate	4,844[1]	29%
Remaining Unaccounted	3,783 — 7,566	49%
Total	8,627 — 12,410	78%

Notes:

1. **From Table 34 including the 10% of the market not covered by Cosmetics Europe.**

---

[501] Gouin et al (2011) A Thermodynamic Approach for Assessing the Environmental Exposure of Chemicals Absorbed to Microplastic, Environmental Science & Technology, No.45, pp.1466–1472

[502] Roland Essel, and et al. (2014) Sources of microplastics relevant to marine protection, Report for Federal Environment Agency (Germany), November 2014

6.5.7 Environmental Fate of Leave-On Cosmetics

Further to the estimate of the amount of plastic being used by the cosmetics industry it is also important to discuss the fate of these additional sources that the industry mostly defines as ‘leave on’. These include many of the cosmetics identified in Section 6.5.7 such as sun creams and decorative make-ups. Whilst the cosmetics industry does not recognise these are potential sources of marine litter—because they are not, by design, automatically sent into the sewerage system during use—there are still potential pathways for these products to end up in the oceans.

Although these products are designed to be ‘leave-on’ many will be removed at some point; sun creams during swimming or abrasion; or decorative makeups at the end of the day by washing or using disposable wipes for example. The pathways to the oceans are not as well defined as the rinse-off products and there is a great deal more opportunity for the microplastics to be captured before they enter the ocean. This is highly dependent on the individual using the product and their routine for removal. Based on this lack of knowledge and data on exactly how much of these products may end up in the marine environment it may be inappropriate to use the waste water capture range (0-57%) that is proposed for rinse off products. Instead, a proposed range of 50-90% will be used for the proportion of microplastics in leave-on products that will be prevented from entering the marine environment. This reflects the assumed lower likelihood of these products entering the marine environment although a much better understanding of consumer habits—one that many of the global cosmetic manufacturers must surely have—would lead to an improved estimate for this.

6.5.8 Deriving Global Estimates

Factoring the European estimate from Table 38 (8,627 — 12,410 tonnes) up to a global scale in order to compare the figure with global estimates of plastic marine litter is problematic as there has been no work undertaken outside of Europe to quantify the amount of PCCP microplastics in any meaningful way. It is, however, possible to create an estimate based on European data by taking into account the relative market size of Europe compared with the rest of the world using the market data discussed in Section 6.5.1 shows a global estimate of between ***38,000 and 55,000 tonnes*** of microplastics that are used in PCCP products every year, which was achieved using this method.

Table 39 – PCCP Microplastic Global Scaling Based on Market Share

Region/Country	2012 Retail Market (Billion €)	Market Share	Tonnes of PCCP Microplastic per year	
			Lower Estimate	Upper Estimate
Europe	72	23%	8,627	12,410
Asia (excl. Japan and China)	61	19%	7,304	10,507
USA	47	15%	5,627	8,094
Brazil	38	12%	4,508	6,484
Japan	26	8%	3,130	4,503
China	14	4%	1,711	2,462
Russia	9	3%	1,127	1,621
Africa	7	2%	838	1,206
Other	45	14%	5,387	7,750
Total	**320**	**100%**	**38,259**	**55,036**

6.6 Overall Estimates for the Proportional Contribution from PCCP Microplastics

Table 40 provides a summary of the estimates provided in Sections 6.3.2 and 6.5.This combines both primary and secondary plastic estimates (secondary estimates being the plastics with the potential to fragment into microplastics) to find that between 149,000 and 493,000 tonnes of plastic ends up in the oceans every year from Europe. PCCP microplastics represent between ***0.68% and 3.1%*** of this. As we do not know how much of the potential secondary microplastics will become microplastics it is difficult to draw too many conclusions from these figures. Of more relevance, perhaps, is the proportion of PCCP microplastics when compared to other primary sources. This is estimated to be between **3.2 and 4.1 %**—significantly larger than other recent estimates.

On a global scale this proportion is reduced due to evidence suggesting that waste management practices may not be a stringent as within the EU and therefore more plastic may find its way into the marine environment. This is based on the assumption that PCCP microplastic usage is consistent globally, which it is almost certainly not. As Europe has the largest and most established cosmetics industry it is possible that usage per capita may be higher there than in many other parts of the world. Without data similar to that provided by Cosmetics Europe, but for other markets, it is impossible to know this for certain. One thing that is known for certain is that the ocean sampling estimates for amounts of plastic residing in the oceans fall well short of what should be found. With the best current estimate sitting at around 268,000[503] tonnes, if the plastics estimated in this study have been entering the oceans on a global basis every year for the last 30 years there should be between 200 and 700 million tonnes in the marine environment—over 2,000 times more than has been found currently.

[503503] Eriksen, M., Lebreton, L.C.M., Carson, H.S., et al. (2014) Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea, PLoS ONE, Vol.9, No.12, p.e111913

Table 40 - Estimates of PCCP Microplastics Annual Contribution

Area Covered	Annual PCCP Microplastics Flow (tonnes)		Annual Primary Microplastic Plastic Flow (excl. PCCP) (tonnes)		Estimated Proportion of PCCP Microplastics		Annual Potential Secondary Microplastic Flow (tonnes)		Total		Estimated Overall Proportion of PCCP Microplastics[504]	
Estimate Range >>	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
EU	2,461	8,627	78,000	210,000	**3.2%**	**4.1%**	69,000	275,000	149,461	493,627	**0.68%**	**3.1%**
Global	10,900	38,300	1,077,000	2,900,000	**1.0%**	**1.3%**	5,400,000	19,700,000	6,487,900	22,638,300	**0.05%**	**0.5%**

[504] Low estimated proportion is calculated by dividing the low PCCP estimate by the ***low*** primary microplastic total and the ***high*** secondary total (1,977/(30,000+275,000) = 0.57%). This is because the high and low estimates are influenced highly by the waste water treatment capture rate and therefore we cannot assume a low capture of one type of microplastic source and a high capture of another without specific research into the capture rates of different microplastic sources.

6.6.1 Deriving an Estimate of the Amount and Proportion of PCCP Microplastics in the Marine Environment

Although this study has highlighted the difficultly in deriving an accurate estimate of the amount of PCCP microplastics that are actually in the ocean currently it is possible to obtain an approximate estimate using a number of assumptions to provide an indication of the order of magnitude.

The medium estimate of the cumulative land-based plastics from the graph in Figure 47 is 2.2 million tonnes of land based plastic deposited in the marine environment between 1980 and 2012. This estimate is based on Jambeck's[505] estimate for 2010 and extrapolating using the annual European plastics production. Applying the same backward extrapolation to the riverine and sea based sources (using plastic production data) adds a further 700,000 tonnes to reach ***2.9 million tonnes***. This is the cumulative total for secondary sources (using the mid-point of upper and lower estimates).

Estimating primary microplastics discharge over the same period is potentially more difficult as it would require activity data for each source over the last 30 years. In many cases data was not publically available from recent years therefore longer periods are even more difficult to obtain. In the case of PCCP microplastics the annual proportion may only be applicable to a few years either side of 2012—as data is shown in Section 7.0, 2012 is considered to be the peak of production for cosmetics containing microplastics as this is the year manufacturers and consumers first began to take action on the issue. There is no data or information available which can point to the date when microplastics first became part of 'mainstream' consumer cosmetics, but Cosmetics Europe suggest this was at some point in the early 1990's.

All other sources of primary microplastic identified in the study (tyre dust, paint fragments, textiles etc.) would certainly have had emissions prior to 1990, but in many cases would have been captured in waste water treatment to a lesser extent before improved treatment was required as part of the Urban Waste Water Treatment Directive in 1991. It is difficult to know the extent to which this may have affected microplastic emission, therefore the level of European plastics production for each year will again be used to extrapolate annual emission tonnages backward from 2012 to 1980.

One notable exception is pellet spills. Although data is sparse, it is accepted that the number and frequency of spills has reduced considerably over the past decade as handling procedures have improved. To account for this and in the absence of specific industry data we will assume that the emission factor would have been double current levels from between 1980 to 1990 and from there onwards would reduce to the current estimated emission factor—each annual emission is still relative to the annual plastics

[505] Jambeck, J.R., Geyer, R., Wilcox, C., et al. (2015) Plastic waste inputs from land into the ocean, Science, Vol.347, No.6223, pp.768–771

production as the two would be very closely linked. The annual estimated emissions modelled for each microplastic source can be found in Table 52 in Appendix A.4.0.

With these assumptions in place the total EU emission to the marine environment of primary microplastics from 1980 to 2012 can be estimated at ***4.3 million tonnes*** (using the mid-point averages for each emission). PCCP microplastics are estimated to account for ***1.5%*** of this (63,623 tonnes).

The total of EU primary and secondary plastics emissions from 1980 to 2012 comes to ***7.3 million tonnes*** with PCCP microplastics accounting for around ***0.91%*** of this.

When comparing these proportions with the ones in Table 40 it is clear that the proportion of PCCP microplastics is much higher now than it has been in previous decades. This can in part be attributed to PCCP microplastics being only relatively recently produced in high volumes and also, in part, to the fact that several other sources such as pellets are significant but have reduced over the years. Because of this, we find that if the consumption and emission of PCCP microplastics continues to grow at the same rate that has been assumed, the overall proportion will increase.

7.0 Task 2.2: Mapping of Manufacturers' Commitments

From around 2012 onwards cosmetic manufacturers have been responding to continued pressure from consumers and NGOs to remove microbeads from their products. Some have made firm commitments, others have indicated their willingness to work towards this goal, whilst most have no public stance on the issue.

In order to map these commitments over time the cosmetic market as a whole must be assessed for its magnitude and the relative market shares that each manufacturer is responsible for. This allows their contribution to the PCCP microplastic issue to be quantified.

7.1 Identifying Major Industry Players in the Cosmetics Industry

The cosmetics industry is dominated by a few large multinationals that manufacture and sell product in many of the global markets. This must not be confused with some of the global brands which are owned by a parent company which may also own several other successful brands and in some cases do not produce any product under the parent company branding.

The process outlined below was carried out in order to identify the manufacturers that are or were producing products containing microplastics. This was done in order to define a priority list for contacting manufacturers believed to be contributing the most, with subsequent mapping of their commitments to remove microplastics from their products.

A top twenty list of cosmetics manufacturers is published on an annual basis by Beauty Packaging Magazine[506]—one of the few published lists that focuses on manufacturer rather than brand. This list was used as a starting point to identify the key players in the industry as a whole before a more focused list was created of the manufacturers that use or used microplastics in their products.

The list was then amended to remove those companies that do not have a large presence in the EU. Natura, for example, is a Brazilian based company which operates mostly in South America. Direct sell companies Mary Kay and Amway are also both private companies which do not publish any financial information; however, they are thought not to have a large presence in Europe as their primary market is the US. Other

[506] http://www.beautypackaging.com/heaps/view/976/1/

manufacturers that are known to sell products that contain microplastics have been added to the list. These manufacturers were found through the product lists created by the Beat the Microbead campaign[507].

Table 41 – Top 20 Global Comestics Companies

Manufacturer	Example Brands	Global Cosmetics Turnover (€ Billion)
L'Oréal	Lancôme, Maybelline, Garnier, Body Shop	€22.3
Unilever	Dove, Simple	€18
Proctor & Gamble	Pantene, Olay, Head & Shoulders	€15
Estee Lauder	Clinique	€7.7
Johnson & Johnson	Neutrogena, Clean & Clear	€5.6
Shiseido	Shiseido	€5.4
Avon	Direct sale of own brands	€5.7
Beiersdorf	Nivea	€5
Kao	John Frieda	€3.8
LVMH	Christian Dior, Benefit	€3.6
Henkel	Schwarzkopf	€3.5
Coty	Adidas	€3.5
Mary Kay	Direct sale of own brands	€2.6
L Brands	Victoria's Secret, Bath & Body Works	€2.5
Natura		€2.5
Yves Rocher		€2.35
Amway	Direct sale of own brands	€2
AmorePacific Corp		€1.9
Chanel	No. 5	€1.8
Oriflame		€1.4

Source: www.beautypackaging.com

Annual company reports for the year 2013 were analysed for all the companies on the list. Only Yves Rocher and Pierre Fabre—being private companies—did not have a public record of their accounts. The remaining company reports were interrogated for the revenue generated from cosmetics sales in order to verify the sales figures from Beauty Packaging Magazine, the proportion of those sales that can be contributed to 'skin care',

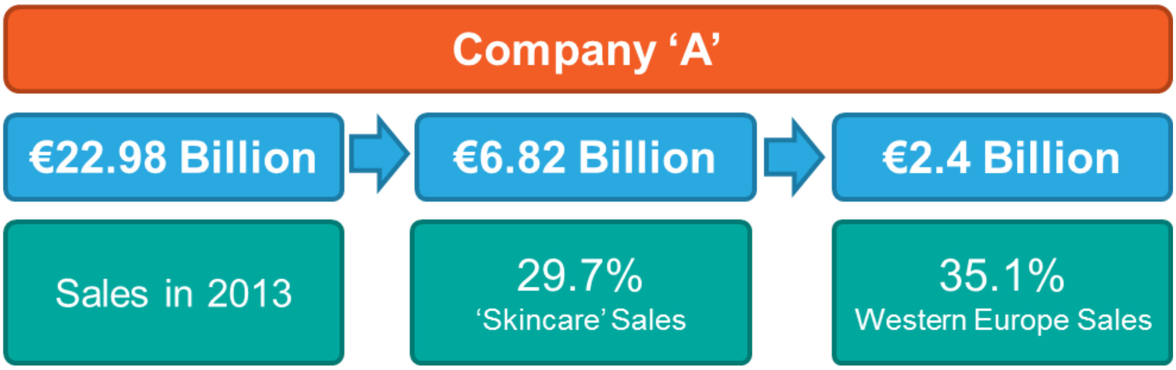
---

507 http://www.beatthemicrobead.org/en/

and the proportion of their revenue generated from European sales. 'Skin care' is the overarching term used by many of the manufacturers to define products that are applied to the skin in order to clean, protect or moisturise and tended to differ from the list in Table 35. Often the term also includes products from the 'toiletries' category such as shower gels and facial scrubs, but it does not tend to include and make-up products from the 'decorative' product category. These terms are not universally applied or adhered to, however. Each company has a different idea of what each term means and the products that are likely to feature in it. This is largely down to the way the business is organised and can be split geographically also. Assessing the size of the presence of each company in the 'skincare' market will, however, provide an indicator as to who the largest players are and their market share within Europe.

The process for identifying the proportion of each manufacturer's sales which can be assigned to 'skin care' in Europe is shown in Figure 60 for an example company. Of the company's €22.98 billion worth of sales in 2013, 29.7% came from 'skincare' products. Western Europe accounted for 35.1% of sales. Without more detailed sales breakdowns, it is assumed that the proportion of 'skincare' sales is consistent across geographic regions. This means that €2.4 billion of sales can be attributed to 'skincare' in Europe by this company. The same process was carried out for all of the manufacturers.

Figure 60 – Company 'A' 2013 Sales Breakdown



In some cases it was not possible to disaggregate revenue figures to identify the total value that can be assigned to skin care or similar. Unilever, for example, had a turnover of €18.1 billion in 2013 under their category of 'personal care', which accounts for 36% of their overall turnover. This category also includes hair products and deodorants, which are considered out of scope by Cosmetics Europe, but—as identified in Section 6.5.6— still may be sources of microplastic. In cases such as these a default value of 24.9% is applied. This is the proportion of sales assigned to the skin care category in 2013 according to Cosmetics Europe and shall be used where no other information is available. Two exceptions to this rule are Shiseido and Beiersdorf. Both of these manufacturers almost exclusively produce products for skin application, with a large proportion from 'leave-on' products and 'decorative cosmetics'. An estimate of 40% has been given to these manufacturers who are suspected to have a higher proportion of their products defined as skin care.

Whilst the total retail market for cosmetics in Europe is around €72 billion per year, the total market value by manufacturers selling price (MSP) is needed to define the overall market from the perspective of the manufacturer. Cosmetics Europe estimates this to be €43.85 billion for 2013; this is an average retail mark-up up of 61% (which can be seen by country in Figure 50 in Section 6.5.1). If this mark-up is assumed to be the same on a global scale we find that the global retail cosmetics market of €319 billion is worth €194 billion to the manufacturers.

Table 42 – Estimated 'Skin Care' Market Shares in Europe

Manufacturer	Cosmetics Europe Member?	Estimated European Revenue from Skin Care Sales (billion €)	Estimated European Skin Care Market Share
Company 'A'	Yes	€ 2.40	21%
Company 'B	Yes	€ 1.24	11%
Company 'C'	Yes	€ 1.22	8%
Company 'D'	Yes	€ 1.13	11%
Company 'E'	Yes	€ 0.87	6%
Company 'F'	Yes	€ 0.85	2%
Company 'G'	Yes	€ 0.73	7%
Company 'H'	Yes	€ 0.65	10%
Company 'I'	No	€ 0.41	1%
Company 'J'	Yes	€ 0.30	2%
Company 'K'	Yes	€ 0.26	3%
Company 'L'	No	€ 0.26	2%
Company 'M'	Yes	€ 0.24	4%
Company 'N'	Yes	€ 0.20	1%
Company 'O'	Yes	€ 0.13	2%
Company 'P'	No	€ 0.10	6%
Company 'Q'	Yes	€ 0.08	1%
Company 'R'	Yes	€ 0.08	1%
Total		**€ 11.14**	**97%**
Total for Cosmetics Europe Members		**€ 10.38**	**90%**
Total Estimated Market		**€ 11.53**	**100%**

Notes:
Cosmetics Europe states that its members cover 90% of the market. As the total revenue for those companies is estimated to be €10.38 billion, the overall market is estimated to be €11.53 billion. By including companies that are not Cosmetics Europe members the total coverage in this analysis is estimated at 97% of the market.

According to Cosmetics Europe the European market for skin care products is 24.9% of the total—a value of €10.38 billion per year. Cosmetics Europe claims that it covers 90% of the market through its members, which means that €9.83 billion worth of sales could be attributed to these members.

Table 42 shows the results of the process described in order to arrive at a value for the whole of the skin care market by analysing the annual reports of the largest manufacturers. This returns the figure of €11.14 billion, which is close to the Cosmetics Europe market valuation. The calculated figure for Cosmetics Europe members in Table 42 is €10.38 billion—just over half a billion or around 5% more than Cosmetics Europe Estimates the skin care market to be. This suggests that the company analysis is broadly representative of the state of the skincare market in Europe.

As well as the skin care market, it is also important to analyse the oral care market. The product of interest in this market is toothpaste, but there are many other products that form this market including toothbrushes, dental floss and mouth washes—none of which are known to contain microplastic particles. Although the oral care industry is also dominated by a few large players, as some specialise in one specific product type, making it inappropriate to adopt the same market share analysis as conducted for skincare.

Table 43 – UK Toothpaste and Toothbrush Sales for 2010

	UK Toothpaste Sales (million €)	Toothpaste Market Share	UK Toothbrush Sales (million €)
Colgate Palmolive	€ 196	47%	€ 50
P&G	€ 16	4%	€ 143
GSK	€ 142	34%	€ 20
Church & Dwight	€ 24	6%	€ -
Wisdom	€ 10	3%	€ -
Other	€ 12	3%	€ 6
Own Label	€ 16	4%	€ 22
Total	€ 417	100%	€ 241

Source: www.marketingmagazine.co.uk/article/1068895/sector-insight-oral-healthcare

As can be seen in Table 43, Colgate Palmolive and GSK—mostly under the brand 'Aquafresh'—accounted for 81% of the UK toothpaste market in 2010. Both of these manufacturers—along with P&G—are Cosmetics Europe members which together represent 85% of the market; this is close to the 90% market coverage that Cosmetics Europe states overall. The important detail is that both toothpaste and toothbrushes are often part of the same 'oral care' function of a cosmetics company, but toothbrushes are not classed as cosmetics. P&G gain most of their sales in the sector from toothbrushes, whereas Colgate Palmolive and GSK inversely gain most of their sales from toothpaste. It would be unfair on P&G, therefore, to assign a proportion of the PCCP microplastic totals based on their figures for oral care sales in their annual report. Instead, the UK market shares will be used as a proxy for Europe as a whole as it is believed that Colgate Palmolive and GSK are the market leaders throughout most of Europe also.

7.2 Review of Stated Commitments

The following is a review of the stated commitments that have either been obtained from public statements from cosmetics manufacturers or through direct communication. It is important to reiterate that every company contacted uses the Cosmetics Europe definition to gauge whether they have fulfilled their commitment:

> *“Plastic microbeads designate synthetic non-biodegradable solid plastic particles >1µm and < 5mm in size used to exfoliate or cleanse in rinse-off cosmetic products.”*

The scope of this includes toothpastes but will not include other potential microplastics source products that are not described as ‘rinse-off’. As identified in Section 6.5.5, there is a further source in ‘leave-on’ products such as sunscreens. The extent to which these occur was not part of the Cosmetics Europe survey, and although they do acknowledge that they may exist in small quantities they are almost certainly not part of the company commitments.

The key players identified in Section 7.1 were contacted to develop an understanding of the issues involved for them and to ascertain whether they have, at any time, used microplastics (according to the Cosmetics Europe definition) in their products. Table 44 shows a summary of the commitments made to date. The top eight by market share account for 82% of the market and all of these have made commitments to end use of PCCP microplastics by the end of 2017 at the latest. Both Companies ‘C’ and ‘H’ have confirmed that they no longer produce any products containing PCCP microplastics. Out of the top eight, only companies ‘B’ and ‘F’ have not made any public commitments to phase out use of PCCP microplastics by a specific date.

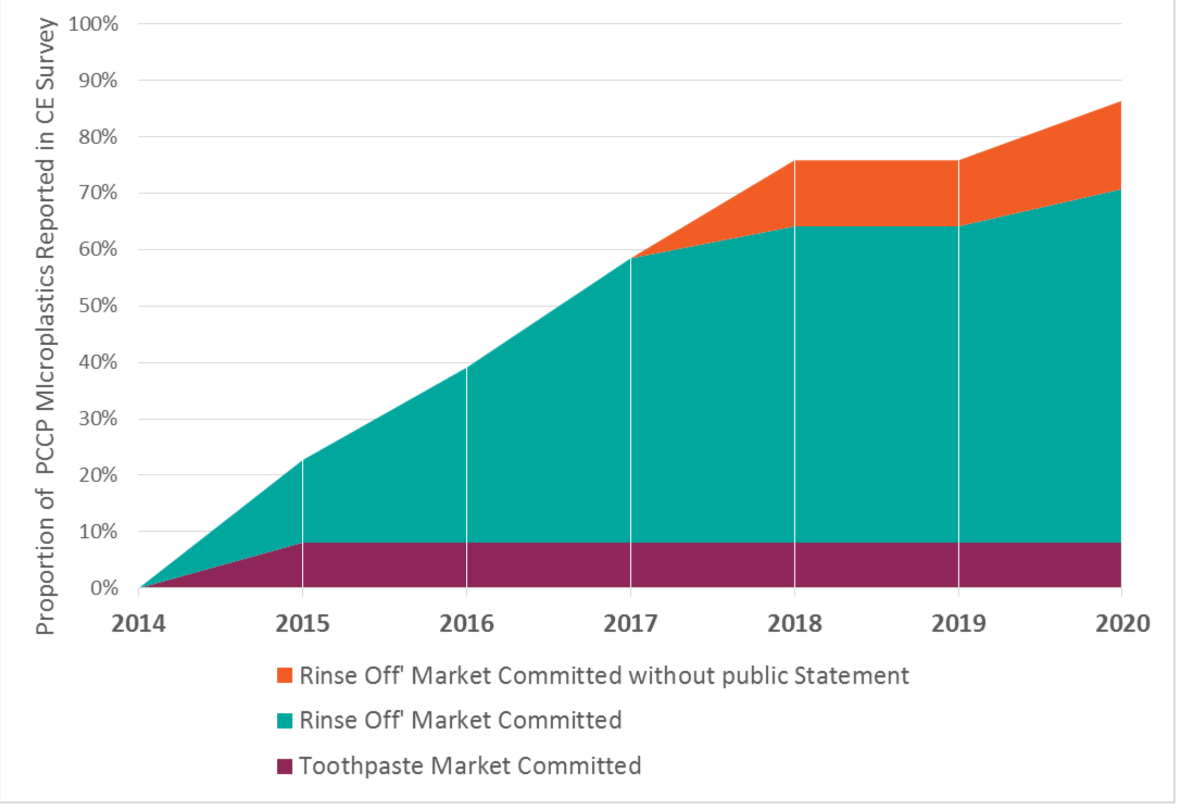
A summary of the commitments in the form of a timeline is shown in Figure 61 using the market data in Table 25 to assign a proportion of the estimated microplastic use to each company depending on the size of their market share and reducing that amount based on the stated commitments in Table 44; a 100% commitment would represent the entire estimated tonnage (4,844 tonnes as shown in Table 38) of microplastics being removed from PCCP products as defined by Cosmetics Europe in their company survey. If all private and public commitments are fulfilled, 86% of the market by manufacturers selling price (MSP) will have removed microplastics from their toothpastes and ‘rinse off’ skincare products in line with the Cosmetics Europe definition. This is based on the assumption that those companies that have committed to removing microplastics from their products, but have not set a date, will have completed the process no later than 2020. Dates were also given by most manufacturers for the commencement of reformulation activities, and it is assumed that from that date and until their respective deadlines there will be a consistent reduction, although depending on product sales proportions this may, in reality, be a series of large step changes as each product is reformulated. Only 71% of the market by MSP is committed to removing microplastics by way of a public commitment, the remaining 15% of the commitments have been obtained through direct contact with the company and are not supported by a public statement—either as a statement on their website, company report, or as part of a third-party requesting a comment (in a news article, for example).

Table 44 – Skincare Product Manufacturers Commitments

Manufacturer	European Skincare Sales(billion €)	Market Share	Public Commitment Made?	Commitment to Remove by
Company 'A'	€ 2.40	21%	yes	End of 2016
Company 'B	€ 1.24	11%	no	End of 2017
Company 'C'	€ 1.22	11%	yes	Jan 2015
Company 'D'	€ 1.13	10%	yes	End of 2015
Company 'E'	€ 0.87	8%	yes	End of 2016
Company 'F'	€ 0.85	8%	yes	Non-specific commitment
Company 'G'	€ 0.73	7%	yes	End of 2017
Company 'H'	€ 0.65	6%	yes	End of 2014
Company 'I'	€ 0.41	4%	no	No commitment
Company 'J'	€ 0.30	3%	no	No commitment
Company 'K'	€ 0.26	2%	no	Non-specific commitment
Company 'L'	€ 0.26	2%	no	End of 2017
Company 'M'	€ 0.24	2%	no	Non-specific commitment
Company 'N'	€ 0.20	2%	no	No commitment
Company 'O'	€ 0.13	1%	no	No commitment
Company 'P'	€ 0.10	1%	yes	End of 2014
Company 'Q'	€ 0.08	1%	yes	End of 2016
Company 'R'	€ 0.08	1%	no	No commitment

Notes:
Companies are anonymised due to some requesting that their commitment is not made public at this time.

Figure 61 – Combined Cumulative Market Commitments Based on Reported Microplastic Tonnage from Cosmetics Europe Survey



For ***toothpastes*** in Europe it is understood—through Cosmetics Europe—that although GSK is one of the market leaders, it has never included microplastic particles in its toothpastes for the European market (this may not be the case for the US). The other two market leaders, Colgate Palmolive and P&G, are thought by Cosmetics Europe[508] to be the only companies to be using microplastics in their toothpastes, however there is evidence that some supermarket own-brands and Church and Dwight have also been found to contain microplastics by the Beat the Microbead[509] campaign. Company 'H' has reported that it completed the removal of microplastics from its toothpastes by the end of 2014. Similarly, Company 'E' has also reported that its toothpaste products have been free from microplastics from mid-2015, and therefore 85% of the market (assuming the European market is similar in consistency to the UK market shown in Table 43) for toothpaste in the European market should now be free of microplastics. While this means that no more will be manufactured, there may still be stocks in shops, although

[508] Personal communication with Gerald Renner, Cosmetics Europe.
[509] http://www.beatthemicrobead.org/images/pdf/redUK.pdf

Cosmetics Europe has suggested that cosmetic products tend to work on a rolling stock of around three months so the majority should be used up by the end of 2015.

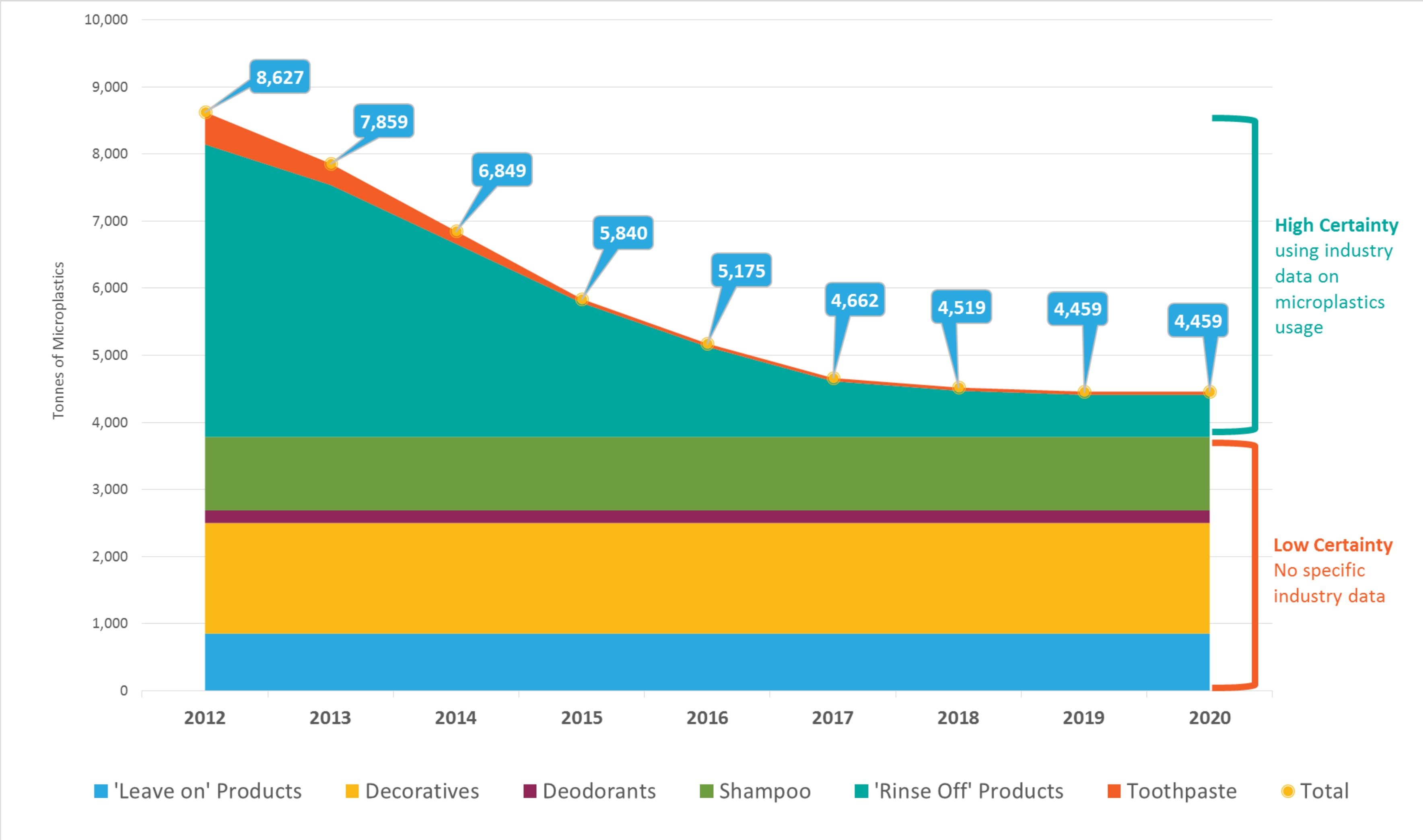
The Cosmetics Europe survey estimated that 436 tonnes (as seen in Table 34) of microplastics are produced by its members every year. Assuming that GSK do not use microplastics, the remaining two members in Table 43 account for the whole of that 436 tonnes. Cosmetics Europe state that their members account for 90% of the cosmetics market therefore 48 tonnes (436/9) is attributable to the remaining market.

Figure 62 gives an illustrative example of how total PCCP microplastics usage in Europe (including all types of plastic materials and all types of cosmetic products known to contain microplastics) may drop from 2012. Cosmetics Europe confirms that it expects that 2012 was the high point in production of PCCP microplastics (according to its definition). After then, cosmetics manufacturers are believed to have responded to calls to remove them from their products. The peak point in 2012 of 8,627 tonnes is based on the low estimate of the products that remain ‘unaccounted for’ by the industry and therefore did not form part of the Cosmetics Europe survey—as discussed in Section 6.5.6. If the high estimate is used the peak would be 12,410 tonnes.

With the low estimate, by 2020 the overall use of microplastics is expected to have almost halved. The remaining 4,459 tonnes is made up of the manufacturers who have not made a commitment to reducing PCCP microplastics (but still may be doing so) and the PCCPs that the industry currently asserts is out of scope.

As discussed in Section 6.5.5 this total may not include all the possible forms of microplastic that could be considered as marine litter; however, it represents the industry’s current actions on the issue, which has been bought to their attention through pressure from NGOs and the subsequent consumer reaction. It also provides an indication of the potential scale of microplastic use in products that have not seen such attention. Further research and engagement with the cosmetics industry will be necessary to ascertain whether there are further, as yet, unidentified microplastics issues with other ingredients in cosmetics.

Figure 62 – European PCCP Microplastics Reduction Timeline



7.3 PCCP Microplastic Alternatives

One of the main reasons given by many of the cosmetics companies contacted as part of this study for removing microplastics from their products is the existence of alternatives. These alternatives—especially the organic types—have been used in cosmetics products for decades so they are well established in the market. There are significant costs of moving existing products to these alternatives as they have to be reformulated and user tested to make sure they are acceptable to the consumer—this is discussed in Section 7.4.

During contact with several of the leading cosmetics companies various alternatives were quoted as being used. However, often companies did not name specific alternatives due to the fact that they differ based on the requirements of specific products and as some companies were only just beginning the process of reformulation. None of the cosmetics companies interviewed divulged the source of either their microplastic or any of their alternatives; however, a number of alternatives are being marketed to cosmetics companies by manufacturers.

All of the alternatives specified are a direct replacement for microplastics used as an exfoliator in rinse-off PCCPs. During the interviews with cosmetics manufacturers no other replacements were offered up as an alternative to the other functions that polymers can perform, especially with regard to leave on products.

The following is an overview of some of the alternatives that are known to be used and is by no means an exhaustive list.

7.3.1 Inorganic Alternatives

Nine of the twelve cosmetics companies interviewed suggested that silica (silicon dioxide) was the main alternative that they were using in their product reformulations, mainly for its inert, non-toxic nature and the fact that it is unlikely to lead to the issues with allergic reactions and product lifespans that organic ingredients can. Although naturally occurring in the earth's crust and abundantly available through the mining and purification of quartz it is not deemed pure enough in its natural crystalline form and is therefore not used in cosmetics.[510] Instead, it is manufactured to create a synthetic amorphous silica (also known as 'fumed' silica) chemically identical to naturally occurring silica but with a higher purity and uniformity in shape.

Evonik Industries[511] manufacture and market one such product (SIPERNAT) aimed at the European market for cosmetics applications. They currently produce two products sized at 320 µm and 120 µm. This is on the lower end of the size range found in the Cosmetics

[510] Cosmetic Ingredient Review (2009) Safety Assessment of Silica and Related Cosmetic Ingredients, September 2009

[511] http://corporate.evonik.com/en/media/press_releases/Pages/news-details.aspx?newsid=47653

Europe survey and as seen in Table 33 in Section 6.5.3 would only be suitable for 27% of the market—assuming that similar sizes of polyethylene and silica have the same effect.

With silica being approximately twice[512] the density of (sea) water its behaviour in a WWT plant would be quite different to that of polyethylene. It will almost certainly behave in a similar way to other sand and grit particles, which either settle out in pre-filtration or in the primary sedimentation process where they will be captured in the sludge. Therefore, even if transported to the ocean the material will most likely sink and become part of the sediment.

A potential issue that may occur—highlighted as a problem in relation to more dense materials in the original US patent—is that these materials may lead to the blocking of drains in households. As they are not neutrally buoyant they will have the tendency to sink and not wash away as easily, which may lead to build up in the household drainage system over time.

There are also health impacts associated with the handling of silica during manufacture. Silica dust can be inhaled and long-term exposure can cause a lung disease[513] known as silicosis, which may be an issue for workers regularly handling it. However, as silica is used in many industries and applications worldwide there are usually well established safety protocols in place to prevent exposure to the workforce and this would certainly not be an issue for the consumer who buys a product containing silica so long as the included particles are not small enough to be respirable (i.e. 10 µm or smaller[514]). There may be trace impurities of heavy metal present including antimony, chromium and barium; however, these are deemed to be in acceptable levels by a UNEP safety study[515] and fall within the requirements of DIN EN 71/3 which sets the safety requirements for children's toys.

7.3.2 Organic Alternatives

A number of organic alternatives were identified during industry interviews, one of the most prevalent being the walnut shell. This has the advantage of biodegrading in most environments—being made from cellulose and lignin—but, according to the cosmetics industry, comes second to silica because of the difficulty of product reformulation. Preservatives must be added to the product formulations to make sure that the walnut does not reduce the product lifespan and a sterilisation process also needs to be applied before walnut can be added to the product.

[512] http://www.azom.com/article.aspx?ArticleID=1114
[513] http://www.silica-safe.org/know-the-hazard/why-is-silica-hazardous
[514] Cosmetic Ingredient Review (2009) Safety Assessment of Silica and Related Cosmetic Ingredients, September 2009
[515] UNEP (2004) Synthetic Amorphous Silica and Silicates, October 2004

In addition, the size and shape of walnut shell particles are not uniform because they are created by grinding. This can create sharp edges which can be more abrasive than plastic. There may also be health implications for those who suffer from nut allergies, and therefore the presence of walnut shells in the product must be clearly labelled. All these considerations mean that it is difficult for manufacturer to maintain a consistent product for the consumer when these changes are made.

Walnut shells and similar ground down organic products are sized by sieve and the size consistency classified by defining the proportion of the shell grindings which fit through certain sized apertures. For example, 35/60 grade shows that the maximum size is 0.5 mm and the minimum is 0.25 mm. One US manufacturer[516] selling walnut shells in this grade specifies that 5% will be over and 5% will be under the upper and lower limits while 70% will be 0.355 mm and under.

Apricot shells and pits, cocoa beans, and pecan shells are all alternatives[517] available on the market, although there is limited information available on the extent to which they are used. It is expected that they would carry many of the same advantages and disadvantages as walnut shells, however.

7.3.3 Biodegradable Plastics

The use of biodegradable plastics as an alternative has become a contentious subject. This is largely due to the ban that was enacted in Illinois allowing the use of biodegradable plastics without defining what this meant and the conditions needed to meet the criteria of the ban. The wording of the Illinois bill and its implications are discussed further in Section 8.1. In this section the suitability of biodegradable plastics as an alternative will be analysed.

Confusing terminology has created a barrier to the use of biodegradable plastics, as they are often called 'bio' plastics for short, while 'bioplastic' can also refer to plastics created from renewable biomass sources. Even though materials in the second group are plant based in origin they are transformed into a plastic with properties similar to that of conventional plastic and are therefore usually not biodegradable. Because of this—and the associated media attention—most cosmetics companies say they are not currently actively working to include these types of alternatives in the near future. This is primarily because the development costs are too high to allow investment without knowing whether biodegradable plastics will be included under any new bans, particularly in the US.

516 http://raw-materials.mckinleyresources.com/item/cosmetic-walnut-shells/ground-english-35-60-walnut-shells-cosmetic-/ground-english-35-60-walnut-shell?

517 http://compomat.com/cosmetics-grade-ingredients/

The US manufacture Metabolix markets a product for the cosmetics market made from polyhydroxyalkanoate (PHA) called Mirel[518], which it claims is biodegradable in the marine environment. A 2012 study[519] by California State University looked at whether Mirel PHA will degrade in the marine environment, using the American Society of Testing and Materials (ASTM) standard D7081[520] as the definition for degradability. This standard has since been withdrawn as it had not been updated recently and therefore there is no current standard for degradability in the marine environment. The standard specified that 30% of the material should be converted to carbon dioxide within six months of entering the marine environment at a temperature of 30°C—a surprisingly high temperature given that it would be rare for any ocean to reach this, especially below the surface.

The test was conducted with two samples, and it was found that they degraded by 38 and 45 percent. The test was extended to 12 months, by which point the samples were found to have degraded by 52 and 82 percent. Both the six month and the 12 month tests showed that PHA degraded at the same rate as the control sample of cellulose. It was also found that the samples did not release any detectable toxic chemicals into the water during the test period.

It remains to be seen whether the degradation period is short enough to prevent physical harm to be caused to organisms and whether the same issues of chemical transport into the marine environment that occur with conventional plastics also exist with PHA. There also appears to be the need for an updated test standard—one that tests in temperatures that are representative of sea temperatures which occur where these plastics are likely to be found.

Until both these issues are researched sufficiently any cosmetics company deciding to use these alternatives faces the risk that they may be included in some of the forthcoming bans—particularly in California and Maryland—although this is an issue which is changing very frequently as the discussion is moved forward between industry, NGOs and governments. There is more discussion on this point and the difficulty in creating an agreed definition for the wording of potential bans in Section 8.1.

7.4 Upstream Impacts for the Plastics and Cosmetics Industries

The potential for the reduction of PCCP microplastic manufacture for European consumption as identified in Section 7.2 shows that there could be around a 4,000 tonne reduction in the microplastic being sold in cosmetic products every year in Europe. There

[518] Also under the name Asensa in partnership with Honeywell
[519] California State University (2012) PLA and PHA Biodegradation in the Marine Environment, Report for California Department of Resources Recycling and Recovery, March 2012
[520] http://www.astm.org/DATABASE.CART/WITHDRAWN/D7081.htm

has so far been no work by the plastics industry[521] to ascertain whether a phase out of PCCP microplastics will have a significant impact on any particular manufacturers or whether there are any that rely solely on the cosmetics industry for their business. We also do not know the makeup of the industry in order to discern whether it is primarily composed of larger moulders capable of divesting and diversifying or whether there are many SMEs which rely on this area for business. Large multinational plastics processors such as Dupont, Dow chemical and BASF are known to be present in this market (as identified in Section 6.2), however, to what extent is not clear. It is, however, known that there has been no significant opposition to the stance of the cosmetics industry on the issue from Plastics Europe or its members and that they support voluntary measures by the cosmetics industry to remove microplastics from their products once suitable alternatives—that will not cause larger issues themselves in the future—are found.

The plastics industry in Europe is known to produce around 57 million tonnes[522] of plastic per year and therefore if all European production of PCCP microplastics were to end this would only represent a reduction of 0.005%.

Through engagement with cosmetics industry representatives it is clear that there is a significant cost associated with the reformulation of each product in order to remove or replace microplastic particles. Specific costs are known to vary as the process of replacing or removing microplastics can be complicated. Plastics have been used for their inert nature and their consistent smooth texture, which cosmetics companies say that consumers are happy with—until they understood that the particles were, indeed plastic. Replacement with other materials such as organic alternatives can mean extra preservatives are needed, and furthermore extensive consumer trials must be carried out to make sure that the replacements meet expectations. This process can take up to three years per product, although more usually taking around a year.

Although specific cost information was not made available by cosmetics companies, Cosmetics Europe suggests that a reformulation can cost in the region of €50,000 per product. All manufacturers interviewed also stated that microplastic containing PCCP products account for less than one per cent of their product range, although for some individual brands owned by a larger company this may be a great deal higher. One of the larger manufacturers stated that they produced around 10 to 15 product formulations containing microplastics; the implication being that these would be used in many more different products under different brands that they own. Again, this refers specifically to rinse-off products under the Cosmetics Europe definition as none of the companies acknowledged an issue beyond this. Assuming the larger manufacturers (with sales in the €billions) all have around 10 formulations this would entail a reformulation cost per company of somewhere in the region of €500,000.

---

[521] According to Plastics Europe as of April 2015

[522] Plastics Europe (2014) Plastics – the Facts 2014/2015: An analysis of European plastics production, demand and waste data, 2014

It is possible to scale up the number of product formulations stated by one of the larger companies for the full market, based on relative market shares. This puts the overall number of microplastic containing product formulations at around 144. To reformulate all of these products would cost around €7.2 million. This is a general estimate for Europe, however, many of the cosmetics companies have global brands and products and therefore there will be some crossover where reformulations will be used in multiple markets. Because of this most companies' commitments to the removal of microplastics have been made on a global basis. To put this figure in perspective, €7.2 million accounts for around 0.06% of annual skin care sales (in MSP) within Europe.

7.5 Mapping of Manufactures' Commitments Summary and Conclusions

With the co-operation of the cosmetics industry and Cosmetics Europe the best available usage data for any primary microplastic source emission has been gathered. The growing consumer pressure and a media spotlight on the issue has led to this data-gathering by the industry, who recognise this as an important issue for them (albeit none of the manufacturers fully acknowledge that the contribution of PCCP microplastics to the marine plastic issue is a significant environmental issue). The driving forces stated by the manufacturers differ, but largely fall into one or both of two categories;

1) ***Responding to consumer pressure*** – Recognising that the negative publicity from continuing to use an ingredient that the consumer sees as undesirable may be problematic especially as other key industry players are known to have removed them already; and
2) ***Wanting to act responsibly*** – Almost all large cosmetic manufactures have a sustainability policy. Many of these state various commitments to improve their environmental performance which includes the removal of certain ingredients that are seen by the public as—if not entirely scientifically proven to be—harmful.

For these reasons, all of the 12 manufacturers that agreed to participate in this study (representing an estimated 87% of the 'skincare' market by MSP) have stated that they are working towards or have completed the removal of microplastics (according to Cosmetics Europe's definition of microplastics) from their products. Five manufacturers representing 10% of the market have neither a public commitment nor provided any positive response to attempts to make contact. The remaining three per cent of the market remain unaccounted for in this study and are likely to comprise many smaller regional and local manufactures.

Timescales differ for the removal process although the majority that have made a commitment have set a deadline of the end of 2016. Some manufacturers had already removed microplastics from all of their product formulations by the beginning of 2015, however;

- three manufacturers—representing 12% of the market—have committed to removal but are unable to provide a date for completion (it has been assumed that all of these manufacturers will have completed that process by 2020) and only one of these has made a public commitment to remove microplastics from their products.
- Of the remaining 75% of the market that participated in the study, eight manufacturers representing 62% of the market were able to provide commitment end dates and have made these or similar commitments publically.
- The remaining 13% of the market have made commitment end dates to this study which are not supported with a public statement as of August 2015.

Although the majority of the voluntary removal of microplastics from cosmetics will take place on a global basis it is clear that Europe is a key global market. Therefore enacting a ban within the EU would further strengthen the economic case for businesses that operate globally to remove microplastics from their products in all of their markets. Similarly, a federal ban in the US may have similar impacts in Europe and potentially negate the need for a further ban.

As identified previously, there may also be cause for concern with regard to other polymers that are used regularly in cosmetics. Little is known about some of these ingredients and how they behave in the marine environment. Many of these are not currently covered by Cosmetics Europe's definition of PCCP microplastics and are therefore not included in any reduction targets. Similarly, any cosmetic products that are not deemed to be 'rinse-off' may also contain microplastics but fall outside of the scope of the definition. Whilst these 'leave-on' products, such as face creams and sunscreens, may not directly be washed into the drain but can, for example, end up in the water system after being removed by tissues which are subsequently flushed away. Little is known about this area and whether it is an issue or not.

One the basis of these results the following is recommended to monitor and look to improve the situation by making sure that the industry is complying with its voluntary removal of microplastics and investigating whether there are other PCCP products which are not currently being addressed by the cosmetics industry;

- ***Agree on a definition that does not contain 'loopholes'***— The current Cosmetics Europe definition is insufficient to adequately cover all of the potential product emissions of microplastic due to;
    - biodegradable polymers being allowed with no definition of biodegradability;
    - being limited to 'rinse off' products when microplastics are known to be a part of many 'leave-on' products; and
    - excluding particles below 1µm (to be noted that 2015 Cosmetics Europe recommendation does not include this threshold) .
- ***Gain understanding of other cosmetics microplastics issues***—There may be other polymer ingredients and indeed other products that contain microplastics that fall outside of the Cosmetics Europe definition. It is recommended that further work is conducted with the support of the industry into whether these pose an environmental threat and the magnitude of this threat. Part of this should be the investigation into whether product ingredient labelling is sufficient to aid consumers in understanding what is contained in the PCCP products that they buy; the International Nomenclature of Cosmetic Ingredients (INCI) may not currently be suitable for this.
- ***Ongoing monitoring of European usage to improve data and transparency***—Cosmetics Europe has suggested that they intend to conduct their survey of their members on an annual basis. It is suggested that the Commission support and liaise with Cosmetics Europe and other relevant trade associations in the process

and that the results are made publically available. There are a number of NGO's such as the Plastic Soup Foundation (under Beat the Microbead) and Fauna and Flora International that have worked in this field and therefore should also be consulted and perhaps provide a portal for updates on progress to the consumer. Furthermore, it is also recommended that this and any other survey looks beyond its current scope to include all cosmetics products.

- ***Ongoing monitoring of commitments***—In a similar way, using the contact information that has been gained in the course of this study, the Commission could contact these manufacturers on an annual (or more possibly frequent basis, due to the fact that many have committed to be microplastic-free by the end of 2016) basis to discover whether they are on track with the commitments reported to this study. Furthermore, Cosmetics Europe issued a recommendation to its members to phase out microplastics from certain products by 2020. Any time slippage, without justification, may help the Commission to decide whether more measures are necessary. This process could also be streamlined by combining it with the abovementioned recommendation as Cosmetics Europe could collect this information at the same time.

Cosmetics Europe released a statement on 21st October 2015[523] in response to the issue and shortly after participating in a stakeholder workshop that was held as part of this project. The recommendation is as follows;

> *"In view of the public concerns expressed over plastic debris in the marine environment, and given the availability of alternative materials, Cosmetics Europe recommends its membership to discontinue, in wash-off cosmetic products placed on the market as of 2020: The use of synthetic, solid plastic particles used for exfoliating and cleansing that are non-biodegradable in the marine environment."*

The findings of this report remain unchanged in the light of this recommendation as this was not thought to be one of the obstacles towards removal of microplastics from cosmetics by the manufactures that were interviewed by this study. Moreover, the recommendation is still limited in scope to exfoliating products which leaves considerable room for manufacturers to maintain the use of microplastics in other products that do not fit this description. It is hoped that Cosmetics Europe can work with other stakeholders to improve this definition in order to cover all applicable products. This will help manufacturers to understand how many of the products should be investigated and reformulated.

---

[523] https://www.cosmeticseurope.eu/news-a-events/statements.html

8.0 Task 2.3: Analysis of Legal Instruments and Options for a Ban

8.1 Existing and Proposed Bans

Existing and proposed bans are mostly focused on the USA. As of the end of September 2015 seven have introduced bills into law that will ban the manufacture and sale of PCCPs containing microplastics in their respective states with at least further seven in the process of doing so; as well as a federal ban. Canada also has at least one ban moving through its legal system at provincial level with a federal ban being considered. Representatives from the Netherlands suggest that although it is one of the countries at the forefront of campaigning for a ban[524], it has come to the conclusion that an EU wide ban would be preferable to one enforced in a single member state; and although the focus in the Netherlands has been on PCCP microplastics there is also work on going to identify and quantify other sources as well.

8.1.1 USA

Personal communication with cosmetic industry sources suggests that with the introduction of a ban within one US state this effectively entails a ban for the entire US, as it is logistically very difficult—if not impossible—to make sure different US states are provided with different product formulations whilst remaining within the law. This essentially suggests that the strongest ban will become the defacto US ban.

As identified in section 6.1, Illinois[525] was the first US state to have fully enacted a ban in 2014, using the following definitions to achieve this:

> *"**Plastic** means a synthetic material made from linking monomers through a chemical reaction to create an organic polymer chain that can be molded or extruded at high heat into various solid forms retaining their defined shapes during life cycle and after disposal.*
>
> ***Synthetic plastic microbead** means any intentionally added non-biodegradable solid plastic particle measured less than 5 millimetres in size and is used to exfoliate or cleanse in a rinse-off product."*

[524] Belgian, Dutch, Austrian and Swedish delegations (2014) Elimination of micro-plastics in products - an urgent need- Information from the Belgian, Dutch, Austrian and Swedish delegations, supported by the Luxembourg delegation, Report for Council of the European Union, December 2014, http://www.euractiv.com/sections/science-policymaking/dutch-rally-support-microplastic-ban-safeguard-their-mussels-310893

[525] Illinois (2014) Illinois State Bill 2727 amending the Environmental Protection Act, June 2014, http://www.ilga.gov/legislation/publicacts/fulltext.asp?Name=098-0638

New Jersey was the second state to enact a ban[526] effective as of March 2015, using the same definitions and timescales as Illinois.

New York is currently in the process of enacting a ban known as the "Microbead-free Waters Act"[527] that would prevent microplastics from being used in cosmetics products from 2016—two years earlier than in Illinois. The Bill—which was almost unanimously passed by the New York Assembly in April 2015—uses a broader definition than that applied in Illinois and New Jersey:

> *"The term **"Microbeads"** means any plastic component of a personal cosmetic product measured to be five millimetres or less in size."*

The definition does not attempt to define plastic in this context and makes no specific comment on its degradability in the marine environment, which suggests that it will preclude the use of biodegradable plastic alternatives. It also does not limit the ban to rinse-off products for the purpose of exfoliation. For the bill to become law an identical version must also pass through the New York Senate (a process required for the introduction of new legislation in most US states, although the terminology can differ). A senate bill with identical wording to the assembly bill is currently going through this process after being sponsored by State Senator Tom O'Mara along with a number of co-sponsors. The issue has, however, become clouded as O'Mara has also personally sponsored and chose to advance another Senate bill[528], which originally used identical definitions to those within the Illinois bill, but was subsequently amended to read:

> *"The term **"synthetic plastic microbead"** shall mean any intentionally added solid plastic particle measured five millimetres or less in size and used to exfoliate or cleanse in a rinse-off product and does not break down completely, in the environment that the substance is likely to encounter, within the context of the relevant international standards for degradation through a physical, chemical or biological process of decomposition."*

The new wording means that biodegradable plastics can be used if they adhere to 'relevant international standards'. However, there are no current standards for

---

[526] Patrick Diegnan (2015) State of New Jersey Bill A3083: An Act prohibiting manufacture, sale, or promotion of cosmetic products containing microbeads, March 2015, http://www.njleg.state.nj.us/2014/Bills/AL15/28_.PDF

[527] Michelle Schimel (2015) New York State Bill A5896: An act to amend the environmental conservation law, in relation to prohibiting the distribution and sale of personal cosmetic products containing microbeads, April 2015, http://assembly.state.ny.us/leg/?default_fld=%0D%0A&bn=A05896&term=2015&Summary=Y&Actions=Y&Votes=Y&Text=Y

[528] State Sen. Tom O'Mara (2015) New York State Bill S4403A- Relates to prohibiting the manufacture and sale of personal care products and over-the-counter drugs containing synthetic plastic microbeads, June 2015, http://open.nysenate.gov/legislation/bill/S4403A-2015

biodegradability in the marine environment since the ASTM[529] standard was withdrawn in 2014 due to it not having been updated for eight years. The bill also stipulates an enaction date of the end of 2017, which is two years later than the Assembly bill while adopting the same timing as Illinois.

The Vermont Senate has also voted on a bill[530] identical in most respects to that of Illinois except that the term 'biodegradable' is given a specific definition:

> *"**Biodegradable** means the capability of a substance to break down completely in the natural environment that the substance is likely to encounter within 24 months of its disposal, through a biological process of decomposition into elements or compounds commonly found in that environment."*

In the absence of a biodegradability standard the bill has attempted to define the meaning, but it remains to be seen whether this definition is adequate in practice and whether 24 months in the marine environment is still enough time to cause harm. The bill has yet to be passed by the Vermont senate, which must happen before it can be enacted into law.

Wisconsin, Indiana, Maine and Colorado have also drafted bills into law with similar or identical wording to the original Illinois and New Jersey bills. Massachusetts, Michigan, Minnesota and Oregon have been waiting on the outcome of Maryland and California's bills, of which the latter has featured prominently in the media. This is because the way in which it defines microplastics, has the potential to exclude 'biodegradable' plastic alternatives in a bid to close the widely reported[531] 'loophole' in the wording of the Illinois bill.

Maryland passed a bill[532] into law in May 2015 which is considered 'strong' in comparison to the older Illinois bill wording by 5Gyres[533]. This is primarily because of its focus on defining the term 'biodegradable'. It is now considered the benchmark for how to word this particular part of the bill and precludes the use of biodegradable plastic unless it can be proven to biodegrade in the marine environment;

> *"**Biodegradable**" means capable of decomposing:*
>
> *(1) in a marine environment; and*

---

529 http://www.astm.org/DATABASE.CART/WITHDRAWN/D7081.htm

530 Sen. Brian Campion (2015) Vermont Bill S47: An act relating to prohibiting the manufacture or sale of personal care products and over-the-counter drugs containing microbeads, January 2015, http://legislature.vermont.gov/bill/status/2016/S.47#detailed-status

531 Mary O'Connor (2015) California considering banning biodegradable microbeads from personal care products, The Guardian

532 https://legiscan.com/MD/text/HB216/id/1248633/Maryland-2015-HB216-Chaptered.pdf

533 http://www.5gyres.org/blog/posts/2015/7/24/4-lesson-learned-from-passing-microbead-legislation

(2) in wastewater treatment plant processes in accordance

With relevant established guidelines identified by the department, Such as:

(i) ASTM international;

(ii) organisation for economic co–operation and development;

(iii) international organization for standardization; or

(iv) other comparable organizations or authorities.

The bill also defines the term 'microbead' as;

"Synthetic plastic microbead" means any intentionally added solid plastic particle that is not biodegradable that:

(1) measures less than 5 millimetres in size; and

(2) is used in a rinse–off personal care product for exfoliation or cleansing purposes.

This still limits the scope of the bill to that of a rinse-off product and therefore may not be considered to completely close all potential loop holes. It remains to be seen whether the Maryland bill will have far reaching implications in terms of the prohibition of biodegradable plastics in PCCP's, but it does leave the door open for inclusion if the cosmetics and plastic industries can prove to meet relevant standards; although as shown in Section 7.3.3, those standards do not currently exist in any up to date form.

California has gone through many versions of many different bills to arrive at a final wording but it began in a similar fashion to New York with a bill[534] that was passed by the Assembly in California in August 2014 with the definition:

*"[The Term]**"Synthetic plastic microbead"** means "an intentionally added particle of non-water-soluble plastic measuring five millimetres or less in size in every dimension.""*

However, this bill has since died and a Senate bill[535] introduced a year later used a different definition:

---

[534] Assembly Member Bloom (2014) California Assembly Bill 1699: Waste management: synthetic plastic microbeads, February 2014, http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB1699&search_keywords=

"[The Term] ***"Synthetic plastic microbead"*** *is an intentionally added non-biodegradable solid plastic particle measuring five millimetres in size or less in every dimension, that retains its shape during use and after disposal, and that is used to exfoliate or cleanse in a rinse-off personal care product."*

During a Senate Committee Meeting for Environmental Quality[536] the issue of the language used in the definitions was identified as a significant problem. It was highlighted that the change from *'non-water soluble'* to *'biodegradable'* left a loophole for the use of biodegradable plastics, the use of which is not necessarily environmentally benign as harm could be done during the time taken to degrade.. It also points out the term *'biodegradable'* is misleading and ambiguous unless paired with appropriate, approved testing methods and that the amount and rate of degradation can be very different depending on environmental conditions. As part of their opposition to the bill the Personal Care Products Council suggested that the term *'synthetic plastic microbead'* should be used; however, the Committee believed this to be flawed as the term *'synthetic'* is confusing and would imply that there are naturally-occurring versions of the plastics used in PCCPs, of which there are none. The committee therefore put forward a recommendation for the following definition to be used in the bill:

"[A ***Plastic Microbead*** *is] An intentionally added [solid] plastic particle measuring five millimetres or less in size in every dimension."*

This definition would appear to preclude the use of biodegradable plastic, although the bill does not currently include a definition of plastic. It may also be strong than the Maryland bill as it does not restrict the scope to rinse-off products.

During a further Senate Committee Meeting for Environmental Quality[537] in June 2015, significant support and opposition for the bill was heard. A coalition of 40 public health and environmental organisations came out in support of the bill which:

"is regarded among stakeholders as the model policy that will not only result in a cleaner environment, but also reduce hazards to both humans as well as marine and aquatic wildlife."

A coalition of eight industry associations came out against the bill because:

---

[535] Senator Galgiani (2015) California Senate Bill 625: Waste management: synthetic plastic microbeads, April 2015, http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB625&search_keywords=

[536] Senator Wieckowski (2015) Bill Analysis: Waste management:synthetic plastic microbeads, Report for Senate Committee on Environmental Quality: California, April 2015, http://www.leginfo.ca.gov/pub/15-16/bill/sen/sb_0601-0650/sb_625_cfa_20150427_162611_sen_comm.html

[537] Senator Wieckowski (2015) Waste management: plastic microbeads, Report for Senate Committee on Environmental Quality: California, June 2015

"… its scope goes beyond a ban of plastic microbeads in personal care products and would create a legal quagmire, leaving the interpretations of the definitions and what is covered up to the courts."

The coalition also pointed out that the Illinois legislation was included in the Council of State Governments (CSG) 'suggested state legislation' with the idea of creating model policy for other states. This suggestion was not incorporated into the Californian bill.

The definition; *"[A Plastic Microbead is] An intentionally added [solid] plastic particle measuring five millimetres or less in size in every dimension"* was subsequently taken up by a new California Assembly bill[538] (with the addition of the word 'solid') which was passed in May 2015 with an enforcement date of the beginning of 2020. This bill was taken forward to the senate and passed on 8th September 2015 making it the only bill in the US which has made it into law without the 'loop-hole' of allowing biodegradability—or, it appears, even the possibility of using biodegradable plastics even if they are found to be safe in the marine environment—and not limiting the ban to only products which as designated as 'rinse-off'.

California is a good example of how a number of bills have arisen from different quarters with one rising to the fore to ultimately become law. Many of the other bills that are being introduced in other states such as Minnesota and Connecticut are adopting the California wording, therefore it appears that this could be the standard that is set for other countries to follow which could also have wide reaching implications for the rest of the US and beyond.

During engagement with the cosmetics industry as part of this study one direct cosmetics industry source suggested that they do not intend to investigate biodegradable plastic alternatives at the current time. This is largely due to the uncertainty created by the differing legislation coming out of the US. Ultimately, they will have to comply with the most stringent legislations and apply this across their whole product range regardless of location. The extent to which this holds true for all cosmetics companies will depend on how localised their manufacturing and distribution is.

At the federal level the US is also considering a national ban. The bill, known as "The Microbead-Free Waters Act of 2015"[539], was introduced in March 2015 and seeks to amend the existing Federal Food, Drug, and Cosmetic Act by including the wording:

"[A cosmetic shall be deemed to be adulterated] — If it contains synthetic plastic microbeads.''

---

[538] Assembly Member Bloom (2015) California Assembly Bill 888: Waste management: plastic microbeads, April 2015, http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160AB888&search_keywords=

[539] http://docs.house.gov/meetings/IF/IF14/20150501/103412/BILLS-114HR1321ih.pdf

The Federal Food, Drug, and Cosmetic Act stipulates that no interstate commerce can contain cosmetic products that are adulterated, therefore effectively placing a ban on them containing “synthetic plastic microbeads” from the beginning of 2018. The bill is currently referred to the House Energy and Commerce Subcommittee on Health. As previously discussed, however, if state legislation is introduced that is more stringent there may not be a need for Federal intervention. However, it is unclear how the term “synthetic plastic microbeads” will be interpreted in practice and whether it leaves room for loopholes in the same way as the Illinois ban has.

An overview of some of the current bans moving through the US state legislative system can be found in Table 45. This is a snapshot of the current situation as of the end of September 2015 showing the which bills are shown to be the strongest i.e. those that do not restrict to just rinse off products but place restrictions on biodegradable ingredients. The only current bill passed into law that for fill both of these criteria at present is from California although, now the president is set, others appear to be following suit with similar wording.

Table 45 – Status of US State Bills to Ban Microplastics in Cosmetics

US state	Bill Status	Restricts ‘Biodegradable’ Plastics	Limited to ‘Rinse-off’ Products
Illinois	Law	No	Yes
Colorado	Law	No	Yes
New Jersey	Law	No	Yes
Maine	Law	No	Yes
Indiana	Law	No	Yes
Wisconsin	Law	No	Yes
Connecticut	Law	Yes	Yes
Maryland	Law	Yes	Yes
California	Law	Yes	No
Massachusetts	Stalled	Yes	No
Michigan	Stalled	Yes	No
Minnesota	Passed Senate, In House	Yes	No
Oregon	Passed House, In Senate	Yes	Yes
New York	Introduced	Yes	No
US Federal	Introduced	Yes	No

8.1.2 Canada

The Province of Ontario in Canada recently tabled the 'Microbead Elimination and Monitoring Act'[540]. The act is concerned with two areas: firstly, the prohibition of the manufacture of cosmetics that contain 'microbeads', and secondly, that the Great Lakes will be tested and monitored on an annual basis with the results publically available. The following definition of 'microbeads' is used:

> ***"microbeads** means non-biodegradable solid plastic particles measuring less than one millimetre in diameter that are used in cosmetics, soaps or similar products as cleansing or exfoliating agents."*

Although similar in wording to the Illinois legislation, the size specified of less than 1 mm is on the limit of what is currently used in cosmetics and may not provide significant coverage to remove all variants in the way that limiting to less than 5mm does. The bill also only bans the manufacture rather than the sale of these products, which is a limitation not found in any of the current US bills.

As part of debating the bill the Standing Committee on Finance and Economic Affairs met to consider its implications (a transcript of which is available[541]). The Canadian Cosmetic, Toiletry and Fragrance Association (CCTFA) states that of the 150 manufacturers that it represents, 14 have or had microplastics in their products with five already having eliminated them and the other nine working towards this. It highlighted that it believed that a federal approach—under the vehicle of the Canadian Environmental Protection Act—was needed to make sure that conflicting and confusing legislation isn't developed at provincial level.

The CCTFA also highlighted that any legislation introduced in Canada (whether provincial or federal) needs to take into account product imports and the ability of importers to be able to check that they are in compliance with legislation. The method for doing so in Canada is through the Cosmetic Ingredient Hotlist.[542] This list is maintained as an awareness tool to help the cosmetics industry stay compliant, but is also the tool which the Canadian border inspection agency uses.

The committee debate identified a number of issues with the current wording of the bill which may create loopholes similar to those found with the Illinois legislation. The latest Californian draft bill is cited as the strongest bill to be tabled to date because of this. There was also discussion on the wording of the current draft of the Ontario bill with regard to whether banning the manufacture of PCCP microplastics in Ontario goes far enough without also banning their sale. It was pointed out that very little is

---

[540] http://www.ontla.on.ca/bills/bills-files/41_Parliament/Session1/b075.pdf
http://www.ontla.on.ca/web/bills/bills_detail.do?locale=en&Intranet=&BillID=3194

[541] http://www.ontla.on.ca/committee-proceedings/transcripts/files_pdf/04-JUN-2015_F024.pdf

[542] http://www.hc-sc.gc.ca/cps-spc/cosmet-person/hot-list-critique/hotlist-liste-eng.php

manufactured in the province, and therefore a significant loophole may be introduced with the current wording.

Canada is also in the process of bringing in legislation at the federal level in a similar way to the US. The bill[543] seeks to amend the Food and Drugs Act, adding a clause that reads:

> *"[No person shall sell any cosmetic that] contains pieces of degradable or non-degradable plastic that measure five millimetres or less in every dimension."*

This definition is possibly more wide ranging than the proposed US federal bill as it specifically precludes both degradable and non-degradable plastics. The bill had its first reading in the Canadian House of Commons on May 2015.

A motion[544] was also tabled for debate in May 2015, which argued:

> *"That, in the opinion of the House, microbeads in consumer products entering the environment could have serious harmful effects, and therefore the government should take immediate measures to add microbeads to the list of toxic substances managed by the government under the Canadian Environmental Protection Act, 1999."*

The government agreed to enlist Environment Canada, which has initiated a scientific review to assess the effect of PCCP microplastics on the environment. According to Environment Canada[545], in order for a substance to be determined toxic for the purposes of being put on the list it must enter the environment under conditions that:

1) Have or may have an immediate or long-term harmful effect on the environment or its biological diversity;
2) Constitute or may constitute a danger to the environment on which life depends; or
3) Constitute or may constitute a danger in Canada to human life or health.

However, it is also possible that substances may also be added to the List of Toxic Substances without having gone through an assessment if, on the recommendation of the Ministers of Environment and Health, the Governor in Council is satisfied that a substance is toxic.

[543] http://www.parl.gc.ca/LegisInfo/BillDetails.aspx?Language=E&Mode=1&billId=7963465
[544] https://openparliament.ca/debates/2015/3/24/megan-leslie-1/only/
[545] http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=EE479482-1&wsdoc=39C6A30B-E760-9B43-DCD7-A041AFF8E84B

8.2 Analysis of Potential Mechanisms

The following is an analysis of a range of potential mechanisms that could be employed within the EU to effect a ban on microplastics in cosmetics. Expert opinion has been sought where appropriate.

8.2.1 Ecolabels

Ecolabels are a way of providing a benchmark for best practice from an environmental point of view. They are usually voluntary in that the manufacturer can chose to submit their product for inclusion if they believe that they meet the criteria. They are not, therefore, a mechanism for introducing a ban throughout a market segment; however, they can set a standard and test for acceptance criteria that could potentially be made compulsory in the future.

There are two types of Ecolabel relevant to cosmetics in Europe: the European Ecolabel for all of the countries in the EU and the Nordic Ecolabel which is operated by the governments of Denmark, Norway, Iceland, Sweden and Finland.

The Nordic Ecolabel for cosmetic products[546] lists microplastics as one of its prohibited substances for use in cosmetic products and ingredients. The definition given by the ecolabel is:

> *"Microplastics are defined as undissolvable plastic particles of less than 1mm size and not biodegradable according to OEC[D] 301 A-F."*

There are potentially two issues with this definition:

1) The limitation on size to less than 1 mm is good from the point of view that it precludes smaller 'nano-particles' that are not covered under the Cosmetics Europe definition, which sets a lower limit of 1 µm. However, it is known that at least 15% of microplastics in cosmetic products are above 0.8 mm (Table 33) and therefore there is a possibility that some could also be above 1 mm. The upper limit of 5 mm set by Cosmetics Europe appears to be more comprehensive in the upper bounds.
2) The use of the OECD testing guidelines[547] from 1992 to define whether the microplastic is biodegradable. These test guidelines are similar in method to ISO Standard 7827-1984, which is currently withdrawn. Since the ASTM standard[548] has also been withdrawn, the OECD guidelines are currently the only way of testing for biodegradability. Testing appears much more stringent than the ASTM

[546] Nordic Ecolabelling (2014) Nordic Ecolabelling of Cosmetic products: Version 2.9 12 October 2010 – 30 June 2016, October 2014

[547] OECD(1992) Test No. 301: Ready Biodegradability, Paris: Organisation for Economic Co-operation and Development

[548] http://www.astm.org/DATABASE.CART/WITHDRAWN/D7081.htm

standard, with a requirement for 70% of carbon content to degrade within 28 days (compared with 30% over six months for the ASTM). The fact that the OECD guidelines were introduced in 1992 would suggest that a review of their applicability to the current understanding of marine degradability would be a valid task to complete.

There are currently two European Ecolabels which cosmetic products in this study could fall under;

- The Eco label for Soaps, Shampoos and Hair conditioners; and
- The Eco Label for Rinse off Cosmetic Products.

The current European Eco-label for Soaps, Shampoos and Hair conditioners does not prohibit the use of microplastics as ingredients. However, in a technical report for revised draft criteria[549] it was recommended that the product group be extended to define 'rinse-off cosmetic products'. Under this new product group it was also suggested that the list of 'Specified excluded ingoing substances and mixtures' should include 'micro-plastics'. This product group has since been given its own Ecolabel as of December 2014[550] separate from soaps, shampoos and hair conditioners although there is potentially some crossover between the two.

The definition of micro-plastics has not yet been established, however. In an interview with a representative of the JRC[551] it was found that the issue of definitions is one that is proving to be problematic and the current feeling is that these definitions need to be aligned on a European (if not global) scale. There are currently no products listed under the 'rinse-off cosmetic products' category within the Ecolabel catalogue[552] and around 500 listed under 'soaps and shampoos'. Most of these are products aimed at the commercial market and the manufacturers identified in this study do not appear on the list. This suggests that many of these products are niche products for a very specific market with environmental demands, possibly driven by procurement criteria. Many appear to be small, localised manufacturers that are looking to differentiate their products. It is clear, however, that the large multinational cosmetics manufacturers do not see this particular Ecolabel as a valuable mark to have on their products at present.

The Ecolabel has an advantage over other mechanisms, such as some of the proposed bans, in that it can adhere to a 'best practice' from an environmental point of view as it does not attempt to cover the whole of the market. The definition can, perhaps, be more encompassing because of this without the cosmetics industry being detrimentally affected.

---

[549] Carme Hildago, Natalia Fuentes, Renata Kaps, and Jiannis S. Kougoulis (2013) Revision of EU Ecolabel Criteria for Soaps, Shampoos and Hair Conditioners, May 2013

[550] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014D0893

[551] Personal Communication with Renata Kaps, JRC.

[552] http://ec.europa.eu/ecat/

8.2.2 The Cosmetics Regulation

The Cosmetics Regulation (1223/2009) has been in force since 2013 as a replacement for the Cosmetics Directive of 1976. The change from a Directive to a Regulation meant that it became law in all Member States simultaneously without the need to be transposed into national law as is necessary for a Directive. This has simplified regulatory matters for companies that want to sell product within the EU. The scope of the regulation applies to:

> *"any substance or mixture intended to be placed in contact with the external parts of the human body (epidermis, hair system, nails, lips and external genital organs) or with the teeth and the mucous membranes of the oral cavity with a view exclusively or mainly to cleaning them, perfuming them, changing their appearance, protecting them, keeping them in good condition or correcting body odours."*

This means that the regulation would apply to all PCCPs that contain microplastics that are placed on the EU market.

Of specific relevance in the context of this study, the regulation specifies that:

> *"A cosmetic product made available on the market shall be safe for human health when used under normal or reasonably foreseeable conditions of use…"*

This definition is key to understanding whether PCCP microplastics could be banned under this regulation. Currently the regulation allows for the prohibition of substances in Annex II only if the substance would be unsafe for humans *under normal use*. Conversations with a representative from the Directorate-General for Health and Consumers (DG SANCO) suggest that *normal use* would be considered as direct contact with the skin during application. The human health concern aimed at PCCP microplastics is generally linked to the fate of the microplastics *after* the consumer has used them and therefore may be out of scope with regard to the Cosmetics regulation.

There may be an argument, however, for the safety of microplastics to be called into question within toothpastes. Several media reports[553,554] surfaced in the US highlighting potential dental health issues for those who use toothpastes that contain microplastics, including circumstances where the microplastics became lodged in the gums. So far, this appears to be limited to the professional opinion of a number of dentists and in a 2014 statement The American Dental Association (ADA)—which endorses several dental products through its 'seal of acceptance'—said that "at this time, clinically relevant dental health studies do not indicate that the Seal should be removed from toothpastes

[553] http://www.washingtonpost.com/news/to-your-health/wp/2014/09/18/why-dentists-are-speaking-out-about-the-plastic-beads-in-your-toothpaste/
[554] http://www.today.com/health/microbeads-toothpaste-safe-brush-1D80157769

that contain polyethylene microbeads."[555] However, this may be a moot point as the manufacturers' commitments stated in Section 7.2 suggest that microplastics are no longer used in toothpastes sold on the European market.

In order to decide whether an ingredient in a certain application should be banned it would have to undergo a safety assessment undertaken by the Scientific Committee on Consumer Safety (SCCS). The SCCS provides opinions on the health and safety risks of non-food consumer products at the request of the Commission. There must, therefore, be a sound scientific basis for the inclusion of PCCP microplastics on the list of banned substance in the Cosmetics Regulation.

8.2.3 REACH Directive

The Registration, Evaluation and Authorisation of Chemicals (REACH) Directive (1907/2006) was put in place in 2007 with the aim of ensuring a high level of protection of human health and the environment against the risks that can be posed by chemicals.

REACH puts the onus on industry to take responsibility for assessing and managing the risks posed by chemicals and provide appropriate safety information to their users. The European Union can take additional steps to restrict dangerous substances from use at EU level. The scope of the directive states that it applies to:

> *"…the manufacture, placing on the market or use of such substances on their own, in preparations or in articles and to the placing on the market of preparations."*

A substance refers to a chemical or compound, a preparation being a mix of two or more substances, and an article would generally be identified as a manufactured product whose function is dictated by its shape or design rather than its chemical composition—a car, for example. By this definition, cosmetics and their constituent ingredients would fall under the scope of REACH.

There is precedent under REACH for the restriction of ingredients meant for inclusion in cosmetics under Annex XVII. Commission Regulation 552/2009[556], which amended the REACH regulation, included the chemical Nonylphenol in Annex XVII and restricts it to concentrations of below 0.1% for a number of applications including cosmetics products.

However, each individual plastic (or polymer) material known to be used in cosmetics would have to be listed separately rather than simply using the term 'plastic' to cover all situations—'plastic' is not a term recognised under REACH. Size, shape, degradability and other physical characteristics could be defined under the 'conditions of restriction' which would allow the ban to be targeted specifically at microplastics in cosmetics.

---

[555] http://www.ada.org/en/press-room/news-releases/2014-archive/september/statement-on-polyethylene-microbeads-in-toothpaste
[556] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:164:0007:0031:en:PDF

Alternatively, if there are certain chemical additives that are used consistently across all PCCP microplastics, these could be banned instead. However, the additive itself would need to be proved to cause environmental harm and have a defined path of exposure. There is also potential for the industry to simply remove the additive and continue using plastic.

According to a source in DG GROW the process for inclusion of a substance in REACH can take around two years. The process can be initiated by any member state which has concerns about a substance. The substance is assessed for its risk and for the socio-economic impacts of restricting it. The results of the process are subsequently sent for public consultation before being written into a draft amendment to the Directive by the Commission.

A source in the Dutch government suggested that after reviewing the REACH Directive for its potential to help ban PCCP microplastics, they decided that it is not fit for the purpose as it does not allow for broad terms such as plastic. It would be too easy to miss out materials or chemicals and creating a scientific basis for all possibilities would be time consuming and expensive in the long run.

8.2.4 Eco Design Directive

The Ecodesign of Energy Related Products Directive (2009/125)[557]—commonly known as the Ecodesign Directive—came into force in 2010. Its current focus is on energy use within products and energy related products— i.e. those that impact energy use indirectly, such as windows. The Directive does not seek to create binding targets but to create a framework for these to be achieved through implementing measures.

There are three main criteria that products must have for inclusion under the Directive:

- A significant volume of sales (>200,000 units);
- A significant environmental impact; and
- A significant potential for environmental improvement.

If a product achieves these three criteria it can be considered for either the introduction of an implementing measure as an amendment to the Directive or self-regulation, the latter usually in the form of voluntary agreements which are expected to achieve the policy objectives more quickly or at lesser expense than mandatory requirements. Annex VIII of the Directive sets out the criteria for self-regulation: most notably the action must represent a large proportion of the overall market, and it must also be publicised, monitored and reported upon on a regular basis with transparency being key to its success. It is also important that there are no market and legislative drivers that may prevent this from working.

[557] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (OJ L 285 of 31.10.2009)

During the drafting of an implementing measure the whole life cycle of the product must be taken into account to include the following life-cycle stages:

- Raw material selection and use.
- Manufacturing.
- Packaging, transport, and distribution.
- Installation and maintenance.
- Use.
- End-of-life.

An assessment of the impact on consumers and manufacturers in terms of costs and benefits should be carried out through stakeholder engagement. There are also several criteria that must be met by the final implementing measure. In particular:

- There shall be no significant negative impact on the functionality of the product from the perspective of the user.
- Health, safety and the environment shall not be adversely affected; and
- There shall be no significant negative impact on consumers, in particular as regards the affordability and the life cycle cost of the product.

Under the Directive (article 16) the Commission is obliged to release a working plan on a periodic basis with an indicative list of energy-related product groups which will be considered priorities for the undertaking of preparatory studies and the eventual adoption of implementing measures. The working plan is now in its third iteration—spanning the years 2015–2017[558]—with the focus still on energy using and energy related products. The draft report identifies a further 16 priority product groups based on the magnitude of the environmental impacts.

Although the Directive currently focuses on energy there is scope to include products based on other environmental factors. Energy has been the primary focus due to the assertion that high energy using products should be an initial priority. It is unclear whether, under the current weight of evidence, PCCP microplastics would be included in the next working plan unless they are specifically requested to be assessed by a Member State. The fact that the whole life cycle is considered means that the Directive is potentially much more suitable for PCCP microplastics than other legislation that focuses on one particular part of the product life. Also, as it deals with products as a whole rather than their constituent chemicals (in the way REACH does) it would be easier to define the parameters of a ban in a way in which all types of plastic (and possibly polymers) could be included without the need to create an exhaustive list.

[558] Dr. Corinna Fischer, and et al. (2014) Preparatory Study to establish the Ecodesign Working Plan 2015-2017 implementing Directive 2009/125/EC, Report for European Commission – DG ENTR, October 2014, http://www.ecodesign-wp3.eu/

It remains to be seen whether using the Eco Design Directive is the best option as it is unlikely that PCCP microplastics will become part of the next list of priority product groups without the influence of one of more Member States' governments.

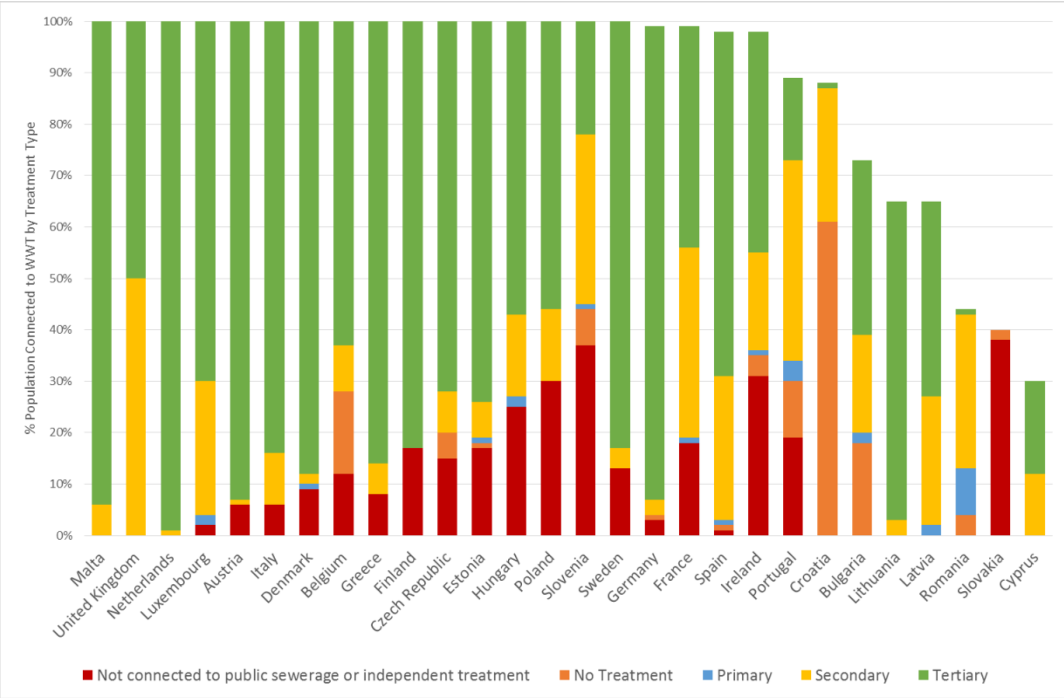
8.2.5 Urban Waste Water Treatment Directive

Unlike the other legislative mechanisms analysed, the Urban Waste Water Treatment Directive (91 /271 /EEC) moves the onus away from the supply and manufacture of PCCP microplastics and on to the waste water treatment (WWT) industry. In discussions with the WWT industry and through the literature studied in Section 6.4 two main barriers to this being used to legislate against PCCP microplastics entering the marine environment were identified:

1) Studies suggest that WWT plants cannot currently capture all of the microplastics that enter their systems. The best estimates suggest that the capture rate could be around 90%, although it may not be as high for more buoyant plastics. This is using the best available technology with tertiary filtration. A large proportion of Europe does not have access to this kind of treatment (as shown in Figure 63) and those that do cannot currently guarantee that microplastics will be filtered out. There is also high potential for any captured microplastics to become part of sewage sludge, which is often placed on land giving the plastic opportunity to leach into water courses.
2) The cost of upgrading all WWT facilities in Europe in order to guarantee the capture of microplastics would be prohibitive, and although specific costs are not available (and the technology needed to achieve this may not even be available) it would almost certainly be greater than the estimated cost to the cosmetics industry for the removal of PCCPs of €7.2 million as discussed in Section 7.4.

These barriers make the use of 'end of pipe' solutions such as the Urban Waste Water Treatment Directive difficult and costly to implement, and certainly against the 'polluter pays' principal. It is also not guaranteed that all microplastics would be captured and therefore it is difficult to justify the cost of implementation.

Figure 63 - % EU Population Connected to WWT



Source: Eurostat and OECD

8.2.6 Issues with Competition Law

The following paragraphs are included as a record of the issue of competition law which has been overcome by Cosmetics Europe through negotiation with the Commission. On 21st October 2015 Cosmetics Europe released a statement[559] with the following recommendation to its members;

> *"In view of the public concerns expressed over plastic debris in the marine environment, and given the availability of alternative materials, Cosmetics Europe recommends its membership to discontinue, in wash-off cosmetic products placed on the market as of 2020: The use of synthetic, solid plastic particles used for exfoliating and cleansing that are non-biodegradable in the marine environment."*

This statement limits its recommendation to products that are considered wash-off and for the purposes of exfoliating and cleansing and allows for biodegradable plastics although it provides no specific definition for biodegradability. This is considered to be a non-binding recommendation.

---

559 https://www.cosmeticseurope.eu/news-a-events/news/822-cosmetics-europe-issues-a-recommendation-on-solid-plastic-particles-plastic-micro-particles.html

The following paragraphs were included in the draft report that was made available to stakeholders-

> One issue that has been highlighted by Cosmetics Europe and one of the large manufacturers that contributed to the study is the limitations that may be imposed by EU competition law. Under article 101 of the Treaty on the Functioning of the European Union[1] the following business practices is prohibited;
>
> "…limit or control production, markets, technical development, or investment."
>
> Cosmetics Europe have interpreted this clause to mean that they cannot therefore issue specific guidance to their members that encourages the removal of microplastics from their products. It is thought that this would mean that suppliers of microplastic particles for use in cosmetics may potentially see this move as anti-competitive. As Cosmetics Europe have not issued guidance to their members this interpretation is, as yet, untested in law. However, all of the Cosmetics Europe members that agreed to contribute to this study have confirmed that they will remove microplastics from their products without official guidance from Cosmetics Europe. It is believed that Cosmetics Europe are still interested in finding a solution to the issue of competition law so they can provide guidance and therefore demonstrate to governments and the public that their industry is acting on, and committed to, removing microplastics from their products.

8.3 Analysis of Legal Instruments and Options for a Ban Summary and Conclusions

There is clear precedent for the enactment of a ban on microplastics in cosmetics from other parts of the world. Examples include the ones currently in place, and moving through the legislative process, in a number of US states. However, as yet there have been no national bans. Looking at the way theses bans have been enacted, the discussion surrounding the terminology, the definitions used and their potential effectiveness gives an insight into how this may also be possible within the EU. It is clear that careful wording would be required to satisfy industry, consumer groups and NGO's but also make sure a ban is effective in its purpose.

The enactment of federal bans in both the US and Canada are currently in process, and appear to be somewhat simpler to achieve than such a ban would be for the EU. This is because both countries already have laws which restrict and control the quality and safety of cosmetic products, being covered by the Food, Drug, and Cosmetic Act in the US and the Food and Drugs Act in Canada. An amendment to the wording of each act, which prohibits the sale of cosmetics products containing 'microplastics' (again, noting the importance of is the terminology and its definition) seems to be the route which these two countries are taking to enact a ban although this may restrict the discussion on the wider use of polymers in some of the 'leave-on' products. It also appears that those charged with enacting both of these federal bans, and several state bans, are looking to how California's ban will be received as it is thought to close 'loop-holes' in other state bans (a process which is proving to be controversial).

Whilst there are two ecolabels in Europe that currently prohibit the use of microplastics in cosmetics these do not appear to be an effective instrument to encourage the industry to remove microplastics from their products. Although the recent addition of 'rinse off cosmetic products' as an EU Ecolabel prohibits the use of microplastics, there is no clear definition and no products are currently certified under this category. The other category of 'soaps and shampoos' appears to be primarily made up from products aimed at businesses which suggests there is an advantage in this market for those that produce 'eco-friendly' products for this market, possibly driven by procurement criteria or in the case of government purchases Green Public procurement (GPP). This appears less of an imperative in the consumer market which is the main focus of this study.

The instruments for a ban in the EU appear to be more complicated than those that may be used in the US and Canada and it is still unclear as to whether any of the Directives and Regulations identified by stakeholders and discussed in this study would be suitable. Each has been identified to have certain key limitations as briefly summarised below;

1) ***Cosmetics regulation***—Concerned with health rather than environmental impact;
2) ***REACH Directive***—Concerned with individual chemicals and does not recognise 'plastic' as a term;
3) ***Eco Design Directive***—Is currently aimed at energy using products; and
4) ***Urban Waste Water Treatment Directive***—May be cost prohibitive and ultimately not 100% effective at removing microplastics from water effluent.

The Eco Design Directive may have the most potential with the support of a Member State. It is recommended that the Commission works with the more active (in the field of microplastic pollution) Member States to decide the best course of action if a ban is deemed necessary. This will largely be based upon whether the monitoring of the situation as recommended in Section 7.5 indicates that enforcement of a ban is required or whether the industry is responding to the issue adequately.

If it is deemed necessary to instigate a ban it is recommended that the definition and scope must be explored thoroughly with all stakeholders as there may be conflict between the desires of the cosmetics industry and NGO's(akin to the situation that observed in California). Learning from the outcomes of the ongoing debate in the US will be key to this and may facilitate the achievement of consensus. In particular, attention should focus on whether 'biodegradable' plastics should form part of a ban. This would require identification of relevant standards for biodegradability (and therefore the possible updating of expired standards) and, importantly, an understanding of how these types of material behave in the marine environment.

APPENDICES

A.1.0 Work Package 1 Appendix: Stakeholder Feedback

A.1.1 Stakeholders Contacted for Work Package 1

Organisation	Organisation Type	Contact
Work Package 1.1		
DG Move	Supranational Government	Anna Bobo-Remijn
OVAM	Regional Government, Industry	Peter van den Dries (formerly of EMSA, Port of Antwerp)
Marine Conservation Society	NGO	Laura Foster
ESPO	Trade Association	Antonis Michail
ECSA	Trade Association	Maria Deligianni
Netherlands Ministry of Infrastructure and the Environment	Government	Coen Peelen – representing the Netherlands in taking forward OSPAR Action 30
Panteia	Consultancy	Geert Smit
Seas at Risk	NGO	Emma Priestland
Groeningen Seaports	Industry	Roeland van der Woug
Transport Malta	Industry	Zammit Mevric
UK Chamber of Shipping	Trade Association	Ana Ziou
Work Package 1.2 – in addition to the above		
Surfrider Foundation	NGO	Gaëlle Haut
Work Package 1.3		

Organisation	Organisation Type	Contact
Ministère de l'Écologie, de l'Énergie, du Développement durable et de la Mer (France)	Government	Laure Dallem , representing France taking forward OSPAR action 35
National Oceanic and Atmospheric Administration (USA)	Government	Nancy Wallace
Icelandic Recycling Fund	Government, Industry	Guðlaugur Sverrisson
Bord Iascaigh Mhara (Irish Sea Fisheries Board)	Government, Industry	Catherine Barrett
DECLG, Republic of Ireland	Government	Richard Cronin
CEFAS, UK	Government	Thomas Maes
Seafish	Trade Organisation	Mike Montgomerie
MEPEX	Consultancy	Peter Sundt
Nofir	NGO	Øistein Aleksandersen
MCS	NGO	Charlotte Coombes
Project Aware, Australia	NGO	Hannah Pragnell-Raasch
Sea Doc Society & The University of California, Davis	NGO, Academia	Joseph K. Gaydos
MARELITT project	Academia	Wim van Breusegem

A.1.2 Task 1.1: Incentivising Waste Disposal at Ports

A.1.2.1 Stakeholder Meeting Discussion

The following discussion points were raised by attendees for discussion in the stakeholder meeting. Where appropriate, a response from the author is also included with details of any resulting amendments.

Anna Bobo-Remijn, DG Move

Comment	Response
Previous studies have only had one conclusive outcome regarding CRS: that the 100% direct system is associated with less delivery of waste. Regarding indirect fees – there are very many systems, applied differently to different waste streams and evidence on them is not conclusive.	The authors hope that the summary of the available data adequately reflects the difficulties in reaching conclusions based on the empirical data available. As many stakeholders have reflected, and we agree, in the real world there is often a great deal of variation within broad categorisations of cost recovery systems, and this is highly likely to be producing the variation which means that conclusions are difficult to reach. It is for this reason that the report also uses an alternative method, i.e. assessing net direct financial incentivisation of different features of cost recovery systems on an *a priori* basis, in order to understand the underlying drivers of behaviour.
Points out that the ability of deposit/penalty systems to provide a disincentive to discharge waste at sea depends on the level at which they are set. There are examples of ports where the penalty is too low to effect behaviour change.	*The text has been amended to highlight this.*
Questions whether it is correct to say that 100% indirect fees do not provide a disincentive to discharge waste at sea - what about the incentive of using services already paid for and not losing the value of a service forgone if waste is dumped.	To be clear, 100% indirect fees do not provide a *net direct financial disincentive* to discharge waste at sea. The value of the service forgone – that of legitimate waste disposal – is at least matched by the non-financial savings made by discharging waste at sea – which represents a 'service' – in that it removes waste from the vessel – even if it is illegal. The only further difference then is the 'guilt' factor and the risk of detection; and many have a high guilt tolerance threshold; and the probability of detection is low. *An extra figure has been included (Figure 11) to compare the financial incentivisation of different CRS features side by side and the text has been amended to highlight the fact that the statement refers to financial incentives.*

Comment	Response
Have decided to improve how concepts in Article 8 of the Directive are explained, including the "significant contribution" (30%) to be made by indirect fees; plus improving how this relates to fees and costs. More transparency is needed. Would like to move towards a degree of harmonisation that is based around better clarification of principles, rather than prescription of one CRS, to which end a correspondence group is being set up, and shared regional development of e.g. waste handling plans.	The authors are interested to understand the direction that policy development and revision is taking. Based on this research, we suggest that the underlying principles and ultimate outcomes that could be used to guide implementation should include an element based on the requirement that CRS should provide a net financial disincentive to discharge waste at sea as opposed to "no incentive" to discharge waste at sea.
Welcomes contribution to understanding the proportion of marine debris attributable to land-based sources and sea-based sources.	

Laura Foster, Marine Conservation Society

Comment	Response
Asked whether the relationship between different CRS and delivery tonnages is sound. Asked whether the data for example takes into account different types of vessel and other factors.	The data does not take these other factors into account, so this is heavily caveated in the report. It is also why the different CRS are evaluated primarily using our *a priori* assumptions regarding net direct financial incentive to discharge at sea. *We have highlighted the caveats more clearly and also acknowledge the limits of possible knowledge – that the sample sizes of ports when all such factors are controlled for would be too small to make any valid correlation*.

Comment	Response
Is there more information available regarding the Baltic NSF system and its progress.	Response from DG Move RE Baltic NSF: the consensus amongst many stakeholders was that NSF was the desired direction but they are starting to pull back from that, and considers that discussions with stakeholders in the Baltic and also the conclusion of this report supports that. The authors of this report comment that one reason that it has been so hard to understand the impact of the Baltic NSF system is that it actually represents, as confirmed by ECSA, a wide range of systems within that, rather than what we define as purely "100% indirect fee". Additionally some of the Baltic ports were only applying a form of NSF to some waste streams such as garbage and not all types of SGW.
Asked how the proposed CRS interact with Deposit Refund Systems)(DRS).	DRS for individual items can be applied in addition to any CRS. The question is then if they provide additional benefit. This depends on the performance of the CRS already applied; and the proportion of that item that is dumped rather than accidentally lost (both CRS and item specific DRS will have a limited effect on accidental loss). However DRS may affect the economics of recovery and mean that recovery rates improve, for both items that are dumped or accidentally lost, and this is an additional benefit that it can offer.

Peter Sundt, Mepex

Comment	Response
Asks how waste prevention/waste hierarchy fits into the CRS schemes considered. Waste tends to get disposed of into the 'cheapest container' and not in line with the waste hierarchy. Consistency is important to avoid distorting the extended waste chain – there are potential negative effects of mixed messages/market signals - and ports are only a small part of the extended chain. A system on the other hand like EPR affects the whole value chain. Asked how the proposed CRS interact with EPR which may be better for some individual items – e.g. fishing gear, ropes.	It is very difficult to find a CRS based on one feature that both disincentivises discharge at sea and incentivises waste prevention; generally measures designed to discourage one outcome also discourage the other; as the outcomes (less waste delivered) are indistinguishable from each other on a broad basis – i.e. without precise recording and evaluating of delivery amounts. Combining direct fees and deposits; or indirect fees, deposits plus a green ships scheme (for example based on adherence to ISO standard for waste management on board) are two different examples of combinations of features that could provide this. It was not strictly within the scope of the study to find a definitive solution for this problem, therefore further research would be necessary to explore this more fully. With respect to the rest of the hierarchy, it is clear that many stakeholders feel that recycling on board vessels is not met with the appropriate corresponding infrastructure at the port. However while the 'cheapest container' remains the sea for many users, the authors consider that this route, not even appearing at the bottom of the waste hierarchy, is the issue that needs priority. Improving adherence to the waste hierarchy was out of the scope of this report, though it is an important question. EPR can also be applied in tandem with different CRS for specific waste items. The CRS probably can address a much wider range of material at one time – including generic residual waste. Many different EPR agreements would be needed to have the same breadth.

Antonis Michail, ESPO

Comment	Response
Considers the conclusion that a penalty/deposit system can potentially provide the best outcome for Annex V garbage is a novel and interesting finding. Harmonisation between ports and between waste streams in terms of fee system is not supported by the outcomes of current meetings and working groups on PRFs. Different conclusions regarding the best CRS are likely to apply to different waste streams. The diversity of ports in terms of size, user base and treatment systems, means that imposing harmonised systems would be unfair. Trying to establish one system that will work best for all ports and waste streams is not empirically practicable because there is so much diversity between ports that robust relationships between system and performance cannot be established. Therefore prefers an approach which focuses on desired outcomes, the principles to guide their achievement, keeping in line with the current directive. Although operators do generally not want to change their system, thinks that some extent of harmonisation on a regional level may be possible; and if there's clear evidence for a particular system they are more likely to change. Also points out the lack of incentivisation of waste prevention in the Directive; which could also impact marine litter.	The authors consider that pursuing harmonisation to the extent possible is of value in order to deliver benefits of the kind outlined in the report to the extent possible. *We have referred to relative attractiveness to port operators as well as port users more explicitly in our relative attractiveness evaluation 'framework'.* Point regarding direction of future policy development has been discussed above. Point regarding waste prevention has been discussed above. Limits of possible empirical knowledge regarding 'optimal' CRS acknowledged as above.

Maria Deligianni, ECSA

Comment	Response
Shares ESPO's view that it is very difficult to establish one 'optimum' CRS for ports; even within one country there may be many variants. However, should strive for as much harmonisation as possible. There is not enough co-operation between ports and waste operators. Notes that sea-based sources of marine litter are not only derived from maritime transport but also other maritime sectors such as fishing. ECSA does not advocate the 100% direct fee because it sends out the wrong message to industry with no incentive to deliver waste. It has traditionally advocated the no special fee system – although this includes a wide range of systems within that categorisation including what appears to be a best practice of no special fee for garbage, and the direct fee system for sewage and oily waste Very much support transparency in terms of pricing, and availability of waste handling plans. Supports simplification of notification system – e.g. via safesea.net.	The available data regarding at-sea sources of marine litter do reflect that multiple sectors contribute. The authors would like to assert the importance of each stakeholder accepting responsibility for what is likely to be attributable to them, even though each sector and subcategory of each sector may contribute only a small proportion of marine litter. Generally we see that the more specific the source categories the smaller the contribution appears and often there is no clear predominance of one source over another. However the problem as a whole does not disappear – it is, generally speaking, the product of relatively small contributions from a very great number of sources. Limits of possible empirical knowledge regarding 'optimal' CRS acknowledged as above.

Gaëlle Haut, Surfrider Foundation

Comment	Response
More information regarding container loss is due to be published shortly; has provided some of this. Would like to see more focus on this in the report.	Cost recovery systems alone cannot influence unintentional loss, and this limitation is noted in the report. *The information provided, including additional comments from DG Move regarding Nairobi International Convention on the Removal of Wrecks have now been included in WP1.2 on the legislative review.*

A.1.2.2 Response to Other Comments Received on the Draft Report

The following additional comments were received regarding the draft report.

Coen Peelen, Netherlands Ministry of Infrastructure and the Environment

Comment	Response
p.21: plastics is said to be an exception but this is on the contrary not an exception to the discharge prohibition.	The original phrasing was attempting to convey that plastics are 'an exception from the exceptions' for certain waste types in certain circumstances –i.e., when it comes to plastics there are never any exceptions from the discharge prohibition for waste. *We have amended the wording so it is clearer.*
P.51/2 good overview of performance indicators. With regard to other drivers: transparency, positive incentivisation and harmonisation have positive results on environmental performance and relative attractiveness. NL does support this and is in favour of advancing on these issues.	

Comment	Response
P.54 report is surprisingly critical on 100% indirect financing, because it would provide no incentive to use the PRF or a disincentive for discharging at sea. Furthermore worries on transparency and high prices. We don't agree with the last. It might also result in lower prices, because the port has a bigger role in the system and the port has more bargaining power to PRFs than individual ships.	We recognize that our report is more critical of 100% indirect fees than previous assessments. The respondee is correct that in large part this is because it can't provide a net financial incentive to use the PRF or a net financial disincentive for discharging at sea. It is also because, in relation to existing fee structures which have a direct fee component, we have seen that the financial costs of disposing of solid waste are only a small percent of port dues. This means that the financial savings to be made by dumping are often very small. Therefore moving from a situation where dumping yields small savings to a situation yielding zero financial savings (i.e. under the 100% indirect fee) means that the benefit, i.e. likely impact of introducing 100% indirect fees will be smaller than if previously, significant financial savings could be made from discharging waste at sea – and then this moved to zero. This argument is not as relevant therefore to sewage or oily waste of which there may be hundreds and thousands of cubic metres to dispose of – however this study is primarily concerned with solid waste because of its marine litter focus. It brings to mind the comments made by the ESPO respondee that each type of waste is different and may not suit the same CRS. Transparency and high prices: This is a concern that has been voiced stakeholders rather than one the authors feel is intrinsic to 100% indirect fees. We agree with the respondee and the text states indeed that "Increased involvement by the port authority is likely around price setting [in 100% indirect fee systems] compared to 100% direct fee systems where prices are set solely by the external PRF operators. It is not essential but may be preferable, to facilitate change, **to make sure that pricing is** appropriately banded **and not inflated**, and information on pricing clearly disseminated to port users." (Text in bold for emphasis)

Comment	Response
P.60 deposit refund /penalty system would provide a positive incentive to discharge in the port and not to discharge at sea (p.62): 'The key strength of the deposit refund/ penalty system is that it provides a disincentive to discharge waste at sea, and no other system is able to do this' This is not true for all deposit/refund systems (depending on the level of refund) and definitely not for penalty systems. As long as the direct costs to discharge in a port with such a system are high the ship owner/captain would have an incentive to discharge ship generated waste in the previous port with e.g. a NSF system or discharge it at sea and leave just a bit of ship generated waste to discharge in the port with a penalty system. This is because the discharge in the port with a penalty system is normally more expensive than in ports with NSF and good ADM systems (or at sea). Good example of a malfunctioning penalty system is Le Havre. According to Euroshore the discharged volumes are very low because of high direct costs and probably also a relative low penalty fee. I would suggest that the difference in effectiveness between NSF and refund/deposit systems wouldn't be that big as long as the level of the incentive is comparable.	The authors agree that the efficacy of penalty/deposit systems will depend on the level at which they are set. The key strength therefore is that they CAN provide a net financial disincentive to discharge waste at sea, while no other system is able. *We have amended the text to highlight this point.* Regarding the incentivisation of *partial delivery* we did consider this. The opinion of one port authority representative we contacted was that under their regime this would be unlikely – as once the vessel has engaged or is planning to engage with the PRF and undergo the non-financial costs of doing so, this would erode much of the non-financial incentivisation to dump waste. Admittedly, their charging system did not entail very high costs for using the PRFs. If there was a high cost for using the PRF, this could indeed lead to the incentivisation of partial delivery scenarios. However our report showed that for solid waste, the direct fee is actually not that large for most users, who dispose of relatively small volumes. It is important to remember that deposits/penalties can be implemented on top of either indirect, direct or partial indirect fee systems. In order to avoid partial delivery scenarios, if the above considerations are not sufficient, we would recommend that the deposit/penalty be imposed on top of a 100% indirect fee, or a partial indirect fee system where most of the costs of most users are met by the indirect fee.

A.1.3 Task 1.3: Marine Litter Reduction Actions for the Fisheries and Aquaculture Sectors

A.1.3.1 Stakeholder Meeting Discussion

The following discussion points were raised by attendees for discussion in the stakeholder meeting, presented in the format received in advance of the meeting. Where appropriate, a response from the author is also included with details of any resulting amendments.

Laura Foster, Marine Conservation Society

Discussion Point	Response
How would the cost recovery systems interact with e.g. EPR for fishing equipment? Nets are expensive and so a lot of loss is accidental; so how would EPR function? In addition mend and reuse are common so a 'net' as sold may not stay a single entity for the duration of its product life. DRS for nets: what impact can it have on accidental loss?	*Practicalities for deposit refund and extended producer responsibility schemes are now discussed in report Section 4.9.2.* Chiarina Darrah responded that EPR and DRS can run in tandem with any of the CRS discussed in the report. George Cole highlighted that EPR and DRS could provide a financial incentive to return end-of-life products for proper waste management and could also impact on accidental losses by providing additional incentive to retrieve the gear. DRS could operate on a volume or weight basis of similar items rather than expecting return of the original product. Chiarina Darrah agreed that the relative importance of dumping vs accidental loss is unknown and so the impact of such measures is hard to evaluate.

Peter Sundt, Mepex

Discussion Point	Response
The role of private (recreational) fisheries vs the professional fisheries (private fishing contributes by 80% of Skagerrak fishing)	This point was not discussed in the meeting. However, it is important to consider, especially when thinking about small operators and small harbours will little or no provision for waste management.
National EPR systems, based on voluntary agreements or legislation as a possible instrument	See discussion point above.

Discussion Point	Response
Too much focus on ports, they're only a tiny part of the value chain whereas EPR can affect the whole value chain. Another example of a mechanism of influence in aquaculture is how Tesco pressure salmon farmers to demonstrate good waste management. Fish farming - has really good plastics for recycling (fishing nets are harder to recycle in comparison) - so it's that they're far from recyclers that is the problem. But would be an easy financial fix.	

Anna Bobo Remijn, DG Move

Discussion Point	Response
What are ways of bring fishing waste in and charging for it?	We discussed two ways in the report: either FFL litter can be covered by indirect fees paid by 'vessels' as a whole and not necessarily including fishing vessels within mandatory (indirect) fee requirement; or they can be brought within mandatory fees and the waste can be delivered under a 100% indirect fee. We also noted that FFL collection and disposal is currently paid for by KIMO / the funding organisations and of course this also is an option.

Emma Priestland, Seas at Risk

Discussion Point	Response
Aquaculture is largely overlooked in marine litter discussions, so glad to see it in this report. Also Blue Green Growth is encouraging growth. The Sustainable Aquaculture Council may therefore have an interest in marine litter.	

A.1.3.2 Response to Comments Received on the Draft Report

The following additional comments were also received regarding the draft report.

Laura Foster, Marine Conservation Society

Comments [Paraphrased from phone conversation]	Response
From correspondence with fishers and those who work in the industry, we think that fishers not intentionally dumping debris. It was rumoured that this happened several years ago but is no longer a major issue. [Laura arranged for the authors to speak to Mike Montgomerie at Seafish UK to further inform the report].	Mike Montgomerie highlighted that the majority of fishers will bring to shore any debris caught during usual fishing operations (i.e. fishing for litter). The majority of UK ports are able to accept and handle this waste, although some will not have the necessary skips and forklifts. In terms of intentional dumping of end-of-life gear, he thought that in the UK fishers generally don't dump old fishing gear; the general trend being to bring all gear to shore that a vessel is able to, especially in the more responsible Scottish fleet. However, Mike provided examples from his direct experience and verbal reports of intentional dumping for a variety of reasons and recognised that it can and does still happen. We agreed that the pressures leading to dumping and operational practices leading to accidental loss are likely to vary depending on local factors. In a follow-up call Laura Foster noted this as an important point to highlight in the report. Section 4.3 has since been added to the final report, and contains a discussion of the regional variation in quantities of marine debris inflow and highlights countries with the largest fishing and aquaculture industries based on the quantity of fish landed or farmed.

A.2.0 Work Package 1 Appendix: Supplementary Information on Legally and Non-Legally Binding Mechanisms

A.2.1 Regional Seas Programme, Conventions and Action Plans

The Regional Seas Programme aims to address the accelerating degradation of the world's oceans and coastal areas through the sustainable management and use of the marine and coastal environment, by engaging neighbouring countries in comprehensive and specific actions to protect their shared marine environment. It has accomplished this by stimulating the creation of sound environmental management to be coordinated and implemented by countries sharing a common body of water. More than 143 countries participate in 13 Regional Seas Programmes, established under the auspices of UNEP. Each of the Regional Seas Programme functions through an Action Plan, which in most cases is underpinned with a strong legal framework in the form of a regional Convention and associated Protocols on specific problems. All programmes reflect a similar approach, yet each has been tailored by its own governments and institutions to suit their particular environmental challenges.[560]

The Regional Seas Conventions involving European Countries are summarised in Table 46.

[560] UNEP *Regional Seas Programme*, accessed 29 April 2015, http://www.unep.org/regionalseas/about/default.asp

Table 46. Regional Seas Conventions involving European Countries

Conventions involving European Countries	Scope
Barcelona Convention	**Mediterranean Sea** Albania, Algeria, Bosnia Herzegovina, Cyprus, the European Community, Croatia, Egypt, Spain, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Morocco, Monaco, Montenegro, Slovenia, Syria, Tunisia and Turkey
Bucharest Convention	**Black Sea** Bulgaria, Georgia, Romania, Russian Federation, Turkey and Ukraine
OSPAR Convention	**North East Atlantic** Belgium, Denmark, the European Union, France, Germany, Iceland, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom of Great Britain and Northern Ireland, and by Luxembourg and Switzerland.
Helsinki Convention	**Baltic Sea** Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden

A.2.1.1 Regional Seas Conventions and Protocols

Each convention generally tackles, in separate articles (supported by a specific Protocol or Annex):

- Pollution caused by dumping (from ships, aircraft and offshore platforms), reflecting the provisions of the London Convention and Protocol; and
- Pollution from ships, reflecting the provisions of MARPOL 73/78.

The provisions in the main repeat regulations within primary international conventions that were around when they originated, and some have been updated since to reflect more recent changes to those conventions. For a discussion of differences in the provisions regarding dumping, see Section 3.9.1.

Additional clauses within the Regional Seas conventions/protocols in the main relate to agreements on inter-state cooperation.

A.2.1.2 Regional Seas Action Plans

Marine litter does not fall easily within one programme area of the Regional Seas conventions, as it cross-cuts land-based sources of pollution, pollution from ships and dumping. The OSPAR commission has produced a specific action plan on marine litter, as have the Barcelona commission.[561,562] The Helsinki commission and the Bucharest commission and have sections dedicated to tackling garbage pollution and litter from fisheries within their overarching action plans.[563,564]

Some include generally worded objectives, such as ‘enforcement of international regulations’, but plans also often include more focused actions. There are actions which are common across plans, and the actions and commitments are summarised here by theme.

PRFs

The Mediterranean Action Plan (Phase II) references an action plan on PRFs, and at a national level assisting design and implementation projects for PRFs. The Baltic Sea has had actions relating to the development of sewage port reception facilities in particular. The OSPAR action plan includes actions on creating a harmonised system for PRFs (and to improve implementation of the ISO standard for PRFs). The provision of adequate PRFs for ship-generated wastes is also a management target within the Black Sea Action Plan.

Harmonised Fee Systems

- Regional Seas Commissions have all engaged to some degree in the development of harmonised fee systems. The development of harmonised fee/cost recovery systems is an explicit management target in the Black Sea action plan. HELCOM 28E/10 sets out guidelines for a no-special-fee system within the Baltic Sea, and also requests the Contracting Parties to support or seek active co-operation with the North Sea States for the purpose of establishing a no-special-fee system also in the North Sea Region.

---

[561] OSPAR (2015) OSPAR Marine Litter Action Plan Brochure

[562] MAP (2013) Regional Plan for the Marine Litter Management in the Mediterranean UNEP (DEPI)/MED WG. 379/5

[563] HELCOM (2007) *Baltic Sea Action Plan*, http://www.helcom.fi/baltic-sea-action-plan/action-plan/

[564] Bucharest Commission (2009) *Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea*, accessed 25 August 2015, http://www.blacksea-commission.org/_bssap2009.asp#_Toc222222312

- The Mediterranean marine litter Regional Plan commits to 'seek ways and means' to charge reasonable costs for PRFs or apply no-special-fee systems where applicable.

Fishing for litter projects

Fishing for litter projects have been adopted by Regional Seas Commissions – Recommendation 2010/19 implemented them within the OSPAR region, the Mediterranean marine litter Regional Plan commits states to explore and apply as appropriate fishing for litter system by 2017, and support for them in the Baltic is indicated through inclusion of litter caught in fishing nets within the no-special-fee system.

Harmonised enforcement

OSPAR plan has an action to analyse the penalties and fines for waste disposal offences at sea, whilst the North Sea action plan includes the management target 'Develop/establish a harmonised enforcement system in cases of illegal discharges from vessels and off-shore installations, including technical means and fines'.

The OSPAR plan also includes identifying best practice in relation to inspections for MARPOL Annex V wastes and to seek to influence the Paris MoU to take the risk of illegal waste discharge into consideration for the prioritisation of PSC inspections.

Aquaculture and Fishing Gear

The OSPAR plan includes an action to identify options to address key waste items from the fishing industry and aquaculture (along with establish best practice in relation to marine litter within the fishing industry).

- The Mediterranean Marine Litter Action plan (Article 9.8) commits states to explore and apply as appropriate the 'Gear marking to indicate ownership' concept and 'reduced ghost catches through the use of environmental degradation of nets, pots and traps concept' through the use of by 2017, along with the establishment of 'Mandatory Deposits, Return and Restoration System' for expandable polystyrene boxes in the fishing sector.

Offshore Platforms

The Baltic Sea Action plan specifically references an objective to reach zero discharges from offshore platforms, whilst the OSPAR plan includes offshore platforms within their action to develop harmonised enforcement.

- ### Dumping

The Black Sea Strategic Action plan management target 59 is 'Improve regulations/ management of dredging / dumping activities'. Article 9.9 of the Mediterranean Marine Litter Regional Plan commits states to close existing illegal dump sites.

A.2.2 Non-legally Binding Mechanisms

Whilst the primary focus of Task 1.2 is to investigate the adequacy of legal provisions, considering voluntary initiatives may help identify potential gaps in the legal framework, and have implications for the necessity of new legislation.

In an international context, examples of non-legally binding mechanisms include: Agreements, Resolutions, Declarations, Guidelines, Codes of Conduct and Action Plans. Although they may be non-legally binding, such mechanisms can represent the first step towards a treaty-making process, in which reference will be made to the principles already agreed. These mechanisms may provide a convenient option when, for political and/or economic reasons, proposition of legally-binding legislation could lead to a failure of negotiations. Adoption of a Resolution or Declaration at an international conference by a representative group of stakeholders (e.g. Non-Governmental Organisations (NGOs), policy-makers, industry and technical experts) can provide the impetus for Governments to pursue more formalized mechanisms, including legislation.[565]

Mechanisms that are not legally-binding can also serve as a testing ground for considering updates to existing legal instruments to better accomplish their specific objectives. Therefore, it is important to consider the influence of non-legally binding mechanisms on the future development of hard law commitments. Changing legislation can become a slow and complicated process, whereas soft non-legally binding mechanisms are more flexible to adapt to new requirements or situations. Deficiencies in existing legislation may be overcome by applying innovative non-legally binding mechanisms that can provide a bridge between a lack of commitment and legally binding instruments.[566]

The following subsections describe non-legally binding initiatives that aim to tackle the issue of marine litter from ships and offshore platforms. Please note that the initiatives described here are not an exhaustive list; they simply illustrate the point as well as demonstrate different approaches to achieving the same objective.

A.2.2.1 Honolulu Strategy

The Honolulu Strategy was established at the Fifth International Marine Debris Conference (2011), organised by the National Oceanic and Atmospheric Administration

---

[565] MARLISCO (2013) *D1.3 Review of existing policies that may be applied to mitigate the impact of marine litter*, 2013, http://www.marlisco.eu/review-of-existing-policies-that-may-be-applied-to-mitigate-the-impact-of-marine-litter.en.html?pdf=266

[566] MARLISCO (2013) *D1.3 Review of existing policies that may be applied to mitigate the impact of marine litter*, 2013, http://www.marlisco.eu/review-of-existing-policies-that-may-be-applied-to-mitigate-the-impact-of-marine-litter.en.html?pdf=266

(NOAA) and UNEP with representatives of 64 nations and the EU attending.[567] This strategy sets forth a results-oriented framework of action with the overarching goal to reduce impacts of marine debris over the subsequent ten years. This goal will be achieved through the collective action of committed stakeholders at global, regional, country, local, and individual levels.[568]

The strategy establishes three main goals in a global framework for prevention and management of marine debris. The most relevant to marine debris from commercial shipping is Goal B, which aims to reduce the 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. The six strategies established to achieve this are as follows:

- Strategy B1: Conduct ocean-user education and outreach on marine debris impacts, prevention, and management
- Strategy B2: Develop incentives and markets to strengthen implementation of waste minimization and proper waste storage at sea, and of disposal at port reception facilities, in order to minimize incidents of ocean dumping
- Strategy B3: Develop and strengthen implementation of industry best management practices (BMP) designed to minimize abandonment of vessels and accidental loss of cargo, solid waste, and gear at sea
- Strategy B4: Develop and promote use of fishing gear modifications or alternative technologies
- Strategy B5: Develop and strengthen implementation of legislation and policies to prevent and manage marine debris from at-sea sources, and implement the requirements of MARPOL Annex V, as well as other relevant international instruments and agreements
- Strategy B6: Build capacity to monitor and enforce (1) national and local legislation, and (2) compliance with requirements of MARPOL Annex V and other relevant international instruments and agreements.[569]

[567] MARLISCO (2013) *D1.3 Review of existing policies that may be applied to mitigate the impact of marine litter*, 2013, http://www.marlisco.eu/review-of-existing-policies-that-may-be-applied-to-mitigate-the-impact-of-marine-litter.en.html?pdf=266

[568] NOAA, and UNEP (2011) *Fifth International Marine Debris Conference: The Honolulu Strategy*, accessed 23 October 2013, http://5imdc.wordpress.com/about/honolulustrategy/

[569] NOAA, and UNEP (2011) *Fifth International Marine Debris Conference: The Honolulu Strategy*, accessed 23 October 2013, http://5imdc.wordpress.com/about/honolulustrategy/

A.2.2.2 Global Partnership on Marine Litter

The Global Partnership on Marine Litter (GPML) was launched on 18 June 2012, during the Rio+20 conference in Rio de Janeiro. Under the Oceans & Seas topic of The Future We Want the conference adopted the following decision (A/RES/66/288 paragraph 163):

"*We note with concern that the health of oceans and marine biodiversity are negatively affected by marine pollution, including marine debris, especially plastic, persistent organic pollutants, heavy metals and nitrogen-based compounds, from a number of marine and land-based sources, including shipping and land run-off. We commit to take action to reduce the incidence and impacts of such pollution on marine ecosystems, including through the effective implementation of relevant conventions adopted in the framework of the International Maritime Organization (IMO), and the follow-up of the relevant initiatives such as the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, as well as the adoption of coordinated strategies to this end. We further commit to take action to, by 2025, based on collected scientific data, achieve significant reductions in marine debris to prevent harm to the coastal and marine environment.*"[570]

The decision to create the GPML arose following inter-governmental discussions within the UNEP GPA (Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities) during the 3rd Intergovernmental Review (Manila Declaration 2012), where marine litter was highlighted as a priority source category for 2012-2016. It takes account of, and will build on, the 2011 Honolulu Strategy, and a series of initiatives involving UNEP and other Agencies in recent years.[571] [572] [573]

A.2.2.2.1 GPML Objectives

The Global Partnership on Marine Litter (GPML), besides being supportive of the Global Partnership on Waste Management, seeks to protect human health and the global environment by the reduction and management of marine litter as its main goal, through several specific objectives. The specific objectives are as follows:

1) To reduce the impacts of marine litter worldwide on economies, ecosystem and human health.

---

[570] United Nations (2012) The Future We Want A/RES/66/288

[571] UNEP (2005) *Marine Litter: An Analytical Overview*, 2005

[572] Macfadyen, G., Huntington, T., and Cappell, R. (2009) *Abandoned, lost or otherwise discarded fishing gear*, 2009

[573] MARLISCO (2013) *D1.3 Review of existing policies that may be applied to mitigate the impact of marine litter*, 2013, http://www.marlisco.eu/review-of-existing-policies-that-may-be-applied-to-mitigate-the-impact-of-marine-litter.en.html?pdf=266

2) To enhance international cooperation and coordination through the promotion and implementation of the Honolulu Strategy - a global framework for the prevention and management of marine debris, as well as the Honolulu Commitment – a multi-stakeholder pledge.
3) To promote knowledge management, information sharing and monitoring of progress on the implementation of the Honolulu Strategy.
4) To promote resource efficiency and economic development through waste prevention (e.g. 4Rs (reduce, re-use, recycle and re-design) and by recovering valuable material and/or energy from waste.
5) Increase awareness on sources of marine litter, their fate and impacts.
6) To assess emerging issues related to the fate and potential influence of marine litter, including (micro) plastics uptake in the food web and associated transfer of pollutants.[574]

A.2.2.3 International Safety Management Code

The IMO adopted the International Management Code for the Safe Operation of Ships and for Pollution Prevention (the ISM Code) in 1993, and it became mandatory in 1998. The code establishes safety-management objectives and requires a safety management system to be established by "the Company", which is defined as the person assuming responsibility for operating the ship. The Company is then required to establish and implement a policy for achieving these objectives. This includes providing the necessary resources and shore-based support.[575] The ISM Code also contains requirements for all vessels to record volumes and types of waste (in accordance with MARPOL 73/78) and method of disposal.[576]

The ISM Code (1.2.1) also requires the ship to take measures to avoid damage to the environment.

A.2.2.4 ISO Standards

The International Organization for Standardization (ISO) has established two standards with regards to ships and marine technology (marine environment protection). Both of these standards relate to MARPOL and Annex V; however it is not a requirement that port authorities and ship operators obtain these standards:

[574] GPA (2014) Global Partnership on Marine Litter...preventing our oceans from becoming dumps
[575] IMO (2013) *Safety Management: Development of the ISM Code*, accessed 23 October 2013, http://www.imo.org/OurWork/HumanElement/SafetyManagement/Pages/Default.aspx
[576] Butt, N. (2007) The impact of cruise ship generated waste on home ports and ports of call: A study of Southampton, *Marine Policy*, Vol.31, pp.591–598

- **ISO 16304:2013** Arrangement and management of port waste reception facilities; and
- **ISO 21070:2011** Management and handling of shipboard garbage.

The scope of each standard is described in more detail below.

The main driver for a ship or ship operator achieving accreditation in either or both of the standards would be to demonstrate to stakeholders the commitment to improving environmental standard of ship activities. This may help win an advantage over competitors, providing the organisation with a lead in the market.

It is currently unknown how many applications for each standard have been submitted and awarded. This standard relating to port waste reception facilities (ISO 16304:2013) was only published in March 2013, therefore the application of this standard is likely to be relatively low until awareness is raised and requirements for port reception facilities become more specific, driving the market towards best practice.

One of the benefits of ISO standards is the requirement for monitoring, as well as internal and external auditing. This ensures credibility, and is an alternative approach to ensuring compliance where enforcement mechanisms fall short.

A.2.2.4.1 ISO 16304:2013

This applies to the management of ship generated waste regulated by MARPOL that is discharged at ports and terminals. It also covers principles and issues that should be considered in the development of a port waste management plan (PWMP), its implementation and port reception facilities (PRF) operations. The operation of any PRF is governed by the principles and procedures included in the PWMP. The procedures to operate the PRF and the development of a PWMP are closely linked and therefore are integrated into ISO 16304:2013.[577]

ISO 16304:2013 provides guidance and sets best practice for the following areas of arrangement and management of port waste reception facilities:

- Waste segregation;
- Storage;
- Waste minimisation;
- Waste handling equipment;
- Recycling;
- Local and national regulations;
- Treatment technologies at the port; and

---

[577] ISO (2013) *ISO 16304:2013 - Ships and marine technology -- Marine environment protection -- Arrangement and management of port waste reception facilities*, accessed 22 October 2013, http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=56129

- Waste management planning.[578]

A.2.2.4.2 ISO 21070:2011

The requirements of MARPOL Annex V set the minimum standard for garbage management that apply to ships. Applicable national and regional regulations exceeding the requirements of MARPOL Annex V will also need to be observed. ISO 21070:2011 applies to the management and handling of garbage generated on board ships during the period the garbage will be on board. The definition of garbage in ISO 21070:2011 is as defined in MARPOL Annex V. ISO 21070:2011 contains procedures for the shipboard management of garbage, including handling, collection, separation, marking, treatment and storage. It also describes the vessel-to-shore interface and the delivery of garbage from the ship to the port reception facility.[579]

ISO 16304:2013 provides guidance and sets best practice for the following areas of management and handling of shipboard garbage:

- Equipment/technology (compactors, comminuters, pulpers, PAWDS (Plasma Arc Waste Destruction System, shredders, and incinerators)
- Calculating the amounts of waste; and
- Segregation of Wastes.[580]

A.2.2.5 Memoranda of Understanding on Port State Control

The IMO recognises that the primary responsibility for implementing the regulations provided for in IMO conventions (such as MARPOL) rests with the flag State. However, it also acknowledges the need for port state control (PSC) with a view to promoting more effective implementation of all applicable standards for maritime safety and pollution prevention. [581]

---

[578] Condino, D. (2013) Environmentally Sound Management of Ship's Waste and Adequate Port Reception Facilities, paper given at World Ocean Council Sustainable Ocean Summit, Washington D.C., 23 April 2013, http://oceancouncil.org/site/summit_2013/Presentation%20PDFs/2-PORT%20WASTE%20SECURED%20PDFS/2-PORTWASTE_Condino%20nn.pdf

[579] ISO (2011) *ISO 21070:2011 - Ships and marine technology -- Marine environment protection -- Management and handling of shipboard garbage*, accessed 22 October 2013, http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=51003

[580] Condino, D. (2013) Environmentally Sound Management of Ship's Waste and Adequate Port Reception Facilities, paper given at World Ocean Council Sustainable Ocean Summit, Washington D.C., 23 April 2013, http://oceancouncil.org/site/summit_2013/Presentation%20PDFs/2-PORT%20WASTE%20SECURED%20PDFS/2-PORTWASTE_Condino%20nn.pdf

[581] IMO (2012) *Implications of the United Nations Convention on the Law of the Sea for the International Maritime Organisation*, accessed 27 November 2013, http://www.imo.org/OurWork/Legal/Documents/Implications%20of%20UNCLOS%20for%20IMO.pdf

A number of PSC resolutions have been adopted by the IMO over the years. Resolution A.787 (19) was adopted in 1995, amalgamating guidelines contained in several IMO resolutions, with the aim of providing one set of basic guidelines on the conduct of PSC inspections. [582]

Through the conduct of PSC inspections and discussions at IMO, member governments realised that more effective PSC could be conducted by establishing regimes for its coordinated implementation at the regional level. Accordingly, many States have entered into Memoranda of Understanding (MoUs) with the view to enhancing compliance by all vessels with international rules and standards for the prevention, reduction and control of pollution from vessels. Each MoU identifies the relevant conventions to be enforced through that particular MoU. Most MoUs establish targets for the inspection of a minimum number or percentage of vessels visiting Member States ports. A total of eight MoUs have been concluded so far.[583]

Take for instance the Paris Memorandum of Understanding (Paris MOU); 27 States in the North Atlantic region have signed the Paris MOU and agreed to control visiting ships in their ports. More than 18,000 inspections take place on board foreign ships in the Paris MoU ports each year, ensuring that these ships meet international safety, security and environmental standards, and that crew members have adequate living and working conditions.[584]

A.2.2.6 International Maritime Organisation (IMO) Member State Audit Scheme

The IMO Member State Audit Scheme is intended to provide an audited Member State with a comprehensive and objective assessment of how effectively it administers and implements those mandatory IMO instruments which are covered by the Scheme – including MARPOL. [585]

---

[582] IMO (2012) *Implications of the United Nations Convention on the Law of the Sea for the International Maritime Organisation*, accessed 27 November 2013, http://www.imo.org/OurWork/Legal/Documents/Implications%20of%20UNCLOS%20for%20IMO.pdf

[583] IMO (2012) *Implications of the United Nations Convention on the Law of the Sea for the International Maritime Organisation*, accessed 27 November 2013, http://www.imo.org/OurWork/Legal/Documents/Implications%20of%20UNCLOS%20for%20IMO.pdf

[584] Paris MoU (2013) *Paris MoU on Port State Control*, accessed 28 November 2013, https://www.parismou.org/about-us/organisation

[585] IMO (2014) *Member State Audit Scheme*, accessed 09 June 2015, http://www.imo.org/OurWork/MSAS/Pages/AuditScheme.aspx

A.2.2.7 'Green Ship' Concepts and Indexes

A.2.2.7.1 The Clean Ship Approach

The Clean Ship approach is the concept of vessels designed, constructed and operated in an integrated manner with the objective to eliminate harmful operational discharges and emissions; it is a ship that is constructed and can ultimately be recycled in an environmentally acceptable way, and one that is energy and resource efficient in its daily operation.[586] A Clean Ship operation maximises the opportunities for safe and environmental navigation while at the same time providing all possible safeguards in the event of an accident. It requires a shipping sector that puts safety and environmental protection first; an industry with a "safety culture" at its heart.[587]

Seas At Risk coined the phrase "Clean Ship" and launched the concept at the fifth North Sea Conference in 2002 (Bergen, 20-21st March). Ministers embraced the idea and since then it has passed into popular parlance, with regulators and other stakeholders increasingly using the term to define and describe their ultimate objective for an environmentally benign shipping sector.[588]

Seas At Risk welcomes this but is increasingly concerned that the concept is being used solely as an argument for more research rather than urgent regulatory action. While research and development is needed in some areas the reality is that if all shipping adopted the technologies and practices that are currently being used by the best operators then the industry would be 90% of the way to implementing a Clean Ship approach. Unfortunately the quality operators occupy a small niche in an otherwise environmentally sub-standard industry, and regulations are rarely an encouragement to high standards, normally lagging far behind current best available technologies and practices. Seas At Risk's work in this area is now focussing on closing this gap between regulatory standards and the best currently available technologies and practices.[589] [590] [591]

---

[586] Seas at Risk (2005) *Background paper on the Clean Ship approach prepared for Gothenburg meeting*, accessed 10 October 2013, http://www.seas-at-risk.org/1mages/Background%20document%20for%20Gothenburg.pdf

[587] Seas at Risk (2013) *The Clean Ship concept*, accessed 29 September 2013, http://www.seas-at-risk.org/n3.php?page=67

[588] Seas at Risk (2013) *The Clean Ship concept*, accessed 29 September 2013, http://www.seas-at-risk.org/n3.php?page=67

[589] Seas at Risk (2013) *The Clean Ship concept*, accessed 29 September 2013, http://www.seas-at-risk.org/n3.php?page=67

[590] Seas at Risk (2005) *Background paper on the Clean Ship approach prepared for Gothenburg meeting*, accessed 10 October 2013, http://www.seas-at-risk.org/1mages/Background%20document%20for%20Gothenburg.pdf

[591] Gothenburg Declaration (2006) Declaration (5 May 2006) Gothenburg, Sweden

The Gothenburg Declaration 2006 (the outcome of an OSPAR conference in Gothenburg) specifically focused on impacts of fisheries and shipping as important pressures on the marine environment of the North Sea. The Declaration reinforces the commitment of North Sea states to the “clean ship approach” as a concept of vessels designed, constructed and operated in an integrated manner with the objective to eliminate harmful discharges and emissions throughout their working life. As an integrated approach of sustainable shipping it addresses all vessel operations and possible impacts on the environment, and will provide an increased opportunity for transport managers to choose environmentally sound sea transport options. The clean ship approach has been followed up by some OSPAR countries, such as Germany through the Blue Angel eco label (see Appendix A.2.2.8 for more details).[592]

A.2.2.7.2 The Clean Shipping Index

The Clean Shipping Index (CSI) is an easy to use, transparent tool which can be used by cargo owners to evaluate the environmental performance of their providers of sea transport. To be included in the Clean Shipping Index, ship-owners are required to complete a questionnaire consisting of twenty questions on a vessel’s operational impact. The information is entered on a ship-by-ship basis but is also added to total carrier fleet score for an overall ranking. Depending on the information provided, scoring is obtained in five different areas: SO_x and PM emissions, NO_x emissions, CO_2 emissions, chemicals, water and waste control. Questions on waste relate to garbage handling and crew awareness. Scores can only be obtained for measures that go beyond existing regulations.[593]

Based on the scores, a ship is ranked as having a ‘low’, ‘medium’ or ‘good’ performance. The final index score is the total average score multiplied by the percentage of reported ships of the totally owned or managed fleet. Data can be analysed in much more detail, down to the level of NO_X emissions for a single engine or stern tube oil usage on a single ship for example. A vessel or shipping company cannot perform well in only one area of the index (for instance sulphur emissions) and get a good overall performance. The index is dynamic; what is perceived to be good environmental performance at one point in time may change as new technology is developed and installed, and environmental legislation becomes stricter. At the time of writing this report, data from around one

---

[592] OSPAR Commission (2009) *Assessment of the impacts of shipping on the marine environment*, accessed 10 October 2013, http://qsr2010.ospar.org/media/assessments/p00440_Shipping_Assessment.pdf?zoom_highlight=clean%2Bship#search=%22clean%20ship%22

[593] Clean Shipping Index (2011) *Clean Shipping Index: Environmental Opportunities for Shipping*, accessed 16 October 2013, http://www.s1137723-4240.crystone.net/cleanshippingindex.org/wp-content/uploads/2012/12/CleanShippingBrochure.pdf

thousand six hundred large vessels is included in the database; more vessels are continuously added as time goes by.[594]

If reasonable but significant environmental demands are coordinated from large cargo owners, a win-win situation could be created. This would be beneficial for quality shipping companies, subcontractors for clean technology and the environment itself. Submission is voluntary and data is only verified if ship owners pay Class Societies (so far Lloyd's Register and Det Norske Veritas offer these services) for third party verification. Amongst the shippers in the Clean Shipping Network, submission of data is becoming a requirement for shipping goods. For example, Volvo requires all ship-owners transporting Volvo goods to submit CSI data.[595]

A summary of benefits to the key users of the CSI are as follows:

- **Port authorities** can use the Clean Shipping Index as a tool to measure environmental performance of the ships calling into the port in question. Well-performing vessels could be offered a reduction in the port dues; this may help to attract high performing vessels as well as environmentally focused cargo owners;
- **Shipping companies** can add vessels to the Clean Shipping database and see the environmental performance of each vessel, and their fleet, compared to competitors. When the performance of a ship or fleet is good, information provided via the CSI can be used to gain market share from competitors; and
- **Cargo owners**: consumers are becoming more and more interested in the indirect emissions of products. The CSI helps cargo owners keep track of which carriers are best when it comes to environmental performance.[596]

A.2.2.8 The Blue Angel

The Blue Angel is an environment-related label that may be awarded to products and services which, from a holistic point of view, meet high environmental standards. The

[594] Clean Shipping Index (2011) *Clean Shipping Index: Environmental Opportunities for Shipping*, accessed 16 October 2013, http://www.s1137723-4240.crystone.net/cleanshippingindex.org/wp-content/uploads/2012/12/CleanShippingBrochure.pdf
[595] Clean Shipping Index (2011) *Clean Shipping Index: Environmental Opportunities for Shipping*, accessed 16 October 2013, http://www.s1137723-4240.crystone.net/cleanshippingindex.org/wp-content/uploads/2012/12/CleanShippingBrochure.pdf
[596] Clean Shipping Index (2011) *Clean Shipping Index: Environmental Opportunities for Shipping*, accessed 16 October 2013, http://www.s1137723-4240.crystone.net/cleanshippingindex.org/wp-content/uploads/2012/12/CleanShippingBrochure.pdf

Blue Angel was created in 1978 on the initiative of the German Federal Minister of the Interior, but can be awarded to a service or product in international markets.[597]

The Blue Angel may be awarded to environmentally-sound ship operations, recognising efforts to reduce emissions and releases of pollutants into the marine environment caused by a seagoing vessel. To achieve the Blue Angel eco-label, particularly high standards are imposed on the management of shipping companies and ships, on ship design and equipment, and especially on the measures for the reduction of emissions. Fishing vessels, tank ships, sports boats and naval vessels are excluded from the Blue Angel.[598] [599]

The standards for waste disposal under the Blue Angel eco-label refer to the requirements of MARPOL Annex V with regards to distances from the coastline for disposal at sea and the maintenance of a Garbage Record Book. The Blue Angel also refers to the EU Port Reception Facility Directive, which requires ships to dispose of their waste on land. Additional obligatory requirements under the eco-label are as follows:

- For cargo ships:
- Implementation of a purchasing strategy aimed at waste avoidance;
- On-board storage of all wastes and disposal on land; and
- Ban on waste incineration at sea.
- For passenger ships:
- Implementation of a purchasing strategy aimed at waste avoidance; and
- Incineration of wastes provided that no intermediate shipboard storage is feasible until the waste can be disposed of ashore in an ecologically sound manner.

Ship operators can demonstrate compliance with these standards by incorporating procedural instructions in the management system stipulating a corresponding waste management (such as the purchasing strategy, storage etc.). There are no optional requirements; all must be adhered to in order to achieve the Blue Angel.[600] The application of the Blue Angel amongst shipping operators has not yet been publicised,

[597] The Blue Angel (2013) *The Blue Angel*, accessed 7 November 2013, http://www.blauer-engel.de/en/index.php

[598] The Blue Angel (2013) *Environment-conscious Ship Operation (Edition January 2010) (RAL-UZ 110)*, accessed 7 November 2013, http://www.blauer-engel.de/en/products_brands/search_products/produkttyp.php?id=506

[599] Seas at Risk (2007) *The Clean Ship Concept: A strategy for uncoupling growth in shipping from environmental harm*, accessed 10 October 2013, http://www.seas-at-risk.org/1mages/Seas%20At%20Risk%20Policy%20Analysis%20_V_W%20case%20study%201_.pdf

[600] The Blue Angel (2013) *Environment-conscious Ship Operation (Edition January 2010) (RAL-UZ 110)*, accessed 7 November 2013, http://www.blauer-engel.de/en/products_brands/search_products/produkttyp.php?id=506

however a wide range of products have been awarded the eco-label, see http://www.blauer-engel.de/en/index.php for more information.

A.2.2.9 Zero Solid Waste Policy

Preventing marine debris from ocean based sources requires the commitment and efforts of companies operating in the marine environment. This includes corporate culture, policies, protocols, and practices to ensure that company activities at sea do not generate marine debris. Matson Navigation transits the Pacific between Hawaii, California and China, and is the only commercial container operator that has a zero solid waste discharge policy.[601]

The "Greentainer" Program with Zero Solid Waste was developed in 1993 through collaboration with the Center for Marine Conservation (now Ocean Conservancy). Matson spent $224,000 to replace existing containers with ones specifically designed for storing solid waste when at sea. This programme was designed to also engage employees of shipyards and containerised freight companies to develop controls on discharges of solid wastes into the ocean and ports. Thus far the programme has been embraced enthusiastically by Matson's personnel, and has resulted in improved handling of solid wastes in port. [602] [603]

The programme consists of signage, workshops for dock employees, increased waste receptacles on ships, and increased shoreline waste management facilities. Since 1994 approximately 12,000 tons of material has been kept on board rather than going into the ocean.[604] [605]

---

[601] NOAA, and UNEP (2011) *Honolulu Strategy: Technical Proceedings of the Fifth International Marine Debris Conference (Honolulu Strategy)*, accessed 23 October 2013, http://5imdc.files.wordpress.com/2011/03/5imdc-proceedings-final1.pdf

[602] UNEP (2009) *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter*, 2009

[603] Matson (2012) *Environmental Stewardship - Zero Solid Waste*, accessed 13 November 2013, http://www.matson.com/corporate/about_us/zero_solid_waste.html

[604] UNEP (2009) *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter*, 2009

[605] Matson (2012) *Environmental Stewardship - Zero Solid Waste*, accessed 13 November 2013, http://www.matson.com/corporate/about_us/zero_solid_waste.html

A.2.2.10 Indirect Fee System: Baltic Sea Example

The concept of an indirect fee or "no special fee" system is that port fees paid for by visiting ships to use the existing facilities also include waste disposal services. Multiple factors can influence the success of this incentive to encourage delivery of wastes in ports, most importantly the institutional framework and design or roll-out of the instrument. The lack of harmonisation throughout ports in close proximity is a factor that may hinder the full potential of the system as an instrument. [606]

The No Special Fee System (NSF) implemented in the Baltic Sea is defined as '*a charging system where the cost of reception, handling and disposal of ship generated wastes, originating from the normal operation of the ship, as well as of marine litter caught in fishing nets, is included in the harbour fee or otherwise charged to the ship irrespective of whether wastes are delivered or not*'. The system is not restricted to any specific type of ship-generated waste, and thus includes the most common wastes from normal operation of ships: oily waste, sewage and garbage.[607]

In spite of efforts to set up a harmonised system for the Baltic Sea, it appears that implementation of the fee system for ship-generated waste reception in ports differs between the countries of the Baltic. This is partly due to the many regulations and recommendations in place (MARPOL requirements, binding EU Directive, the HELCOM recommendation and existing or new national legislation). Such differences can exist in terms of granted exemptions, waste types and amounts under the system, and the level of the waste fees. [608]

The EU Directive on port reception facilities aims at the further development of these facilities in Member States, leaving ports and countries a degree of freedom to decide on the port reception facilities financing mechanism. The No Special Fee system works in combination with other policy instruments (prohibition of discharging, e.g. MARPOL special area, mandatory delivery) that are generally difficult to enforce.

Additional difficulties arise from equity issues (fair sharing of the cost burden amongst ships and between ships and ports) or bottlenecks in the extended waste chain. Cooperation and the involvement of all stakeholders in defining the requirements (e.g.

---

[606] Arcadis (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, http://ec.europa.eu/environment/enveco/water/pdf/report.pdf

[607] Arcadis (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, http://ec.europa.eu/environment/enveco/water/pdf/report.pdf

[608] Arcadis (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, http://ec.europa.eu/environment/enveco/water/pdf/report.pdf

adequate port reception facilities) may help to increase acceptance and uptake of the necessary actions.[609]

The No Special Fee system has gained acceptance from different stakeholders. The shipping industry believes it is a good and suitable system if it is applied in a transparent and harmonised manner, and environmental NGOs oppose direct fees for waste services as this is considered to be the largest disincentive to deliver on land. The majority of Baltic ports are also in favour of the system, while not ignoring the necessity of an increased harmonisation of the implementation in order to share the waste burden. [610]

[609] Arcadis (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, http://ec.europa.eu/environment/enveco/water/pdf/report.pdf

[610] Arcadis (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, http://ec.europa.eu/environment/enveco/water/pdf/report.pdf

A.3.0 Work Package 2 Appendix: Primary Microplastic Source Calculations

A.3.1 Abrasion of Automotive Tyres

4,500 tonnes of tyre particles are estimated by the Mepex study to be released into the environment in Norway every year—around 0.9 kg per capita. Of this, 50% are assumed to enter the marine environment. This assumption does not appear to be literature based and is perhaps overestimating the amount that will enter the marine environment.

As part of the emissions inventory for the Netherlands tyre wear has been studied with regard to the particulate matter that is worn away during use.[611,612] This study applied tyre wear emission factors based on the type of transport (car, motorcycle, truck etc.) and the road type (urban, rural, highway) to activity rates for the Netherlands transport system in 2012 (see Table 48 for emission factors). The substances of concern in this instance are the 'coarse particulates' broadly defined as particles that are not fine enough to be released into the atmosphere. The composition and size of these course particulates from tyre wear is not particularly well known but research suggests that they can be around 100um is size and that they are mainly composed of organic compounds along with styrene and butadiene polymers[613].

The overall composition of a car tyre is thought to be around 50% elastomer, most of which is synthetic[614]. Therefore, as a basis for an estimate it will be assumed that 50% of the tyre wear particles can be classed as a microplastic; however, further work is recommended to help understand tyre wear in more detail, especially with regard to whether it is comparable to other microplastic pollution.

The Dutch study also applied assumptions as to where the particles would end up based on spatial distribution. In rural areas and highways much of the course particulates were assumed to end up in the soil of verges, with 10% entering surface water via run-off. Urban emissions were assumed to enter sewage systems 60% of the time based on the area of land that is covered by sewers in the Netherlands along with an assumption of the proportion that will leach from soil to sewer. By applying these assumptions to

[611] Deltares, and TNO Consulting (2014) Emissieschattingen Diffuse bronnen Emissieregistratie: Bandenslijtage wegverkeer, Report for Rijkswaterstaat - WVL, May 2014

[612] Above study is also available in English from 2008 using 2006 data "Emission estimates for diffuse sources. Netherlands Emission Inventory: Road traffic tyre wear"

[613] Boulter, P., and et al. (2004) Measurement of non-exhaust particulate matter, Report for EUROPEAN COMMISSIONDirectorate General Transport and Environment, 2004

[614] EER Ltd (2006) The Composition of a Tyre: Typical Components, Report for WRAP, February 2006

activity data on each road type we find that 25% of the plastic particles enter surface waters.

This is summarised in Table 47 which shows the total coarse particles generated in the Netherlands of 15,452 tonnes per year and also gives a 0.92kg per capita which compares closely with the Mepex study's estimate for Norway of 1.12kg per capita. This also compares well with the Nova study, which provides figures for overall tyre wear in Germany with estimates of between 0.75 and 1.38 kg per year per capita from data gathered by two different German studies. The per capita estimate of 0.92 kg from the Netherlands study is on the low end of this range but of the same order of magnitude. The Nova study does not provide any further estimate of how much of this debris can be considered microplastic and states that there is no reliable information on their fate with regard to the marine environment.

The Mepex study assumed that 60% of the tyre wear is polymer based and that of this 50% would enter the marine environment—totalling 30% of the total tyre wear. Based on a polymer content of 50% and using the Dutch estimates for the proportion of the particles that enter waterways (25%) we now find this figure is potentially much lower at between 1.3% and 12.5% depending on how much is captured in the waste water treatment process (See Table 47— total tyre wear is 15,452 tonnes in the Netherlands, of which between 194 (1.3%) and 1,939 (12.5%) tonnes ends up in the ocean).

Waste water treatment capture is estimated to be between 0—57% as discussed in Section 6.4, although potentially on the lower side of this estimate (i.e. fewer captured particles) due to the fact that much of the surface run-off that carries tyre microplastics away will enter storm drains and separate sewers than lead straight to rivers; data for this is not available currently.

Upscaling this for the whole of the EU based on population (also summarised in Table 47) shows that emissions from automotive tyre wear could be between ***25,000 and 58,000 tonnes per year***. A more accurate figure may be achieved by looking at the activity data of each of the EU countries—however, the Netherlands serves as an adequate proxy for the purposes of developing a broad estimate. This is considerably lower as an overall proportion than the Norwegian estimate for the following reasons:

- More detailed and road specific activity data is used from the Netherlands;
- Polymer content is assumed to be 50% rather than 60%; and
- Fewer particles are expected to reach the marine environment after waste water treatment (in the case of the high capture estimate).

Table 47 – Annual Tyre Wear in the Netherlands (2012)

	Tyre Coarse Particulates (tonnes)						
	Total Wear	Of Which Plastics		Assumed to Enter Water Systems		Remaining After Waste Water Treatment	
Urban driving	4,666	50%	2,333	60%	1,400	43%	602
Rural driving	4,121	50%	2,061	10%	206	43%	89
Highways	6,665	50%	3,332	10%	333	43%	143
Total	**15,452**	**50%**	**7,726**	**(25%)**	**1,939**		**843**
Netherlands Population	16,730,348						
kg per capita/ year	0.92				0.12		0.05
EU Population	504,056,505						
EU Tyre Wear Particles Transported to Oceans	**465,554**				**58,424**		**25,122**

Table 48 – Vehicle Tyre Wear Emission Factors for Netherlands

Vehicle Category	Urban Driving (mg/km)	Rural Driving (mg/km)	Highway Driving (mg/km)
Passenger Car	158	79	79
Motorcycle	71	36	36
Moped	23	12	0
Van	190	95	95
Lorry	1,014	507	507
Truck	785	393	393
Bus	495	248	248
Special vehicle (light)	167	84	84
Special vehicle (heavy)	712	356	356

Source: Deltares, and TNO Consulting (2014)

A.3.2 Marine Paint

The second largest contribution to marine microplastics as highlighted by the Mepex study emanates from the painting of marine vessels (both commercial and recreational) with estimates for Norway of 330 and 400 tonnes respectively.

According to the OECD[615] the marine paint market in the EU was 55,000[616] tonnes in 2002—1% of total paint sales. The OECD has also generated estimates for how much of this paint is discharged to water during the life of the coat of paint: 1.8% during painting, 1% due to weathering and 3.2% during removal—totalling 6%. The Mepex estimate for Norway includes these direct discharges to water using the OECD estimates, but also adds to this the OECD estimate of emissions to soil of 5%—thereby assuming that all emissions to soil end up in the marine environment, which may well be an over-estimate.

The polymer resin used as a binder can be anywhere between 20% and 40%[617] of the volume of the paint. Therefore Mepex's estimate of 25% will be used in the absence of more specific information. Similarly the Mepex assumption of a split of 75:25 between commercial and recreational craft will be used and without any available information on the paint losses for recreational craft, we present a range between best and worst case.

The flow chart in Figure 64 shows the EU estimate which is built up from these assumptions totalling between ***825 and 4,056 tonnes per year***. This is considerably lower as an overall proportion than the Norwegian estimate for the following reasons:

- Total EU sales are half of what is quoted in the Mepex report;
- Losses to soil have not been included; and
- Norway is expected to have a larger marine industry relative to its population than much of the rest of Europe.

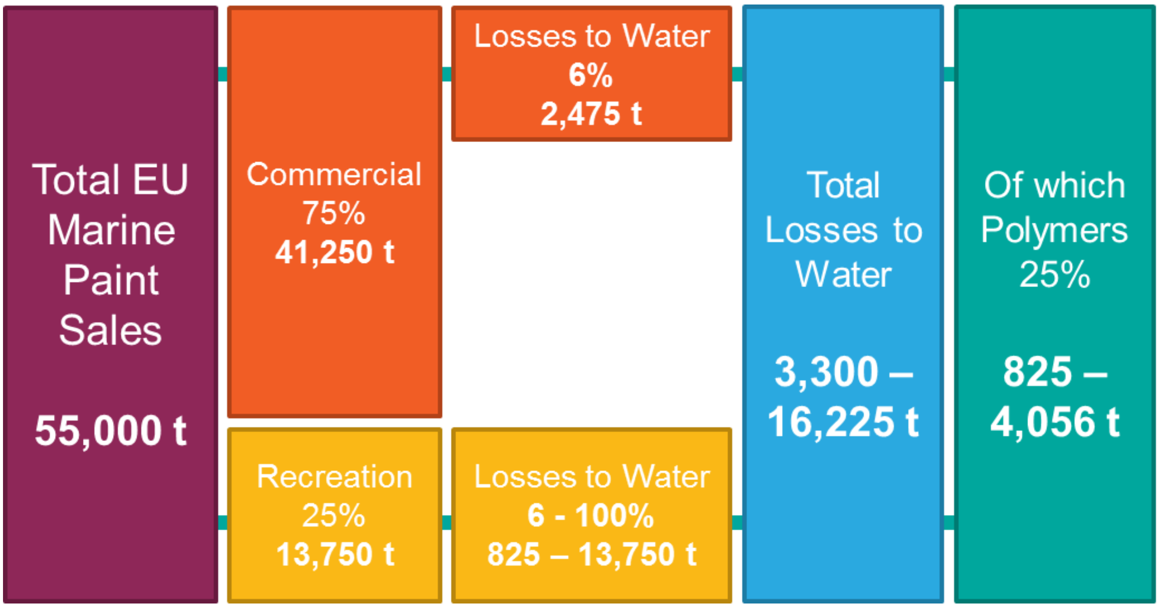
---

[615] OECD (2009) Emission Scenario Document On Coating Industry (Paints, Lacquers and Varnishes), 2009

[616] This figure has been quoted as 110,00 tonnes in the Mepex report as a result of an error in OECD report which states two different figures for marine volumes. However, the correct value of 55,000 tonnes can be derived from the market value which is also given.

[617] http://www.essentialchemicalindustry.org/materials-and-applications/paints.html

Figure 64 - European Marine Paint losses to Water



A.3.3 Construction, Buildings and Road Paint

The loss of paint to the environment when new and existing structures are painted is highlighted in the Mepex study as a further possible cause of microplastic pollution. According to the OECD[618] 3,465,000 tonnes of 'decorative' paint were sold in Europe in 2002. The term decorative "covers the use of paints applied to buildings, their trim and fittings and for decorative and protective purposes by both professionals and the general public".

Estimating the volume that will be lost to water is difficult as the OECD has an emission factor of 1.5% losses to water for DIY applications only. No losses are assumed for professional use, which seems unlikely. It also seems unlikely that there are no losses due to removal, although within the DIY sector it is arguably more likely that individuals might paint over an existing coating rather than remove it before re-painting. The figure for total sales also includes various masonry and wood stain products that do not contain polymer binders. The study also notes that the relative market share between professional and DIY varies considerably from country to country and therefore without individual country analysis it is not possible to assign a volume to each sector.

In the Mepex study the authors apply a 5% emission factor (higher than the OECD estimate of 1.5%) to accommodate the potential for extra loses and they then apply this

[618] OECD (2009) Emission Scenario Document On Coating Industry (Paints, Lacquers and Varnishes), 2009

across both the DIY and professional market. The Mepex study also has a separate estimate for wear and tear on painted surfaces, using the OECD estimate of 3% losses to land/soil. Again, it appears inappropriate to assume that losses to soil should be treated in the same way as losses to water. It would seem more appropriate to apply the assumption used in the urban tyre wear case, that 60% of land based emissions will find their way to sewers—although even this estimate may be on the high side. This would mean losses of 1.8% due to wear and tear (60% of 3%).

Due to the lack of available information the emission factor of 3.3% (1.5% during application and 1.8% during use) will be applied across the whole sector as a conservative estimate. Assuming a 25% polymer content as applied to the marine coatings estimate we arrive at emissions of ***28,600 tonnes per year***. As the emissions are not primarily taking place by the ocean there will also be some capture along the way, most notably in waste water treatment. This is estimated to be up to 57% (see section 6.4) in the EU which would mean that a lower estimate of ***12,300 tonnes*** could be achieved. As discussed in Section 2.4, however, there may be far fewer particles captured in this way due to the fact that much of the surface run-off that carries paint microplastics away will enter storm drains and separate sewers that lead straight to rivers; data for the extent to which this may happen is not available currently.

A final area of paint degradation is from abrasion of road markings. The Mepex study estimates that in Norway 320 tonnes are abraded every year with half of that tonnage ending up in the marine environment. This figure would be highly variable depending on the infrastructure of the country and the local climate, and therefore factoring it up for Europe may lead to an overestimate, given Norway's relatively harsh winter climate. Data does exist, however, putting the volume of paints produced in the EU-27 for road markings at 123,905 tonnes during 2006[619].

The Mepex study assumes that all paint will be used as a direct replacement for worn paint and therefore that the paint sold will equal the paint worn away; however, some will be applied to new roads and some will be used in resurfacing. Data from the OECD suggests that the European road network has only grown by 2.5% between 2000 and 2011[620] so the effect of new roads does indeed appear to be minimal, reducing the annual replacement rate to 123,600 tonnes.

Similarly, data from the UK suggests that roads are resurfaced every 63 years[621] on average. Spending on roads in the UK is considerably less than some other EU

---

[619] Okopol Institute (2011) Report on Potential Scope Extension of the Directive Covering Road Markings, May 2011

[620] OECD (2013) 'Road traffic, vehicles and networks', in Environment at a Glance 2013: OECD Indicators, 2013

[621] The Asphalt Industry Alliance (2015) Annual Local Authority Road Maintenance Survey, 2015

countries—France spends 75%[622] more—and with less harsh winters than many central European countries roads may be expected to be replaced less often. If all EU roads were to be replaced every 63 years, assuming replacement was consistent this would happen at a rate of 1.6% per year. This is increased to 3.2% to take account of other EU countries' higher spending. This reduces the annual paint wear to 120,500 tonnes.

Applying the same polymer content assumption of 25% and the assumption that 60% will end up in the sewers as per the tyre wear particles and that 57% of the particles that end up in the sewerage system will be captured, there is potential for between ***7,800 and 18,000 tonnes*** to end up in the marine environment.

A.3.4 Pellet Loss

Pellets are defined in ISO 472:2013[623] as a "small mass of preformed moulding material, having relatively uniform dimensions in a given lot, used as feedstock in moulding and extrusion operations". As such, these pellets are manufactured and shipped worldwide by the plastics manufacturing and conversion industry. During this process many of these pellets are lost to spillages. The industry has been tackling the issue for some time through 'Operation Clean Sweep' initially in the US, but now internationally and the 'Zero Pellet Loss' initiative in Europe. Neither initiative has published any figures relating to their success, nor are there any industry figures available on the proportion of current pellet loss.

The Declaration of the Global Plastics Associations for Solutions on Marine Litter—a declaration signed by many of the plastic associations in an agreement to combat marine litter—produced a progress report in 2014. Although many initiatives and case studies were cited, no figures were presented as to the effectiveness of the declaration or the initiatives that support it. It is therefore very difficult to quantify the extent to which pellets are entering the environment.

The Mepex study estimates that pellet loss through production, conversion and transport of plastic pellets is the third largest contributor to marine microplastics in Norway. Their estimate is derived by taking overall plastics production combined with an emission factor of 0.9kg per tonne handled (~0.09%). This consisted of a 5 kg per tonne estimate from the OECD[624], for the emission factor for dust emissions from transferring solid *powders*. It is unclear from the report whether it is appropriate to apply this estimate to pellet loss during transport as it appears to be concerned more with the health implications of dust inhalation. This emission factor may be on the high side for

[622] Department for Transport (UK) (2013) Action for Roads: A network for the 21st century, Report for UK Parliament, July 2013
[623] ISO 472:2013 – Plastics - Vocabulary.
[624] OECD (2009) Emission Scenario Document On Adhesive Formulation, 2009

application to pellets as one would expect powers to be harder to contain. With no further data, Mepex assumes that 10% of this will not be contained in spill control measures—a 0.9kg per tonne emission rate.

Production losses were estimated by Mepex to be a further 0.4 kg per tonne from information obtained by direct contact with a reprocessor in Norway and therefore may be considered more accurate depending upon how well the facility is able to identify and record spillages.

The Nova study estimated losses to be between 0.1 and 1 per cent of plastics production based on German[625] estimates of production yields although figures for these yields generally do not take into account pellet loss, but rather the total plastic available after the polymerisation process. In a presentation from Plastics Europe cited[626] in the Nova study the losses appear to be primarily due to waste gases from incineration rather than pellet losses and therefore it is difficult to justify the use of this source to estimate this emission.

On this basis, the Mepex emission factors will be used with 0.5kg per tonne for transport emissions combined with the production emission of 0.4kg per tonnes to reach a total emission of 0.9kg per tonne handled. This is applied to the European plastics production of 57 million tonnes in 2013[627] to arrive at a total pellet loss of 51,300 tonnes for the EU. The fate of these pellets is also unknown at present. Mepex estimates that 90% of pellets end up in the marine environment; however, there appears to be no defined pathway for spills outside of ports or during oceanic shipping. Production spills may be washed into surface water drains, although as effluent from manufacturing is tightly controlled in most of Europe, much of this should be captured in waste water treatment plants— up to 90%. It seems prudent to apply different assumptions to losses from production or transport; for production losses we will assumes the same 0—57% range for the capture of particles in waste water treatment as has been assumed for other primary emissions; for transport, 10—50% of microplastic emissions are assumed to be captured in some way before they reach the oceans. This reflects the assumed increase in the likelihood that pellet spills that occur during transport—especially oceanic—will not be captured in a waste water treatment system.

The result of this are between 9,800 and 22,800 tonnes for production losses and 14,250 to 25,650 for transport losses. This totals to between ***24,000 and 48,450 tonnes*** of microplastics from pellet spills emitted into the ocean every year from activity in the EU—although the evidence base for this certainly requires more research and

---

[625] Sartorius, I. (2012): Kunststoffe und Ressourceneffizienz. Präsentation auf dem Ressourceneffizienzkongress Baden-Württemberg, Karlsruhe, 28. September 2012. available in German at: http://www.ressourceneffizienzkongress.de/files/f_15_sartorius.pdf

[626] ibid

[627] Plastics Europe (2014) Plastics – the Facts 2014/2015: An analysis of European plastics production, demand and waste data, 2014

cooperation from the plastics industry in order that a better understanding should be reached.

A.3.5 Washing Garments

Washing of synthetic garments has recently been highlighted as a significant source of marine microplastics by an increasing number of studies finding fibres in waste water treatment effluent and marine sediments. Browne *et al*[628]*,* in one of the first studies to observe this in marine sediments, also sampled waste water from washing machine effluent to discover the extent to which synthetic clothing made from polyester sheds its fibres during a normal wash cycle. The study found that between 100 and 300 fibres were shed per litre of effluent.

The market share of synthetic fibres in the developed world for 2010 is put at around 48%[629], but this is a growing share, increasing by around 1% per year, and therefore this will be rounded up to 50%. It is difficult to say whether the total volume of washes will be split evenly between synthetic and natural fibres in this same fraction. As there is currently no data to suggest whether one type of fibre is likely to be washed more than another this assumption will be used.

Overall estimates for wash cycles for each European household are put at 165 cycles per year with an effluent of 60 litres per cycle[630]. With 213 million households[631] in the EU there could be between 100 and 300 trillion synthetic fibres being ejected in the effluent of washing machines every year. This equates to between ***15,800 and 47,600 tonnes per year***. As the fibres will be ejected straight into the municipal sewerage system, it is possible that 90% of these fibres are captured in waste water treatment plants. Therefore, between ***1,580 and 4,760 tonnes*** of fibres could find their way into the marine environment every year.

Further to this, the Mepex study included an estimate of the emissions from commercial laundry. Although most dry cleaning is a closed loop process with no effluent sent to the sewers, there may also be a considerable amount of fibres emanating from public laundries. Little data is available on this; however, Mepex used an estimate from Finland which suggests that 10% of garments are washed commercially. With consideration given to this the overall estimate including both domestic and commercial laundry is

---

[628] Browne, M.A., Crump, P., Niven, S.J., Teuten, E., Tonkin, A., Galloway, T., and Thompson, R. (2011) Accumulation of microplastic on shorelines worldwide: sources and sinks, Environmental Science & Technology, Vol.45, No.21, pp.9175–9179

[629] Food And Agriculture Organization Of The United Nations, and International Cotton Advisory Committee (2013) World Apparel Fiber Consumption Survey, July 2013

[630] Christiane Pakula, and Rainer Stamminger (2010) Electricity and water consumption for laundry washing by washing machine worldwide, Energy Efficiency, Vol.3, No.4, pp.365–382

[631] Eurostat 2013, EU-28

7,500 tonnes if 57% of the fibres are captured in waste water treatment. If, however, the worst case example of no capture in waste water is achieved, the upper limit could be as high as ***52,400 tonnes per year.***

The Nova study also attempts to frame the issue using Browne's research as a basis. By assuming that every person in the EU owns a fleece pullover with a weight of 500g and that it can lose between 1 and 5 per cent of its weight due to micro particle loss during laundry cycles, Nova estimates that 500 to 2,500 tonnes would be discharged into the sewerage systems every year. This obviously does not provide a full estimate of the issue but shows that the order of magnitude will be in the thousands of tonnes as our estimates also show.

A.3.6 Household Waste and Recycling

The Mepex study has estimates for several primary sources of microplastics as a result of waste and recycling practices in Norway. Plastic bags that are often used to collect food waste can become part of the compost that is put on land. Mepex estimates this contributes 34 tonnes of microplastic per year to the marine environment. There is little EU based data to allow a sensible estimate to be developed and upscaling based on Norwegian figures may prove to overestimate the issue as separate collection of food waste varies considerably between countries. It is therefore not appropriate to estimate the contribution until further work has been undertaken in this area especially with regard to the pathways to the ocean for material that is applied to land.

Similarly, paper recycling has also been highlighted as a possible point source from the Norwegian effluent of recycling plants due to plastic coatings becoming more prevalent. The estimate is low at 54 tonnes, although the pathway is more direct due to the microplastics being ejected straight into water effluent. And again, it is difficult to upscale to a European level due to the differences in recycling rates and treatment types. Sampling of the effluent from paper recycling along with sampling of the input paper types would help to provide a better understanding of the extent to which this may be an issue.

Another source of microplastic is the shredding of cars necessary to comply with the end of life vehicles (ELV) directive. Around 25% of a car is shredded and therefore becomes automotive shredder residue (ASR) which contains varying proportions of plastics, textiles, glass, oils, flame retardants and heavy metals[632], much of which is either incinerated or landfilled. It is possible to assume that primary microplastics are generated during the shredding process, but to what extent these will be released into the environment and then to the oceans is unknown. With an order of 10 million

[632] Ron Zevenhoven, and Loay Saeed (2003) Automotive shredder residue (ASR) and compact disc (CD) waste: options for recovery of materials and energy, Report for Ekokem Oy Ab, April 2003

tonnes[633] of ASR generated worldwide this is potentially an issue that may need to be addressed.

A.3.7 Industrial Products

Besides PCCP microplastics and feedstock pellets, another primary source of microplastics that are designed and manufactured in the form in which they may enter the environment is air blasting media for use as a mechanical way of stripping paint from metallic surfaces. Known as plastic media blasting (PMB) it was pioneered in the early 1990s by the United States Airforce as an alternative to removing paint by chemical means[634]. Although PMB microplastics are reused many times before they degrade enough to be disposed of, the way in which they are disposed of needs careful management in order to make sure that they are not washed into drains and eventually the sea. As discussed below, this may well depend on the scale of the operation.

PMB microplastics are likely to be contaminated with small amount of paint along with heavy metals such as chromium and cadmium which may be hazardous. Certainly, large scale blasting operations will have an efficient system for recovering the blast media for each reuse and therefore when it becomes too small to use it will often be sent back to the supplier for recycling. It is therefore unlikely that significant proportions of the blast media would find its way into the sea.

It is unknown how much small scale open air PMB is happening that is not part of a closed loop system. The Nova study found that in Germany most of the blast media is composed of polyamide, which has a density greater than that of sea water, and therefore it would be unlikely to find the media in surface waters. The study could not conclusively establish the total volumes of microplastics used in PMB, however.

One potentially more concerning source of plastic blast media is its use to remove paint from ships, both at a commercial and recreational level. The extent to which this practice is performed is unknown. The level of recycling of the blast media is also unknown but there would appear to be a significant potential for release of microplastics into the oceans. Indications suggest that plastic media is mostly used for removing paint from composite hulls as they are less aggressive than sand or steel blast media. One US media supplier suggests that plastic should only be used inside, and that walnut shells could be used if the blasting is to be conducted outside[635]. A number of marine services operators

[633] ibid

[634] Miles, R., Clark, L., Ellicks, D., Hoch, R., Garrett, L., and Chambers, B. (2002) Plastic Media Blasting: The paint remover of choice for the Air Force, Metal Finishing, Vol.100, No.7, pp.14–17

[635] http://compomat.com/boat-paint-removal-soft-abrasives-blasting/

are now offering ultra-high pressure (UHP) water blasting as a modern and more environmentally friendly alternative to using blast media[636].

Several sources also highlight the use of microplastic beads for use as a drilling lubricant, primarily in oil and gas exploration[637, 638]. The extent to which microplastics are used in this application is unclear although it is suggested that as the beads are expensive to produce recovery is necessary[639]. The mechanisms for this recovery are also unclear.

Industrial products, including those highlighted here, were estimated by the Mepex study to account for 50 tonnes of microplastic from Norwegian sources. This estimate was not based on any data, but merely as a placeholder to draw attention to the sources to allow further investigation into the extent to which they might be an issue. These sources are therefore excluded from this report.

Detergents for cleaning and maintenance in trade and industry have also been highlighted as a potential source of microplastic pollution in the Nova study. The study suggests that some water-based floor cleaners contain particles of polyethylene waxes, but the industry does not consider these to be classed as microplastics at present. However, Leslie et al[640] confirm that polyethylene waxes fall under the definition of marine microplastic litter cited in section 6.1 as they are non-degradable, water insoluble and are solid materials with a melting point well above sea temperatures. The extent to which these waxes are used is unclear although the Nova study found that members of the German industry association Hygiene und Oberflächenschutz (surface Protection) (IHO) manufacture products which contain polyethylene wax even though the association states its members do not use microplastics. This is a prime example of how important it is to accurately and scientifically set out a definition that can help to prevent misleading claims.

---

[636] http://www.davidsons-ships-painters.co.uk/marine-services , http://www.heritage-marine.com/water-blasting.asp

[637] Nur Suriani Mamat, and et al. (2013) The performance of polymer beads in water-based mud and its application in high-temperature well, Journal of Petroleum Exploration and Production Technology, Vol.3, No.3

[638] Skalle, P., and et al Microbeads as Lubricant in Drilling Muds Using a Modified Lubricity Tester, paper given at Society of Petroleum Engineers Annual Technical Conference and Exhibition, Houston

[639] Ibid

[640] Leslie, H., and et al. (2014) Review of Microplastics in Cosmetics, Report for Dutch Ministry of Infrastructure and the Environment, July 2014

A.4.0 Work Package 2 Appendix: Supporting Data

Table 49 - Plastics Data

	European Plastics Production[1]	Density (kg/m^3)[2]	Buoyant in Sea Water[3]
PET	7%	1,370	No
HDPE	12%	980	Yes
PVC	10%	1,380	No
LDPE	18%	930	Yes
PP	19%	905	Yes
PS	7%	1,060	No
PU	7%	1,200	No
Other	20%		

Notes:

1. Source: Plastics Europe: The Facts 2014/15
2. British Plastics Federation
3. Sea water density is around 1,025 kg/m^3

Table 50 – UK Cosmetic Product Groups and their Market Shares

Product Type	Market Share (RSP)
Fragrances	**16%**
Fine Female Fragrance	9%
Fine Male Fragrance	5%
Mass Female Fragrance	1%
Mass Male Fragrance	1%
Colour Cosmetics (Decorative)	**16%**
Face	6%
Lips	2%
Eyes	4%
Nails	3%
Skincare	**22%**
Prestige Skincare	6%
Face Care Non-medicated	9%
Face Care Medicated	1%
Face Care Male	1%
Hand Care	1%
Body Creams & Lotions	2%
Baby Care Products	0%
Lipsalves	1%
Sun Preparations	3%
Haircare	**21%**
Shampoo	5%
Hair Colorants Inc Lightening	4%
Conditioners	3%
Hair Sprays & Setting Sprays	2%
Hair Creams/Waxes and Gels	1%
Settings Lotions and Mousses	0%
Home Perms	0%
Salons (Industry estimate)	5%
Toiletries	**25%**
Toothpaste	5%
Depilatories	1%
Foot Preparations	0%
Deodorants	7%
Shaving Soaps	1%
Mouthwashes	2%
Talcum Powder	0%
Bath Additives	1%
Shower and Body Wash	4%
Liquid Soap	2%
Toilet Soap	1%
Total	**100%**

Source: CPTA

Table 51 – Estimates of Microplastic Consumption in Liquid Soaps

Country	2012 Pop (m)[1]	Total liquid soaps (000 litres)[2]	Microplastic Use(Tonnes)	Per Capita Microplastic Use (mg/day)
Austria	8.4	11,951	68	22.2
Belgium	11.1	10,698	61	15.1
Bulgaria	7.3	1,534	9	3.3
Croatia	4.3	1,512	9	5.5
Cyprus	0.9	1,112	6	20.2
Czech Rep	10.5	7,716	44	11.5
Denmark	5.6	4,842	28	13.6
Estonia	1.3	544	3	6.4
Finland	5.4	6,056	35	17.5
France	65.3	94,925	541	22.7
Germany	80.3	111,888	638	21.8
Greece	11.1	14,195	81	20.0
Hungary	9.9	15,656	89	24.6
Ireland	4.6	4,446	25	15.2
Italy	59.4	56,025	320	14.7
Latvia	2.0	541	3	4.1
Lithuania	3.0	761	4	4.0
Luxembourg	0.5	516	3	15.4
Malta	0.4	240	1	9.0
Netherlands	16.7	20,440	117	19.1
Poland	38.1	23,809	136	9.8
Portugal	10.5	14,572	83	21.6
Romania	20.1	9,364	53	7.3
Slovakia	5.4	4,218	24	12.2
Slovenia	2.1	1,316	8	10.0
Spain	46.8	124,912	712	41.7
Sweden	9.5	11,030	63	18.2
UK	63.5	113,153	645	27.8
Norway	*5.05*	*7,199*	*41*	*22.3*
Switzerland	*8.04*	*12,778*	*73*	*24.8*
Total	**517**	**687,948**	**3,924**	**20.8**[3]

Notes:

1. Population data from Eurostat.
2. Sales data from Euromonitor for 2012 via Gouin et al[641]
3. Europe Average

[641] Gouin et al (2015) Use of Micro-Plastic Beads in Cosmetic Products in Europe and Their Estimated Emissions to the North Sea Environment, SOFW Journal, No.03-2015

Table 52 – Annual Primary Microplastics Emissions (tonnes)

Source	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Tyre Dust	16,224	16,653	17,081	17,510	17,938	18,367	18,795	19,224	19,652	20,080	21,698	23,316	24,934	26,552	28,170	29,788	**31,406**	33,024	34,642	36,260	37,878	39,496	41,114	42,418	43,723	45,027	46,331	47,636	43,972	40,307	41,773	42,506	41,773
Marine Paint	948	973	998	1,023	1,048	1,073	1,098	1,123	1,148	1,173	1,268	1,362	1,457	1,551	1,646	1,740	**1,835**	1,929	2,024	2,118	2,213	2,307	2,402	2,478	2,554	2,631	2,707	2,783	2,569	2,355	2,441	2,483	2,441
Pellet Spills	28,160	28,904	29,647	30,391	31,135	31,878	32,622	33,366	34,109	34,853	36,805	39,506	42,195	44,873	47,536	50,181	**52,807**	55,408	57,979	60,514	63,004	65,435	67,791	69,533	71,145	72,569	73,715	74,412	66,780	58,300	54,378	36,888	36,252
Textiles	11,634	11,941	12,248	12,555	12,862	13,170	13,477	13,784	14,091	14,398	15,559	16,719	17,879	19,039	20,199	21,359	**22,519**	23,679	24,840	26,000	27,160	28,320	29,480	30,415	31,351	32,286	33,222	34,157	31,529	28,902	29,953	30,479	29,953
Building Paints	7,943	8,152	8,362	8,572	8,782	8,991	9,201	9,411	9,621	9,830	10,622	11,414	12,207	12,999	13,791	14,583	**15,375**	16,167	16,959	17,751	18,543	19,335	20,127	20,766	21,404	22,043	22,682	23,320	21,526	19,732	20,450	20,809	20,450
Road Paint	5,018	5,150	5,283	5,415	5,548	5,680	5,813	5,945	6,078	6,211	6,711	7,211	7,712	8,212	8,713	9,213	**9,713**	10,214	10,714	11,214	11,715	12,215	12,716	13,119	13,523	13,926	14,330	14,733	13,600	12,466	12,920	13,146	12,920
PCCP											241	482	723	964	1,205	1,446	**1,687**	1,928	2,169	2,410	2,652	2,893	3,134	3,375	3,616	3,857	4,098	4,339	4,580	4,821	5,062	5,303	5,544
Total	**71,907**	**73,754**	**75,602**	**77,449**	**79,297**	**81,144**	**82,992**	**84,840**	**86,687**	**88,535**	**94,894**	**102,002**	**109,099**	**116,183**	**123,253**	**130,306**	**137,338**	**144,346**	**151,325**	**158,267**	**165,163**	**172,002**	**178,765**	**184,107**	**189,319**	**194,344**	**199,089**	**203,387**	**186,564**	**168,893**	**168,986**	**153,625**	**151,344**

A.4.1 'Unknown' Ingredient List

The following is a list of 'unknown ingredients' that has been provided for this report by Fauna and Flora International. These are thought to be used in PCCPs available on the UK market and could be solid microplastics but their INCI names do not reveal whether they are used in solid or liquid form:

Acetates Copolymer

Acrylamide/Sodium Acryloyldimethyltaurate Copolymer

Acrylated/C10-30 Alkyl Acrylate Crosspolymer

Acrylates Copolymer

Acrylates/Aminoacrylates/C10 30 Alkyl PEG-20 Itaconate Copolymer

Acrylates/ammonium methacrylate copolymer

Acrylates/Dimethicone Copolymer

Acrylates/Palmeth-25 Acrylate Copolymer

Acrylate / PEG-10 Maleate / Styrene Copolymer

Acrylates Crosspolymer-4

Acrylates/Steareth-20 Methacrylate Copolymer

Acrylates/Stearyl Acrylate/Dimethicone Methacrylate Copolymer

Dimethicone/Vinyl Dimethicone Crosspolymer

Alkyl methacrylates crosspolymer

Ammonium Acryloyldimethyltaurate / Carboxyethyl Acrylate Crosspolymer

Ammonium Acryloyldimethyltaurate/VP Copolymer

Bis-isobutyl peg/ppg-20/35/amodimethicone copolymer

Butylene/ethylene/styrene copolymer

Cera Microcristallina

C30-45 Alkyl Cetearyl Dimethicone Crosspolymer

Dimethicone Crosspolymer

Dimethicone/Divinyldimethicone/Silsexquioxane Crosspolymer

Dimethicone/Methicone Copolymer

Dimethicone/Peg-10/15 Crosspolymer

Dimethicone/Phenyl Vinyl Dimethicone Crosspolymer

Dimethicone/vinyl dimethicone crosspolymer

Dimethylacrylamide/Sodium Acryloyldimethyltaurate Crosspolymer

Diphenyl Dimethicone/Vinyl Diphenyl Dimethicone/Silsesquioxane Crosspolymer

Ethylene/propylene/styrene copolymer

Ethyltrimonium chloride methacrylate/hydrolyzed wheat protein copolymer

Gelatin Crosspolymer

Gylcereth-7 hydroxystearate/IPDI copolymer

Glyceryl Acrylate/Acrylic Acid Copolymer

Hdi/Trimethylol Hexyllactone Crosspolymer

Hydrogenated Styrene/Isoprene Copolymer

Hydroxyethyl Acrylate/Sodium Acryloyldimethyltaurate Copolymer

Hydroxyethyl Acrylate/Sodium Acryloyldimethyl Taurate Copolymer

Lauryl Methacrylate/Glycol Dimethacrylate Cross
polymer

Methyl Methacrylate Crosspolymer

Palmitoyl Hydroxypropyl Trimonium Amylopectin/ Glycerin Crosspolymer

PEG-7M

PEG-8/SMDI Copolymer

PEG/PPG-116/66 Copolymer

Peg-12 Dimethicone Crosspolymer

Polyacrylamide

Polyamide-2

Polyacrylate-1 Crosspolymer

Polyacrylate Crosspolymer-6

Polyglyceryl-2 Isostearate/Dimer Dilinoleate Copolymer

Poly(Glycol Adipate)/Bis-Hydroxyethoxypropyl Dimethicone Copolymer

Polypropylene Terephthalate

Polysilicone-1 Crosspolymer

Polyurethane-40

Polyvinylalcohol Crosspolymer

PPG-17/IPDI/DMPA Copolymer

PPG-51/SMDI Copolymer

PVM/MA copolymer

Styrene/Acrylamide Copolymer

Sodium Acrylate/Acryloyldimethyl Taurate Copolymer

Sodium acrylates copolymer

Sodium polyacrylate

Styrene/Acrylates Copolymer

Styrene/Acrylates Copolymer C11-15 Pareth-7

Taurate/Vp Copolymer

Vinyl Dimethicone/Methicone Silsesquioxane Crosspolymer

VP/DMAPA acrylates copolymer

VP/Eicosene Copolymer

VP/Hexadecene Copolymer

VP/Methacrylamide/Vinyl imidazole copolymer

VP/VA copoylmer

A.5.0 Work Package 2 Appendix: Stakeholder Feedback

A.5.1 List of Stakeholders Consulted

Organisation	Organisation Type	Contact
Plastics Europe	Trade Association	Ralph Schneider
Cosmetics Europe	Trade Association	Gerald Renner
Dutch Cosmetics Assoc	Trade Association	Lonneke Jongmans
Plastic Soup Foundation	NGO	Jeroen Dagavos
Seas at Risk	NGO	Emma Priestland
Fauna and Flora International	NGO	Tanya Cox
L'Oréal	Manufacturer	Laurent Gilbert
Unilever	Manufacturer	Todd Gouin
Procter and Gamble	Manufacturer	Simon Webb
Procter and Gamble	Manufacturer	Gillian Marsh
Procter and Gamble	Manufacturer	Harald Schlatter
Estée Lauder	Manufacturer	Michael Krugman
Avon	Manufacturer	Amanda Long
Johnson and Johnson	Manufacturer	Mathias Rietzel
Beiersdorf	Manufacturer	Michael Meyberg
Shiseido	Manufacturer	Yuri Endo-Malamant
Coty	Manufacturer	Hans Joachim Kaetker
Oriflame	Manufacturer	Tanya Day
Colgate Pamolive	Manufacturer	TF M Marie Johansson
Reckitt Benckiser	Manufacturer	Dave Challis
Netherlands	Government	Louisa Crijns
National Institute for Public Health and the Environment (Netherlands)	Government	Anja Verschoor
JRC	European Commission	Renata Kaps
DG Sanco	European Commission	Giulia Carlo
DG GROW	European Commission	Giuseppina Luvara
Institute for Environmental Studies IVM	Research org	Heather Leslie
Baltic Eye, Stockholm University	Research org	Katja Broeg

Organisation	Organisation Type	Contact
Nova Institute	Research org	Roland Essel
Aquafin	Waste Water Treatment	Greet De Gueldre

A.5.2 Stakeholder Comments

A.5.2.1 Cosmetics Europe

The following are the comments from Cosmetics Europe submitted to the project team after reviewing the draft final report. Where appropriate, a response from the author is also included with details of any resulting amendments.

Comment	Response
Regarding the choice of the definition the author adopts the definition proposed by Leslie et al. as this is less limiting than other approaches proposed by Cosmetics Europe and for example RIVM. However, the argument for adopting the definition because it is less limiting is not necessarily logical since a broader definition introduces scientific challenges that have yet to be addressed, whereas the narrower definition can enable an assessment that is scientific more robust.	In this paper we attempt to provide an indication of the scale of the issue. The scientific challenges for removal of microplastics from products does not have any relevance to the impact on the marine environment.
An extensive review on establishing a definition of microplastic has recently been published by RIVM. The report clarifies that a definition of Microplastics should be based on much more detail as outlined in this draft report for DG Environment. For example the answer to when a substance is solid, semi-solid or liquid requires further in depth investigations (i.e. exclusion of liquid and gaseous properties). Size (distribution), solubility, biodegradability and chemical composition are further factors to be evaluated in more detail as outlined here.	It is agreed that all of these issues should be investigated further and it is encouraging to find that the industry will look to do this.
The use of the broader definition then leads to difficulties later in the report, particularly as the ability to distinguish between polymers in the form of plastics and polymeric 'chemicals' becomes harder to establish.	It is agreed that it is hard to establish the differences which is why the co-operation of the cosmetics industry is needed to help remove this barrier to action.
Important to note that the scientific literature investigating the use of microplastic in cosmetic products since 1995 has focused on exfoliate function, consistent with the CE definition, and inconsistent with the Leslie definition.	This is true, but this is no justification to continue with the narrow scope when new evidence suggests this is not appropriate.

Comment	Response
It is important to define what is the concern that is driving the definition choice. Is it mere presence of polymers in cosmetics or is it related to persistent materials accumulating in the aquatic environment.	The concern is, of course, the latter, but the first step is to quantify the former.
Furthermore and as the later studies in the document prove, there is no proof that the synthetic waxes/semi-solid materials utilized in other cosmetic products are released to the environment. Further on, the (potentially negative) environmental effects currently discussed for microplastics are mainly related to the solid particles. As such, they should not be included in the management of this.	The report highlights the use of plastic/polymers in cosmetics products. There is equally no proof that these are not released into the environment.
The debate started because there was public concern that plastic microbeads in cosmetics might end up in marine environment. Public concern was focused on plastic scrubbeads. The industry developed a definition to address public concerns based on the available knowledge at the time. The report suggests that some sort of a loop hole was created while the industry operated in a transparent way. (see also page 106"Agree on a definition that does not contain loopholes")	The report does not suggest that a 'loop hole' was created in a deliberate fashion, but merely that one may exist according to some NGOs. It is important that attention is drawn to this discussion so that any future bans may be all-encompassing.
At one point the author states that "There is also evidence that Modified Terephthalate Polymers such as Polyethylene terephthalate (PET) are used in concentrations close to 100% in the form of powders and flakes in 'leave-on' products such as lipsticks and eye shadows as bulking and viscosity increasing agents". However, we believe that it would be beneficial to understand how the physical properties of the material change as a result of the manufacturing process. i.e. they may be supplied in a powder form but will be heated to molten temperatures during manufacture. What is then the physical form of the polymer after cooling and in the finished product? Is the finished good ever released to the environment after it's use, if it is, what is the form of the material that is emitted to the environment? If the issue is really about reducing the emission of plastic materials to the marine environment to reduce marine plastic debris, then it seems important to consider the life cycle of the polymer as part of this evaluation.	Agreed. These are important questions that need to be answered and this can only happen with full industry support.
Page 11 – last paragraph. Author is citing lack of transparency on cosmetic ingredients but is not implying what this relates to. Is this focusing on the ingredient labels, the Cosmetics Europe survey, or the interviews conducted for the purpose of this report? In his conclusions he argues against using INCI nomenclature to label cosmetic products. In this sense Cosmetics Europe would like to clarify the following: • The Cosmetics Regulation sets out labelling	See next comment box for response to first point. The clarification of the purpose of the INCI labelling is important and it is clear that it was not designed with the intention of addressing the issue of microplastics. In this use it is not fit for purpose. The (unchanged) conclusion

Comment	Response
requirements in order to provide consumers with access to the information they need. In Europe, cosmetic container labels must list all ingredients in the product formulation using identical terms across the whole European Union. These terms are based on the International Nomenclature for Cosmetics Ingredients (INCI) along with descriptions of certain substances specified in the Regulation. • The widespread use and international recognition of INCI names can be attributed to the use of uniform, science-based ingredient names that minimize the language barriers that often hinder consumer understanding and international trade. This has received widespread support from raw material and finished product manufacturers, the scientific and medical community, and regulatory bodies. • A key element of this acceptance is the establishment of a single ingredient labelling name for each material that promotes a common understanding throughout the world. In this sense, there are many benefits to a uniform system of labelling names for cosmetic ingredients, including the transparency provided to consumers as ingredients are identified by a single labelling name regardless of the national origin of the product. In addition, dermatologists and others in the medical community are ensured an orderly dissemination of scientific information, which helps to identify agents responsible for adverse reactions.	states *"Part of this should be the investigation into whether product ingredient labelling is sufficient to aid consumers in understanding what is contained in the PCCP products that they buy; the International Nomenclature of Cosmetic Ingredients (INCI) may not currently be suitable for this".* The comments made by Cosmetics Europe say that the INCI "has received widespread support from raw material and finished product manufacturers, the scientific and medical community, and regulatory bodies", however this is not in the context of microplastics and appears to discount the views of the consumer. The current labelling may not be enough to allow the consumer to make appropriate decisions about the cosmetics products they buy.

Comment	Response
Page 11 – “The scale of the use of these ‘nano-plastics’ in the cosmetics industry is not well understood at present—due, in part, to the lack of transparency in included ingredients, and potentially, the industry’s low size limit cut-off that fails to recognise these as potential plastic emissions.” Insoluble or biopersistant and intentionally manufactured materials with one or more external dimensions, or an internal structure, on the scale from 1 to 100 nm are being notified and have a labelling obligation. Therefore it is incorrect to suggest there is a lack of transparency.	The lack of transparency refers to the extent to which nano-plastics are used in the EU rather than the labelling and that the labels inform of the presence but not the quantity of nano-plastics. It is also important to understand whether consumers are aware—through the current labelling—of the existence of plastic nano-particles in the products they use. The sentence has been changed from; “The scale of the use of these ‘nano-plastics’ in the cosmetics industry is not well understood at present—due, in part, to the lack of transparency in included ingredients, and potentially, the industry’s low size limit cut-off that fails to recognise these as potential plastic emissions.” To; “The scale of the use of these ‘nano-plastics’ in the cosmetics industry is not well understood at present—due, in part, to the lack of data from the cosmetics industry caused by the low size limit cut-off that fails to recognise these as potential plastic emissions.”
Page 14 – Author cites that leave-on cosmetic products are a major potential microplastic source without providing any evidence that the material is released into the environment. Additionally and as mentioned before, by choosing a broader definition, the author reaches conclusions that are highly speculative and fails to consider alternative reasons (e.g. understand if the materials mentioned are actually in the form of plastic particles or not). Given the implied uncertainty it would be prudent to express a greater degree of caution, and to attempt to help articulate key research needs and data gaps.	On page 14 (closing paragraphs of Section 6.2) there is no reference to leave on cosmetics being a ‘major potential microplastic source’. The wording is as follows; *“No studies have yet been conducted into cosmetics that incorporate micro or nano plastics for other functions in leave-on products such as sun creams and face powders. “* We have added the following to clarify; *“This suggests there is a significant gap in understanding at present, with the definite need for research to be conducted in this area.”*

Comment	Response
Page 16 – "The process of sampling in the oceans by analytical equipment meant that particles smaller than 0.33 mm could not be captured and there may be a significant number of that size or smaller. This would certainly be the case for PCCP microplastics which, as already identified, are known to enter the oceans at a size not much larger than this." To our best knowledge there currently exists no data that would be supportive of the statement. Our understanding is that the statement wishes to suggest that they are 'assumed' to enter the oceans; we cannot say that we 'know' that they do. This is demonstrated quite clearly in the report itself, and it would therefore be prudent to reword accordingly.	This has been changed from 'known' to 'assumed'.
Pages 20-21 – In reviewing the Great Lakes study, the author correctly acknowledges that it is unclear how much of the material found in the Great Lakes derives from personal care products but fails to acknowledge other materials which would have similar profiles under an EDS.	The Great Lakes study does not specifically mention other materials that would have a similar profile, assuming there are any.
Page 30 - "As it appears all but impossible to estimate the level of plastics pollution in the marine environment with the data and models currently drawn from direct sampling." This is an extremely important observation, with significant implications towards estimates of relative contribution. Modeled data seems to have more credence in the author's view than actual data sampled. In reviewing the Norway and German studies against the actual Danube River sampling, the author concludes that the actual sampled numbers are not representative because they do not correlate with the modeled numbers from the government reports. However when coming up with his own estimates on pages 36-39, the author extrapolates out much greater figures than either of the government reports actually shows. His numbers appear to consistently extrapolate the worst case scenarios without comparing this to actual situations. In the Danube and Rhine studies on page 50, the author states "the equipment should have collected more plastics as the aperture of the microplastic sampler was smaller than the Lechler model" and then concludes that the data sampled is inaccurate because it does not compare with modeled data rather than examining the model to see if is misjudging the environmental fate of these materials.	We are not sure which Danube study is being referred to. The first one has significant issues and the second was not available to comment on (only the results were given). It is unclear what is meant by *"However when coming up with his own estimates on pages 36-39, the author extrapolates out much greater figures than either of the government reports actually shows. "*. If this is specifically referencing the cosmetics microplastics figure then it should be clear from the report that a different and more rigorous methodology (that is explained in its entirety in Section 6.5) was used to discern these figures. The Danube and Rhine studies were not arbitrarily disregarded and were used to directly estimate the flow of plastics from the rivers in Table 27. It is also noted that some overlap may be expected from both the modelled and sampled studies and that neither approach is currently capable of providing a suitably accurate figure at present.

Comment	Response
The New York State Attorney General report did not positively identify cosmetic microbeads and they used the same methodology that the author discounted on pages 20-21 as part of their analysis.	It is unclear what this is referring to as the study referenced in page 20-21 relates to sampling in the Great Lakes and has no bearing on waste water treatment capture. No methodology was 'discounted'.
This chapter concludes that "any microplastics that are thought to enter the sewerage system will be given a capture rate range of 0-90%". This value is misleading and may give the impression that the capture rate is highly uncertain and a capture rate of 0% might be used elsewhere as a worst-case assumption. The author justifies this range by several assumptions that are very conservative and unrealistic: • He assumes that 44% of sludge is still disposed on agricultural land and 9% is used for landfilling. He further concludes that the total amount of microplastics in these 9% would enter waterways through surface run-off.	The capture rate is highly uncertain as the studies were all conducted at single plants at singular points in time and are not representative of the whole of the EU. There will be many instances where microplastics (not just from cosmetics will not be captured at all) The sludge disposal is based on data from Eurostat and is thus not an assumption. It also did not form the basis of the original 0-90% capture rate, however it has now been used to reduce this to 0-57% as it was concluded that using a 90% rate across Europe would heavily underestimate the issue. It is unclear how Cosmetics Europe have arrived at their conclusions on the basis of the following from the report; "This means that at least 53% of the sludge—as the 'other' category includes composting applications—will be introduced to the land and therefore *could* enter waterways through surface run-off. The extent to which this may happen has not been the subject of research at this time, but to assume that all microplastics captured by WWT via sludge will not find their way into the ocean is to potentially underestimate their contribution to marine pollution. It does appear that there is significant potential for plastic build up in agricultural lands, and this may require further exploration."

Comment	Response
This is an overestimation of the amount that may actually reach the receiving or groundwater. Water content of sludge is quite high and thickening usually is done as a first step in a sedimentation tank or in a sedimentation pond. The water removed from thickening is further treated and a lining of the landfill with e.g. clay or plastic liner is usually required to prevent contamination of groundwater. The assumption made by the author implies that none of these methods would be able to remove any microplastic. This seems to be rather unrealistic and as such it should be reflected in the conclusion.	See above about misinterpretation of results.
The author suggests a ratio of 50:50 for combined and separate sewer systems, and further states that hereby 50% of wastewater will be washed directly into water bodies. He does not cite a relevant literature reference to prove this assumption. He mentions just one old study form 1989 with data for only two member states (Sweden and NL). Prior to the application of this assumption a closer examination or relevant literature would be needed.	This, again, is not an assumption that is used for any conclusion, but merely part of the discussion on the uncertainties of the capture of microplastics by the sewerage system.
Page 69: When referencing the use of polymers in leave-on products the author does not discuss the environmental fate of these materials.	Please see Section 6.5.7 for a discussion on this subject with updated assumptions included.
Pages 78 and 79: Author brings in the discussion of the melting point used to classify a substance, yet does not show any evidence other than hypothetical that this is correct. Author once again attacks our legally required ingredient labelling.	Unfortunately, without specific field studies being conducted it remains that theoretical analysis must be used. Cosmetics Europe has not provided any evidence that this is incorrect. Once again, we also state the need for unambiguous substance identification that the INCI fails to achieve in this instance.
The author does not accurately portray a difference in the quantity of polymers used in leave-on products to solid plastic particles discharged from the ocean. The author states that PCCP microplastics emissions are greater now without showing any evidence that there are any PCCP emissions in his report.	Please see Section 6.5.7 for a discussion on this subject with updated assumptions included.

Comment	Response
An important missing chapter: the current knowledge about the ecotoxicity of plastic in the environment (e.g. beads vs. any other source of microplastics like degradation products from greater parts, dust from tyres, fibers). This report does not mention that there is hardly any scientific evidence and that the discussion is mainly driven by concerns. To present a complete picture, the report should include a chapter on this topic – or at least mention that there is no clear situation in regards of proven hazard effects.	As Cosmetics Europe are aware the scope of this report—as defined by the Commission in the terms of reference—does not include any analysis of ecotoxicity of plastic in the environment.
·There are no arguments to broaden the scope, other than, 'to be complete'. Why are the other categories all of the sudden a risk for the marine environment as well? Additionally, the author fail to differentiate between rinse off and leave on products. The mode of application/usage does not necessarily lead to disposal down the drain. It is unrealistic to assume that 100% of this 'plastic' can end up as marine litter.	The scope has not been broadened (unless this is specifically referring to the scope as defined by Cosmetics Europe), but attempt has been made to draw attention to further forms of microplastic litter that may come from cosmetics.
It is inappropriate to highlight the worst case scenario without mentioning the worst case scenarios for other possible sources (when you add up all worst case percentages, the percentage will be way higher than 100%, which will show that the numbers are estimations). Presenting results like this is misleading. It should only be presented relatively to other sources.	It is unclear which specific figures this is referring to. For all sources we present a range between best and worst case scenarios. The large gap between these two scenarios is the result of the lack of data. We look forward to the cosmetics industry working towards narrowing that gap in knowledge in a transparent way.

A.5.2.2 Fauna and Flora International

The following are the comments from Fauna and Flora International submitted to the project team after reviewing the draft final report. Where appropriate, a response from the author is also included with details of any resulting amendments.

Comment	Response
A majorissue with the process of mapping the coverage and credibility of existing commitments is the missing acknowledgement of inconsistent definitions (and inconsistencies between the interview results and publicly available statements): - For example, the report states that every company contacted uses the Cosmetics Europe definition ("synthetic non-biodegradable solid plastic particles >1µm and <5mm in size") to gauge whether they have fulfilled their commitment (Section 3.2, page 94) but Beiersdorf's public statement defines microplastics as "small pieces of plastic with a size of less than 5mm" and Beiersdorf's Senior Communications Manager has provided us with a third definition of microplastics (personal communication): "Regarding the current definition of microplastics, we stick to the official version of our industry association Cosmetics Europe: Micro plastic beads designate synthetic non-biodegradable solid plastic particles >50µm and <5mm in size used to exfoliate or cleanse in rinse-off cosmetic products. Plastic in that context is defined as synthetic material made from linking monomers through a chemical reaction to create an organic polymer chain that can be molded or extruded at high heat into various solid forms retaining their defined shapes during life cycle and after disposal." - Such inconsistencies misrepresent the scale of the issue and the impact that voluntary measures alone could have on this source of microplastic pollution. • In order to put PCCP microplastics in the context of marine litter, all solid microplastic ingredients and all types of personal care and cosmetic products need to be considered.	We agree that the issue of definitions is a problem and the cosmetics industry do not appear to be consistently applying the Cosmetics Europe definition.
It is stated that "PCCP microplastics are estimated to contribute 0.1% using the assumption that 90% is captured by waste water treatment plants" (page 34) but the limitations of this assumption (e.g. the gross overestimation that waste water treatment across Europe includes widespread tertiary treatment) are not highlighted and this leads to underrepresentation of the PCCP microplastic pollution issue.	The 90% capture rate assumption has been changed to 57% to reflect the different waste water treatment practices across the EU.

Comment	Response
The estimate of PCCP microplastics (page 36) is based largely on one study and there is no information regarding the number and size of the companies that participated in Cosmetics Europe's survey in 2012 or about the amount and reliability of the data provided by each of the companies that took part – this a very serious limitation that needs to be highlighted and addressed. In Table 6 (pages 38 and 39) the representativeness of the PCCP industry data needs to be discussed in the Overall Data Reliability column. Suggested data improvements need to include expansion of the scope of Cosmetics Europe's survey to include not only all types of microplastic, but also all types of PCCPs, and also improved transparency regarding the survey methods and results: was the survey mandatory, how many companies responded, how many of the 'top' players participated, how much data did each company provide and were any documents provided to support the claims of these companies?	We agree that more information on the scope of the Cosmetics Europe study would be very useful and hope that this will be more forthcoming in future Cosmetics Europe surveys. "Improved transparency of survey methods" has been added to the data improvements column.
The section on secondary microplastic estimates (Section 2.3.2.6) does not attempt to estimate volumes of secondary microplastics – it only quotes volumes of macroplastic pollution and potential secondary sources of microplastics, which makes the section confusing and the contribution of PCCPs to microplastic pollution more difficult to understand.	The only way of estimating the secondary microplastic pollution from a top down method is to estimate macroplastics. There is no way of knowing how much of this will become a microplastic and is therefore a worst-case scenario approach. It is correct that a better comparison is with the primary microplastics estimates.
• There are additional product types in which solid microplastic ingredients are known to be used and these also need to be taken into consideration when discussing the contribution of PCCPs to environmental microplastic pollution. - Relevant datasheet for Polytetrafluoroethylene (PTFE) powders used in shaving gels, creams and lotions (some of which can be considered rinse-off products without exfoliating purposes), face powders, blushes, mascara, eye shadow, make-up bases, foundations and sunscreens: Microslip - There are two Gillette shaving gels in our database that contain PTFE and one post shave balm from The Real Shaving Company that contains Nylon-12: UK product lists on the Beat the Microbead website	Section 6.2 has been updated with these other plastic source examples.

Comment	Response
• There are also additional solid microplastic ingredients that are known to be used in PCCPs and these also need to be taken into consideration when discussing the contribution of PCCPs to environmental microplastic pollution. - See Table 2.1 on page 13 in Leslie (2015): Plastic in Cosmetics - At the moment our UK PCCP database, which is a regularly updated random sub-sample of the UK PCCP market, includes a total of 221 PCCPs, across a wide range of product types,containing one or more of the following most commonly used solid microplastic ingredients: polyethylene (in 91% of all plastic containing products currently in the database), polypropylene (in 1% of all plastic containing products currently in the database), polyethylene terephthalate (in 2% of all plastic containing products currently in the database), polymethyl methacrylate (in 1% of all plastic containing products currently in the database), polytetrafluoroehylene (in 1% of all plastic containing products currently in the database) and nylon (in 6% of all plastic containing products currently in the database). - Our UK PCCP database also includes 214 PCCPs, across a wide range of product types, containing one or more of 70 'unknown ingredients', which could be solid microplastics but their INCI names do not reveal whether they are added to products in solid or liquid form. Products containing any such 'unknown ingredients' are not submitted for inclusion in the Beat the Microbead database, unless the manufacturer has provided clarification regarding the state of each unknown ingredient in the given product. Please find the latest version of our unknown ingredients list, which is also regularly updated, at the end of this document.	Section 6.2 has been updated with these other plastic source examples. The 'unknown ingredients' list has been added to the Appendix and referenced in Section 6.5.5.
Additional criteria need to be taken into account when providing guidance on the contribution of PCCPs to the microplastic pollution issue – the estimated (based on large assumptions and limited sources of information) quantity of marine litter that a microplastic pollution source is contributing should not be the sole determinant of whether there is a need for potential measures and this should be acknowledged.	This is correct and this report is not intended to be the sole determinant in policy decision.
The effectiveness of voluntary actions needs to be discussed in light of inconsistent definitions and details included in companies' commitments. Mapping the impact of a company's voluntary actions requires the following information: - The date by which all products across the company's entire range of PCCPs that currently contain any solid microplastic ingredients will be reformulated so that these ingredients are removed; - The date from which all new own-brand PCCPs being developed by the company will be free from all solid microplastic ingredients; - Confirmation whether the commitment applies to all regions worldwide where own-brand products are available. • Mapping the impact of commitments also needs to take into account the relationships among multinational corporations, parent companies and the brands that they own, and third party formulators. • It is important to clarify exactly what was discussed during the industry	A reformulation date was given by most of the manufacturers. In all cases this was said to be for all products. In most cases this was global, but it was beyond the scope of this report to analyses the issue on a global basis. The study involved looking at parent manufacturers included their subsidiary brands. The results of the interviews are presented

Comment	Response
engagement part of this study and to include details about the interviews with personal care and cosmetic companies.	throughout the report.
• The recommended ongoing monitoring of commitments needs to extend to monitoring and regulation of practices – these commitments are voluntary and as such, there is no regulatory framework to prevent companies from resorting to plastic ingredients in the future. • Including collaboration with trade associations and NGOs in the recommended ongoing monitoring by the Commission can help improve dialogue and ensure consistency.	This is addressed in the conclusions.

A.5.2.3 Dow Europe GmbH and European Federation of Cosmetics Ingredients (EEFCI)

Comment	Response
We are concerned that some definitions (either adopted or in discussion in certain jurisdictions) are overly broad, and some may inadvertently include functional polymers that are sold in personal care products, where those polymers have important functionalities as thickeners, emulsifiers and UV boosters. These vague and ever expanding definitions are leading to much uncertainty for suppliers to the personal care industry and our customers. Dow advocates the following definition of "synthetic plastic micro particle" as any intentionally added, non-water soluble, solid plastic particle used to exfoliate or cleanse in rinse-off personal care products; where "Plastic" is defined in this context as a synthetic material made from linking monomers through a chemical reaction to create an organic polymer chain that can be molded or extruded at high heat into various solid forms retaining their defined shapes during life cycle and after disposal.	The function of the polymer that is used in the product is irrelevant to the issue of marine litter. This study highlights possible sources of marine litter and the fact that more work is needed to discern whether some of the additional sources from PCCPs should be included under the definition.
Dow suggests that the authors should use caution in specifically identifying trade products. It should not be assumed that these particular products contribute to the microbead concern because they have not been found in any analysis of microbeads or microplastics. Until the definition and scope of microbeads is fully assessed, and data is available to support the assertions regarding the contribution of particular chemistries or products to the microplastics issue, we strongly recommend the authors refrain from targeting specific trade products and respectfully request that references to specific companies and trade products be removed from the report.	This report does not seek to target or single out particular products but it is required that evidence of the use of microplastics in PCCPs is shown. Various ingredients from manufacturers (including Dow) have been cited to demonstrate the uses of plastic microplastics.
Further, Dow requests that the authors do not conflate plastics producers with suppliers of functional polymers to the personal care industry (Section 3.4 among other citations). This gives the erroneous impression that these companies are focused on the use of plastics in personal care products, which in many cases is simply false.	We believe the particular statement is referring to this sentence: "Large multinational plastics processors such as Dupont and Dow chemical are known to be present in this market (as identified in Section 6.2), however, to what extent is not clear." We believe that this is a statement of fact and does not give the erroneous impression that these companies are

Comment	Response
	focused on the use of plastics in personal care products.
Pages 11 and 71 uses Dow's product SunSpheres™ is used as an example of a non-rinse-off, non-exfoliating use of plastics in cosmetics. *"Dow chemical produces a product called Sunspheres aimed at the sunscreen market. These are styrene/acrylates copolymer hollow spheres of between 300 and 350 nano meters (0.0003 mm) in diameter. The small size range means that they would fall outside of the definition by Cosmetics Europe as their minimum size is 1 µm (0.001 mm). These spheres are used for increased ultraviolet light resistance and are designed to remain on the skin after application. The recommended concentration of between 1 and 5 percent means that each sunscreen product may contain 10 to 100 trillion particles. The scale of the use of these 'nano-plastics' in the cosmetics industry is not well understood at present—due, in part, to the lack of transparency in included ingredients, and potentially, the industry's low size limit cut-off that fails to recognise these as potential plastic emissions."* It is important to note that Dow does not sell synthetic plastic microbeads for use as exfoliants or cleansers in rinse-off personal care products. Further, we recommend the authors refrain from targeting specific trade products and respectfully request that references to specific companies and trade products be removed from the report.	The cited passage does not refer to Dow as a supplier of microbeads for use as exfoliants or cleansers in rinse-off personal care products
If the authors insist on referencing specific trade products, they should recognize that SunSpheres™ are not omitted from the microbead discussion due to their small particle size; SunSpheres™ is a functional polymer (not a microplastic or nanoplastic) and will not behave in the same manner as traditional PE/PP microbeads used in exfoliant applications. There is no evidence supporting that SUNSPHERES have been found in waterways, thus they should not be assumed to contribute to the microplastic concerns. Additionally, SunSpheres™ polymers have a particle size of about 350nm. In that sense, the product should not be equated as a nano-plastic, since its particle size is too high to meet the EU definition of nanomaterials in the Cosmetic Regulation (1-100 nm). The report should also reflect a proper balance by noting the human health and environmental benefits of the SunSpheres™ technology, which allows a much reduced use of the active ingredients in sunscreens; in fact, the higher Sun Protection Factors (SPF) cannot be achieved without them. Dow SunSpheres™ is an SPF booster and enables greater SPF efficiency in sun care SPF products. Manufacturers of sunscreens and moisturizers use SPF Boosters, like Dow SunSpheres™, which scatter UV light to help improve the UV absorption of the sunscreen film on the skin in combination with organic and inorganic UV filters.	Once again, the function of the product is not relevant to the issue of marine litter. Sunscreen, being 'leave-on' products do, however, have a different pathway to the ocean than 'rinse-off' products. This is discussed in Section 6.5.7. The positive human benefits, or otherwise are out of scope of the study.
Page 16-18 provides an incomplete theory as to why the expected	The cited paragraph is taken out

Comment	Response
concentration of microplastics is not being found in the oceans. "There may be other sinks that remove the plastics from the ocean surface. Degradation, ingestion by organisms, or, as identified by Barnes et al, a decrease in buoyancy due to bio-fouling from various organisms which can lead to the microplastics sinking to the seabed." The authors do not acknowledge the likelihood that primary microplastics may not be entering the ocean in the first place, having been removed from effluent via sorption to sludge.	of context. The discussion in this part of the report is centred on secondary microplastics and why the large number of macro-plastic in the ocean does not translate to an even larger number of microplastics.
Figure 8, Page 33 implies that 100% of the sludge spread on land will run off into waterways. The authors should consider that runoff from sludge is highly improbable since the polymers are unlikely to desorb to water. The report by Sack *et al*.2 demonstrated that over 99% of cross-linked, high molecular weight polyacrylates were retained in sand column after elution, indicating that those polyacrylates would not move appreciably through common soil types in or near landfills. SunSpheres™ are styrene/acrylates copolymer, which behave similarly as polyacrylates. Therefore, the mobility of SunSpheres™ in sludge or soil is expected to be minimal.	This implication is not true as the diagram is an indication of possible pathways. In no way does it suggest that 100% of sludge will end up in the waterways. This is discussed more in Section 6.4.
Page 78 conflates high melting point with low water solubility for Carbowax Sentry™ "A polyethylene glycol named Carbowax Sentry is currently marketed by Dow Chemical for use in cosmetics, with variations from PEG-6 to PEG-180. PEG 12 and 20 are both classified by Dow as semi-solid and indeed the technical data sheet for the substance states that PEG-12 has a melting temperature of between 15 and 25oC. This would mean that it would remain solid in most surface waters for much of the year. PEG-32 has a melting temperature of over 42oC, far higher than any ocean temperatures will reach, and therefore it will certainly remain solid after it has entered the marine environment." Again, we recommend the authors refrain from targeting specific trade products and respectfully request that references to specific companies and trade products be removed from the report. The Carbowax™ Sentry™ materials produced by Dow are comprised of a series of a series of polyethylene glycols (PEGs) with average molecular weights ranging from 190 to 9000. The report states that the PEGs "would remain solid in most surface waters for much of the year". This statement is incorrect and reflects a misunderstanding of the actual physical chemical characteristics (aqueous solubility3) or the environmental fate of this class of materials. These polyethylene glycols are water soluble nonionic synthetic polyethers of ethylene oxide and are completely miscible (i.e. dissolved) in water and seawater. Solubility routinely decrease as molecular weight (MW) increases and even the highest MW Carbowax™ Sentry™ materials (average MW 8000-9000) have a reported aqueous solubility of 67% by weight (e.g., 67 g in 100 ml of water). This high aqueous solubility demonstrates that the Carbowax™ Sentry™ materials would not exist as solids in the	This report has been updated (Section 6.5.5) with the information in the Bernad (2008) study. We find, however, that the study does not fully support your conclusions as, whilst fully degradable in WWT the evidence suggests PEG is only degradable up to a MW of 7,800 in (simulated) sea water. This is very much on the border of the products that Dow supplies. With this in mind, the passage referring to Carbowax is removed, but we recognise there is still no conclusive evidence to eliminate PEG from all lines of enquiring with regard to microplastic marine litter from PCCPs.

Comment	Response
environment and would be completed dissolved in water. The PEGS that comprise the Carbowax™ Sentry™ materials are very biodegradable and would not be expected to be found in the environment. PEGs with average MW up to 10,000 have been shown to be effectively treated through biodegradation in wastewater treatment plants4,5. A more recent report by Bernad and coworker demonstrated using standard OECD testing protocols that PEGs up to average MW 10,000 were biodegradable in both municipal wastewater and seawater. Taken together this information clearly demonstrates that the Carbowax™ Sentry™ materials are highly miscible in water at environmentally relevant temperatures, are effectively treated (biodegraded) in municipal wastewater treatment plant, and would be rapidly biodegraded when introduced into the aquatic environment (freshwater/seawater). As a result the Carbowax™ Sentry™ materials should not be considered as contributing to the microplastic debris issue.	

A.5.3 Stakeholder Meeting Minutes

The following are the minutes taken from the discussion following the presentation of work package 2 during the stakeholder meeting.

F+F = Fauna and Flora International

CosEU = Cosmetics Europe

SHann = Presenter and report author

CSherrington = Project Director

MPap = Michail Papadoyannakis (DG Env)

MCS = Marine Conservation Society

PSundt= Peter Sundt, Mepex

Definitions: important to establish to move forward.
F+F:Microbeads focus of original campaign because recognisable issue for public and achievable pressure point. Have own definitions like California. No lower size limit.
Without definitions - can't make a commitment that everyone agrees with.

CosEU: Can't define microplastic by function, but by properties e.g. floating, sinking, pathways, impacts. Not everything has to be dealt with same way - doesn't have to be managed in same way - if e.g. some don't end up in ocean.
CosEU- wanted to highlight what industry was focused on

F+F: Hard to distinguish biodiversity impacts for different types of microplastics - thinks solid microplastics is the issue as a whole.

SHann: All industry said - no evidence for impacts - is this a problem?
F+F -yes - concerned

F+F: reputational risk drove target of campaign. Impacts are important.
MCS: counters - reputational risk about perception of consumer - consumer won't have that scientific knowledge, and their opinions/impressions just as important to industry.

SHann: definitions – is there a danger of loopholes?
RE: Biodegradability and no standard.
CosEU - yes it's an issue, want to benchmark biodegradability for plastic etc against that of other materials e.g. for cellulose/sand
SH drew attention to the fact that the scope is just about biodegradability of plastics.
MPap: there is a standard -produced by CEN - these are never mandatory. (**SHann**: out of date)
If you include that word, MUST have a standard - **CosEU** - seemed to agree

F+F - if use word biodegradable, then industry will work to create standard.
SHann: Maryland has stipulation that must be done

CosEU: uncertainty does mean the industry not pursuing biodegradable plastics but natural inc. inert materials.

MCS: why put legislation in place mentioning a product that does not yet exist (like biodegradable plasticbags)

PSundt: grey areas around compostability, biodegradation etc… Should we just accept just one definition to make things simple. He things that biodegradable is a 'dangerous word'. Plastic bags in Italy/France - biodegradable ones - mess up recycling, gaseous emissions, composting issues. Don't want to close doors to real solution rather than a quick fix. Not everything is biodegradable everywhere - think about e.g. arctic waters.

Surfrider: Concurs that biodegradable bags only compostable in IVCs really confused issue

SHann: Really change world - if there are better alternatives, use them

F+F: nanoplastics - harder to replace and have to acknowledge this- but do want to work towards it.

CosEU: replacements do exist for microbeads. Data is good. Therefore no excuse to still do. Expect tail off to progress quickly to zero.
Competition law - cross EU agreement - cleared - and will release statement
Uncertainty about other figures - concerned about hi estimate of range. But do acknowledge that industry have just started learning about this - have issued a survey. Will publish.
SHann: will they make the scope obvious? Requests itemisation - 2012 study didn't make this clear enough.
CosEU: learned this from that 2012 survey. Will include plastics <1um. Will make clear what proportions of e.g. PE that can exist as a liquid or solid - are solid.

Availability of replacements - very limited at the moment. Think will be unable to issue recommendation until alternatives exist - just not reasonable to expect companies to do this otherwise and big issue under competition law.

CosEU: different product groups will have different tonnages and different concentrations so for this reason know that the upper range in the report is not right. <**SHann** challenges>. Concedes 'think it's highly improbable'.

MPap: felt that the estimated contribution of cosmetics of 0.25% - as bigger than 0.01% in other studies - already shows benefit from making rough estimates. DG Env appreciates that no alternatives but their concern is protection of marine environment.

CosEU: survey - will take until end of year.May not be possible to include in this report.
MPap: that's fine there may be ongoing work.

SHann: around the high estimate - is there a compromise - what about just publishing reduction timeline with overlay. That just reflects low estimate. **CosEU** agrees (also says - might be even lower than low estimate - but yes, we don't know).

CSherrington: we should talk about whole range, while mentioning survey efforts of CosEU.MP and CosEU nod.

F+F: In statements about phase outs there must also be a commitment to not reintroduce other objectionable things or new products with microplastics in.

MCS - they do have examples of new products coming online with MPs in - tracking is not possible.

CosEU - committing to transparency - will help industry maintain commitments over time - survey is not a one off.

A.6.0 Satisfaction of Terms of Reference

Table 53. Requirements from the Terms of Reference for Work Package 1, Task 1.1 and Work Undertaken

ITT Item -Description	Subtasks	Description of Work Undertaken
WP 1.1 - Establish a series of options to incentivise adequate waste disposal at ports, while respecting the polluter pays principle	Review existing data on waste collected at EU Ports	Definitions of waste and fate under existing legislation. Review of waste delivery data - (EMSA 2012) - up to 2010. Integration of data from Panteia 2015 on waste. (Extrapolation of waste delivery figures to total EU levels already carried out in the Panteia report)
	Understand relative attractiveness of policy options	Review of provisions of PRF directive. Review of current implementation of PRF Directive - prevalence and distribution of cost recovery systems (EMSA 2012 and other relevant sources) Exploration of performance criteria and selection. Definition of relationship between performance criteria and relative attractiveness.
	Develop scenarios	Review of features of PRF cost recovery systems. Scenario design according to maximum range of environmental outcomes.

ITT Item -Description	Subtasks	Description of Work Undertaken
WP 1.1 - Estimation of the reductions in marine litter made possible through different options.	Generate high level estimates of marine litter reduction	Review data on total quantities of marine litter Review of available data on proportion of at sea sources of marine litter. Estimation of waste generated by vessels and associated time series. Comparison of estimated waste generated versus delivered. Evaluation of scenarios using finalised baseline (delivery gap), drivers of performance, generation estimates, and waste data.

Table 54. Requirements from the Terms of Reference for Work Package 1, Task 1.2 and Work Undertaken

ITT Item -Description	Subtasks	Description of Work Undertaken
WP 1.2 - carry out a scoping exercise of the relevant legal provisions applicable to waste generated from ships and offshore platforms	Review existing legal provisions	Review and mapping of existing legislation Review of surrounding peer-reviewed and grey literature for potential gaps
	Identify gaps where further regulatory action could result in significant reductions of marine litter	Thematic analysis assessing comprehensiveness of legislation for each waste type and summary Reports of barriers to implementation which may reveal further legislative gaps and summary

Table 55. Requirements from the Terms of Reference for Work Package 1, Task 1.3 and Work Undertaken

ITT Item –Description	Status	Description of Work Undertaken
WP 1.3 - The current study, fully considering available information and pilot studies, should identify options to contribute to the 2020 fishing gear reduction goal and to support the European Commission in co-leading the abovementioned OSPAR action.	Complete	Using available case studies the approaches have been categorised by their litter removal or prevention effect and by the manner in which litter is reduced. The EC reduction goal and OSPAR action are analysed in the report to understand their aim, function, and likely implementation and evaluation. The litter reduction options are analysed against these targets accordingly.
WP 1.3 - The identification of options should serve as a basis for an expanded list of possible activities which would contribute to the OSPAR action, taking also into account OSPAR specificities covering not only fishing gear, but other sources and types of litter originating from the fishing and aquaculture sectors.	Complete	Under this categorisation, several methods of implementation are highlighted for each litter reduction option. For example, 'Removing the Financial Incentive to Dump Waste at Sea Description' can be achieved through deposit refund schemes, EPR, or improving the waste facilities to lower the cost of their use. Litter from fishing and aquaculture industries is considered for all options, unless the option is intrinsically tailored to a single industry or product.
Such options should be based on an analysis of these sources and types of litter	Complete	Litter is analysed in terms of item types and sources using survey data from different marine compartments that provide the necessary level of detail. A top down estimate is created for the quantity of litter inflow and stock, with a discussion of the level of uncertainty in the figures. The size of national industries are mapped based on the weight of fish production to illustrate the first step in understanding regional losses. This analysis is referred to in the discussion of the litter reduction options in order to understand strengths and weaknesses, and where possible the potential impact of measures.

ITT Item –Description	Status	Description of Work Undertaken
and should include a cost-benefit analysis of reduction options	Not possible, agreed change of requirement with client	Full CBA of each option is not possible due to issues with the information available. The range and extent of the impact of lost fishing gear, and marine debris in general, are poorly understood, and very rarely quantified or valued. The benefits of removing or preventing gear loss are therefore impossible to calculate. Furthermore, costs and results of projects are rarely published in sufficient detail if at all. Instead we discuss costs, benefits and other key properties are discussed for each option, where the data permits, in order to facilitate a comparison of the measures. This high-level discussion is deemed more useful to the general comparison of litter reduction approaches rather than relying on individual case studies which may not be indicative of results elsewhere.
including, where feasible, an estimation of the percentage reductions which could be brought about through their implementation.	Complete where supported by data	The potential impact of measures, in terms of litter reduction, are discussed where the data supports such analysis. This is more applicable to options that could target specific sources, pathways or litter items in which the estimates of losses can be used to make quantitative analysis.
It should also take account of the results of relevant marine litter retrieval projects. [13]	Completed	Litter retrieval projects are discussed in detail as one litter option and presented separately to litter retention (fishing for litter) and gear buy-back approaches. The study is able to draw upon results of three case studies, two of which are detailed CBA of the approach.

ITT Item –Description	Status	Description of Work Undertaken
Footnote [13]: Notably, the Commission-supported MARELITT project aims at developing best practice in marine litter retrieval and will begin to deliver results in the autumn of 2014: http://www.marelitt.eu. The DeFishGear is also relevant In this regard: **htto://www. defishgear.net/**	Completed	We contacted Wim Van Breusegem, project manager for MARELITT, and reviewed MARELITT publications but found that projects did not report costs and results in a way that allowed meaningful analysis suitable for this study. Similarly, no suitable case studies were derived from DeFishGear.

Table 56. Requirements from the Terms of Reference section for Work Package 2 and Work Undertaken

ITT Item -Description	Description of Work Undertaken
WP 2.1 - Estimate the proportion and quantity of microplastics in the marine environment which are present as a result of the use of such materials in cosmetic products. To the extent possible, a specific quantification exercise should be carried out,	A review of relevant papers and reports has been undertaken to provide high level estimates of the contributions of PCP microplastics to the *flow* of plastic into the ocean for both primary and secondary sources. An attempt was made to estimate the proportion of PCP microplastics currently residing in the marine environment. Due to lack of data relating to the source of microplastics and the inability to differentiate PCP microplastics from other sources when in the marine environment this estimate is highly uncertain. Results suggest that cosmetic microplastics account for 0.7—3% of overall marine plastics flowing annually from Europe and around 3—4% of microplastic emissions.
WP 2.2 - Map the coverage and credibility of existing commitments from the major industry players to phase-out microplastics in their products.	Interviews have been conducted with the cosmetics industry which is calculated to cover 90% of the market. Cosmetics Europe provided additional data and support to help to make sure that our calculations match the results of their survey (which cannot be provided in full due to confidentiality).The industry have mostly declined to provide any data on an individual company basis but have provided information on the timescales for any voluntary reductions. Interviews and statements have been gained from 85% of the industry (by value).
WP 2.2 - To the extent possible, a detailed analysis of the proportion of the market which will have phased out microplastics across their product range in the medium term (e.g. between 2015 and 2020)	The industry commitments have been mapped against the usage data to create a timeline to 2020 which suggests around 80% reduction. Manufacturers have been differentiated based on whether their commitments have been made public. Further sources of microplastics beyond that of the exfoliants have been identified and estimated. Data for this part of the estimate is sparse and the cosmetics industry refute claims that these additional sources should be considered. The estimate remains as an indication of the magnitude of the additional sources in the hope that improved data will be forthcoming in the future.
…as well as of the impact such measures could have on upstream plastic producers and converters.	A summary of interviews with Plastics Europe and the cosmetics industry has been included. Mostly there is little information on the impact to convertors and plastics Europe do not know or hold data on this type of production as it is a very small amount compared with overall production.

ITT Item -Description	Description of Work Undertaken
WP 2.3 - Analyse the existing legal instruments which are relevant for the inclusion of microplastics in cosmetics, and their discharge into the water supply	A review of the bans and proposed bans in the US and Canada has been undertaken which found that the definitions used are very important. The banning of 'biodegradable' plastics as an alternative may not be fully founded at present and should be explored further if a ban is likely. It is unlikely that the Cosmetics Directive will be suitable for a ban due to it being for human health concerns. REACH is concerned with individual chemicals and does not recognise 'plastic' as a term. It would therefore require all types of plastic/polymer of concern to be tested individually. The Urban Waste Water Treatment Directive may be cost prohibitive and ultimately not be 100% effective at removing microplastics from water effluent. The Ecodesign directive may be the best possibility under existing legislation although it would require the broadening of its current scope.

A.7.0 Work Package 3 Appendix

Work package 3 relates to presentation and communication of the project, and consists of two tasks:

Task 3.1: Present and discuss the draft and/or final results of the project at meetings of relevant experts at least three times during the project period.

Task 3.2: Provide a summary slide presentation (e.g. PowerPoint format), including speaking notes, which would be made available to Commission in order to be able to showcase the results of the project.

Task 3.1 was completed by presenting draft findings at the following meetings:

- MSFD Working group in Dublin 29th June 2015: Interim findings were presented to gain feedback and help to engage the group into participating in the research for WP1.
- The results from the draft final report were presented to stakeholders in a meeting held at the European Commission offices in Brussels on 20th October 2015. The list of stakeholder invitations was agreed with the European Commission and attendees received a copy of the draft final report in advance of the meeting. The purpose of the meeting was to present key findings for peer review and to receive comments from stakeholders that could be incorporated into the final report. The stakeholder meeting discussion and other comments received on the draft final report are discussed in Section A.1.0 for WP1 and Section A.5.0 for WP2.
- Cologne 23rd November- Final results were presented to 165 attendees at a microplastics conference held by the Nova Institute. http://microplastic-conference.eu/
- Rotterdam 9/10th December – Results were discussed during this OSPAR/Netherlands workshop involving industry, NGOs and government representatives.

The slide presentations from the stakeholders meeting on the 20th of October were made available to the Commission, therefore fulfilling the requirements of Task 3.2.