Literature review:

Mapping Economic, Behavioural and Social Factors within the Plastic Value Chain that lead to Marine Litter in Scotland

Literature review

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Executive Summary

Aims and approach

In the context of growing public concern around marine litter and a fast moving policy landscape of measures to address marine litter and plastic waste, this research sought to understand opportunities within the plastic value chain to help tackle marine litter. The factors and decisions that lead to marine litter in Scotland were researched with a focus on four products that are not fully addressed by current or planned marine litter and plastics waste policy measures. These four product categories were:

1. Commercial fishing gear
2. Crisps, snack and sweet wrappers
3. Artificial grass pitch
4. Menstrual products

The research findings are presented in six documents as follows:

1. **Summary report**
2. **Commercial fishing gear**
3. **Crisps, snack and sweet wrappers**
4. **Artificial grass pitch**
5. **Menstrual products**
6. **Literature review**

This document is the *Literature review* and was researched and written in the early stages of the project to help inform and direct the research. Some information presented here is also used in the final report documents listed above and updated following subsequent research findings. The findings of the literature review are presented for each product in turn, considering product and market information, the problem plastics cause in the marine environment, pathways to the marine environment, why leakage happens, and opportunities to tackle the problem through regulatory and non-regulatory measures.

Commercial fishing gear

Fishing gear is a technical product group. Fishing nets in particular can be constructed from many components and materials. Netting, ropes and coatings used in the sector use plastics to provide product strength, low weight, and flexibility. Fishing gear needs to maintain high performance in an environment with many destructive and abrasive forces and so durability is paramount. There are many fishing gear companies based in Scotland and the UK, but the majority of products are imported.

Fishing gear is a significant marine litter issue, as demonstrated by beach surveys, aerial coastline surveys and benthic surveys in the ecologically active sediment layers of oceans and estuaries. Nets and ropes accounted for between 13% and 33% of marine litter in OSPAR beach surveys most representative of

Scotland and surrounding maritime areas.[1] In addition to ingestion and other issues associated with marine litter, fishing gear is particularly dangerous in entanglement of wildlife.

The EU estimates that 20% of fishing gear is lost at sea due to either accidents, storms, entanglement or intentional abandonment[2], and in a recent study conducted in Australia and Indonesia fishers identified snagging of nets to be the main cause, followed by gear conflict and poor weather[3]. There is currently no such research which quantifies the causes and pathways of Abandoned, Lost or Discarded Fishing Gear (ALDFG) in Scotland.

The decision to litter is often linked to a 'commons dilemma', a situation that occurs when people choose options that are of personal benefit without considering the costs to others. Commons dilemmas and personal cost/benefit analysis are considered the cause of most littering decisions which apply across all four product categories in this research and are particularly relevant to fishing gear littering.

In the UK, fishing and fish processing employs 22,000 people and there were 2,065 active Scottish based fishing vessels in 2017[4]. The fishing industry is highly competitive and actors are under considerable financial pressure, with many port neighbourhoods offering limited alternative employment opportunities. Large fishing gear items, such as nets, are typically landfilled at end of life at high cost, incurring UK Landfill Tax. Costs can be prohibitive[5], which has been cited as a factor leading to illegal discard at sea internationally[6]. However, many fishers demonstrate pro-environmental behaviour, actively fishing for litter and bringing recovered items to shore for safe waste disposal. Recycling opportunities are being explored by small companies and at government level[7] and aim to reduce the financial burden on fishers for waste management. The EU has proposed Extended Producer Responsibility (EPR) for fishing gear[8] [9] which would move the majority of the financial burden onto producers, reducing disposal costs for fishermen and ports and potentially encouraging a national collection and recycling scheme.

There are no legal requirements for gear marking in Scotland, although Government guidance exists and plans to introduce legislation have been announced. There are also gaps around discharge of waste at sea which is prohibited under international agreement, but with less strict requirements for small vessels in the UK transposition of the agreement and not yet criminalised under Scottish law. Furthermore, the requirements for port reception facilities for waste from fishing vessels are not as comprehensive as they should be. Current revisions to EU Directives could be designed to bridge this gap and remove the economic disincentive to deliver waste to port (i.e. the high cost of managing waste gear).

[1] 13% in the Celtic Sea and 33% in the Northern North Sea. https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities/marine-litter/beach-litter/
[2] EC, 2018 (https://bit.ly/2xirnPV)
[3] Richardson et al., 2018 (https://bit.ly/2UAac7A)
[4] Scottish Sea Fisheries Statistics (2017) https://www.gov.scot/publications/scottish-sea-fisheries-statistics-2017/pages/4/
[5] As landfill costs typically exceed £100 per tonne and fishing nets can weigh several tonnes.
[6] http://www.fao.org/3/a-i5051e.pdf
[7] https://www.britishirishcouncil.org/sites/default/files/BIC%20-%20Marine%20Litter%20Symposium%202019%20%20-%20Communique%20-%20Final.pdf
[8] http://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy-brochure.pdf
[9] http://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf

Non-regulatory interventions can be effective in encouraging pro-environmental behaviour through localised penalty systems, financial or social incentives, timely prompts, communicating consequences and promoting cooperation. Training requirements and education in particular have been highlighted as effective measures for the fishing industry. The KIMO 'Fishing for Litter' initiative has shown significant positive results in reducing the occurrence of marine littering amongst its members whilst also increasing the frequency of litter collection by members[10].

Crisps, snacks and sweet packets and wrappers

Crisps, snacks and sweet packets and wrappers are typically made from aluminium-coated polypropylene (PP) or polyethylene (PE). Other polymers and aluminium are also commonly used in multiple layers, and some packets are filled with a protective atmosphere of nitrogen gas[11], commonly known as Modified Atmosphere Packaging to protect the contents. The wrappers are designed for food contact safety, to reduce the fragility of the crisps, snacks or sweets within the wrapper and preserve the product for longer, thus extending shelf life. There are Scottish brands, with presence of bigger companies in the UK, whilst many products are imported from abroad.

It is estimated that in the UK, of 8.3 billion packets of crisps eaten annually, 0.3 billion (3.5%) end up as litter[12]. In Scotland, surveys suggest roughly half the population have littered at some point[13]. Crisps, snack and sweet wrappers are typically very common marine litter items, as seen in beach surveys[14] [15], and experts rank food wrappers highly in marine litter items which cause most damage [16]. Whilst no cases of ingestion by marine life were found in the scientific literature, there were over 2,000 recorded incidents of ingestion of 'food packaging' in general, many are reported in newspaper articles. The sources and pathways to the marine environment are clear. Crisps, snack and sweet wrappers that are consumed outdoors are dropped on land, blown from bins or skips and littered from cars, a proportion of which are then washed down surface water drains and discharged to the marine environment. Some are directly littered on beaches or blown in from the coastal environment.

This study scope focusses on the supply chain rather than public littering behaviour which is the subject of other ongoing research and policy development. However, it is important to gain an overview in order to understand how the solutions can be targeted across the supply chain. Having carried crisps, snacks and sweets to eat in public spaces and cars, some are then consciously or unconsciously dropped as litter. Research reveals a cultural dependency on bin infrastructure and government street cleansing services that cannot meet the public's propensity to drop litter. The issue is further compounded by public conceptions of 'acceptable' littering for certain products or littering where people think the items will later be cleaned up. There are very few propositions or case studies focussed on the value chain for crisps, snack and sweet

[10] Defra (2014), An evaluation of the Fishing for Litter (FFL) scheme. www.fishingforlitter.org.uk/assets/file/Report%20FFL%202011%20-%2014.pdf
[11] https://www.walkers.co.uk/faq/quality-control/do-you-put-nitrogen-gas-in-the-bag-of-crisps-to-keep-them-fresh
[12] EarthWatch Institute, 2019 (https://bit.ly/2U4XBUT)
[13] Zero Waste Scotland, 2013 (https://bit.ly/2Dk1FuH)
[14] JRC, 2016 (https://bit.ly/2UWfyt5)
[15] MCS, 2018 (https://bit.ly/2rdV4vj)
[16] Wilcox et al., 2016 (https://bit.ly/2HI2CNw)

wrappers, with the exception of the recent Walkers crisps takeback scheme and new recycling technologies but the impact on litter is not clear.

Packets and wrappers have negative economic value after the contents have been consumed as recycling options are scarce and likely to be uneconomic/unsustainable. Furthermore, economic value is lost through the direct and indirect impacts of littering (clean-up costs, litter disamenity and pollution externalities costs), estimated to amount to many millions of pounds of damage each year. Arguably, a product that is designed to last a matter of months does not need to be packaged in materials that will take hundreds of years to degrade and have negative economic value to society and the economy after the contents are eaten.

Key market players are exploring alternative materials and product designs, but have not yet developed alternative product designs that reduce marine litter beyond traditional pick-and-mix style sweet sales and potential opportunities with niche plastic-free shops/aisles. Many alternative materials (e.g. bioplastics) are more expensive than conventional plastics, do not provide the same use qualities, and are still in R&D phase of development. Examples of recycling exist but are product specific and relatively small scale. Moreover, although there is growing awareness of the issues caused by plastics packaging in the marine environment, it has not yet had a significant impact on consumer behaviour as the crisps, sweets and snacks market in the UK continues to grow[17].

A lifecycle based approach can be taken to tackling plastic issues, whereby products are categorised by how long they are in use as this typically indicates which solutions are most applicable. This approach supports elimination or substitution of plastics for small products with a short use-phase [18], but the market would need to produce functional alternatives for the specific requirements of crisps, snacks and sweets. Exploration of alternatives could benefit from innovation funding to explore R&D opportunities.

Legislation has been enforced to issue strong and immediate penalties for people caught littering. However, issuing penalties and the deterrent effect they create are dependent on the scale of resources allocated to monitoring and enforcement, which varies across Scotland. If non-payment of penalties is not backed up with legal action, as has been recently publicised, the deterrent effect is reduced. EPR is one regulatory solution that could engage the supply chain in shared responsibility and finding solutions. Recent research reveals insight into littering behaviour that could be used to target future non-regulatory measures.

Artificial grass pitch

There are two types of artificial grass pitch (AGP): those using a performance infill crumb and those that don't. Typically, AGP used for sports facilities uses infill crumb whereas artificial grass for domestic/garden use does not. In addition, hybrid pitch designs are available that support soil and grassroots with synthetic materials and do not require infill. The infill is used in sports facilities to replicate the bounce and performance of grass pitches, allow for drainage, protect and support the synthetic fibres and help prevent injuries by increasing stability[19]. However, there are some artificial pitches which come without infill, which

[17] https://ahdb.org.uk/news/consumer-insight-continued-innovation-key-to-a-healthy-future-for-crisp-sales
[18] https://ciwm-journal.co.uk/wordpress/wp-content/uploads/2018/06/Eliminating-avoidable-plastic-waste-by-2042-a-use-based-approach-to-decision-and-policy-making.pdf
[19] Neograss, 2019 (https://bit.ly/2Jh1GED)

are promoted for use on small pitches (up to five-a-side)[20]. These operate using a shock absorbing underlay and shorter turf with a special yarn and tuft design – curled fibres to support the synthetic 'grass' stems in staying upright[21].

The infill is commonly made from recycled car tyres (a plastic polymer of polymer styrene butadiene rubber (SBR)), although other materials are available including virgin plastics (thought to leach less toxins) and non-plastics. The infill material is periodically reapplied indicating there are direct losses of the infill material, a proportion of which is thought to enter watercourses and transferred to the sea.

Beach and other marine litter surveys typically do not separately identify microplastics of which the infill would be categorised. The infill may be too small to be easily observed or it may be counted as part of the 'small plastic fragments' categories which are typically the most common beach litter items. Loss rates estimates are relatively high, between 1% and 4%, resulting in between 1,200 tonnes and 4,900 tonnes of microplastic emissions per year in the UK. Just considering the 296 full size synthetic pitches used by football clubs in Scotland[22] represents between 359 tonnes and 1,435 tonnes lost per year. Estimates suggest that 45% of infill is lost during waste disposal, 45% to soil/grass, 5% to internal drains (showers, washing machines) and 5% to surface water drains[23]. Infill is walked out on players' shoes and clothes and then washed down drains from washing or showering. In rainstorms infill is washed into drains and sewers. Sewers and wastewater treatment works are not designed to deal with microplastics and the ability to remove these items before discharging to waterways is highly variable. The best removal rates are in works with tertiary treatment, however only 20% of treatment works in Scotland have tertiary treatment. Drains may bypass WWTW entirely through combined sewer overflow spills.

Research into microplastics is in its infancy but early evidence elicits considerable concern as microplastics appear to enter the lowest levels of the food chain and pass up levels through predation. Ingestion has been linked to detrimental impacts including reduction in feeding capacity, energy reserves, and reproductive output [24]. In response, Fidra and KIMO have researched infill as marine pollution and developed guidelines to minimise losses[25] [26] **[27]**. The European Synthetic Turf Organisation is also engaged on the issue and has suggested a number of design alternatives to reduce infill loss[28].

In the absence of 'design, build, and maintain' contracts, the supply chain for AGP is distanced from the direct costs of replacing lost infill (part of the maintenance costs of up to £10,000 per year for a full-size facility) and the environmental costs are not internalised in the market at all. Non-plastic infill is available, and choosing cork potentially carries additional benefits environmentally and socially for Mediterranean

[20] Arturf (https://bit.ly/2JbjEbm)
[21] Arturf (https://bit.ly/2JbjEbm)
[22] ESTC (https://bit.ly/2WhHRzS)
[23] Eunomia, 2018 (https://bit.ly/2OZDLt9)
[24] Nelms et al., 2018 (https://bit.ly/2Pe7Cyg)
[25] KIMO (2017). Pitch In to reduce microplastic loss from artificial pitches: Guidelines for Designers and Procurement Specialists. Accessed from http://www.kimointernational.org/pitch-in/
[26] KIMO (2017). Pitch In to reduce microplastic loss from artificial pitches: Guidelines for Owners and Maintenance Teams. Accessed from http://www.kimointernational.org/pitch-in/
[27] FIDRA (accessed 2019). Plastic Pitches. https://www.fidra.org.uk/artificial-pitches/
[28] ESTO, 2018 (https://bit.ly/2Gox9BO)

countries that farm it. At present, there are no known sustainable infill non-plastic alternatives which are produced in Scotland.

Not preventing loss of infill may be an offence under Waste Duty of Care, but this would need to be tested in a court of law. The Irish Government is trialling use of planning consent to require zero plastic loss from artificial pitches, although there are no details published at the present. Comprehensive guidance has been published for designers, procurement specialists, owners and maintenance teams to minimise infill losses [29] [30].

Likely the key barriers for uptake of any of these options is lack of awareness of the issue, possible lack of functional alternatives, lack of public pressure driving change and lack of financial or regulatory incentives.

Menstrual products

Disposable menstrual products such as pads and tampons are made from synthetic materials, predominantly a range of different plastics. Products are typically multi-component items using different materials designed for absorbency and feeling of dryness against the skin. It is estimated that pads contain around 90% synthetic polymers, whilst a tampon is around 6% plastic (tampon only – not including applicator) and the rest is predominantly cotton. Around 4.3 billion disposable menstrual items are estimated to be used in the UK each year, and although the disposable menstrual product market is competitive, it has a number of key players who dominate the marketplace [31]. Of the towel products, Always (by Procter & Gamble) has the majority of the market share in the UK, Bodyform (by Essity) has about half as many users, and other brands and products have much smaller shares. None of the key players identified in our review are based in Scotland and evidence suggests companies with HQs in England manufacture outside of the UK.

Reports suggest that 1.5-2 billion menstrual products are flushed every year[32], representing around 35-47% of all menstrual products. Marine Conservation Society (MCS) data shows that 4.8 pieces of litter identified as menstrual waste are found per 100m of beach based on beaches included in their Beachwatch citizen science project[33]. Menstrual products have been found in the stomach of birds[34], and some menstrual products contain chemical that could risk leaching into the marine environment[35]. The associated 'yuck' factor has a considerable impact on the enjoyment value of beaches and the related tourism economy. Waste menstrual products have negative economic value in disposal costs and cause wider value loss to the economy as marine litter through sewerage blockages and devaluing the coastal environment. They almost solely enter the environment through poor behaviours - a proportion of users flush them down toilets and

[29] KIMO (2017). Pitch In to reduce microplastic loss from artificial pitches: Guidelines for Designers and Procurement Specialists. Accessed from http://www.kimointernational.org/pitch-in/

[30] KIMO (2017). Pitch In to reduce microplastic loss from artificial pitches: Guidelines for Owners and Maintenance Teams. Accessed from http://www.kimointernational.org/pitch-in/

[31] http://ahpma.co.uk/docs/Menstruation%20Facts%20and%20Figs.pdf

[32] MCS, 2015 (https://bit.ly/2I5Ba05)

[33] Reloop, 2018 (https://bit.ly/2zQzbqL)

[34] Edwards, 2004 (https://bit.ly/2ZdX5rt)

[35] Organicup, 2018 (https://bit.ly/2PaoOVc)

in the event of combined sewer overflow spills they are discharged to waterways. A lack of adequate sanitary bin provision in workplaces and public spaces is identified as a contributing factor, despite it being compulsory for employers to provide these bins and arrange for waste management under Duty of Care requirements set out in the Environmental Protection Act 1990[36].

Plastic-based products are likely to contribute to the low plastic recycling rates in the UK[37]. A use phase based approach to tackling plastic issues supports elimination or substitution of plastics and education on 'non-flushable' products[38]. Reusable and non-plastic menstrual products are available but presently have a very small/niche market share and evidently market awareness and perception barriers of hygiene and cultural concerns will need to be overcome in this market if it is to develop significantly. In the UK, this market appears to be dominated by newer companies and start-ups. Reusable alternatives are believed to be cheaper over the product lifetime but require a higher initial sales price.

There are no legal product labelling requirements to discourage flushing behaviour, but this is proposed in the recent EU Single-use Plastic and Fishing Gear Directive[39]along with awareness raising measures. The menstrual product and water industries have developed voluntary labelling and flushability standards that could be applied universally. Marine litter considerations could be included in initiatives on 'plastic-free periods' and wider movements on 'period poverty', 'period positivity' and gender equality, which aim to break down taboos and open discussion for the benefit of society as a whole.

[36] https://www.principalhygiene.co.uk/sanitary-waste-faq

[37] Figure ES1: https://ciwm-journal.co.uk/wordpress/wp-content/uploads/2018/06/Eliminating-avoidable-plastic-waste-by-2042-a-use-based-approach-to-decision-and-policy-making.pdf

[38] https://ciwm-journal.co.uk/wordpress/wp-content/uploads/2018/06/Eliminating-avoidable-plastic-waste-by-2042-a-use-based-approach-to-decision-and-policy-making.pdf

[39] http://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf

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Tables

Figures

1 Introduction

This research focusses on four products chosen in collaboration with the project steering group. The basis of the product selection was the risk of a product becoming marine litter, the risk that they are not being sufficiently addressed in other policy action and research activities, and the potential for action in Scotland. The four chosen products were:

1. Commercial fishing gear
2. Crisps, snack and sweet wrappers
3. Artificial pitch
4. Menstrual products

This report reviews the literature and publicly available sources of information on the products themselves, the environmental risk, and where solutions might be best targeted. The report assesses each product in turn and is structured as below:

- Product and trade information
- Qualifying the problem in the marine environment
- Key points of leakage and pathways into the marine environment in Scotland
- Why leakage happens – economic, behavioural and social factors (drivers and barriers)
- Decision points with opportunities to minimise marine plastics
- Levers available to the Scottish Government (intervention and support)
- Summary

2 Commercial fishing gear

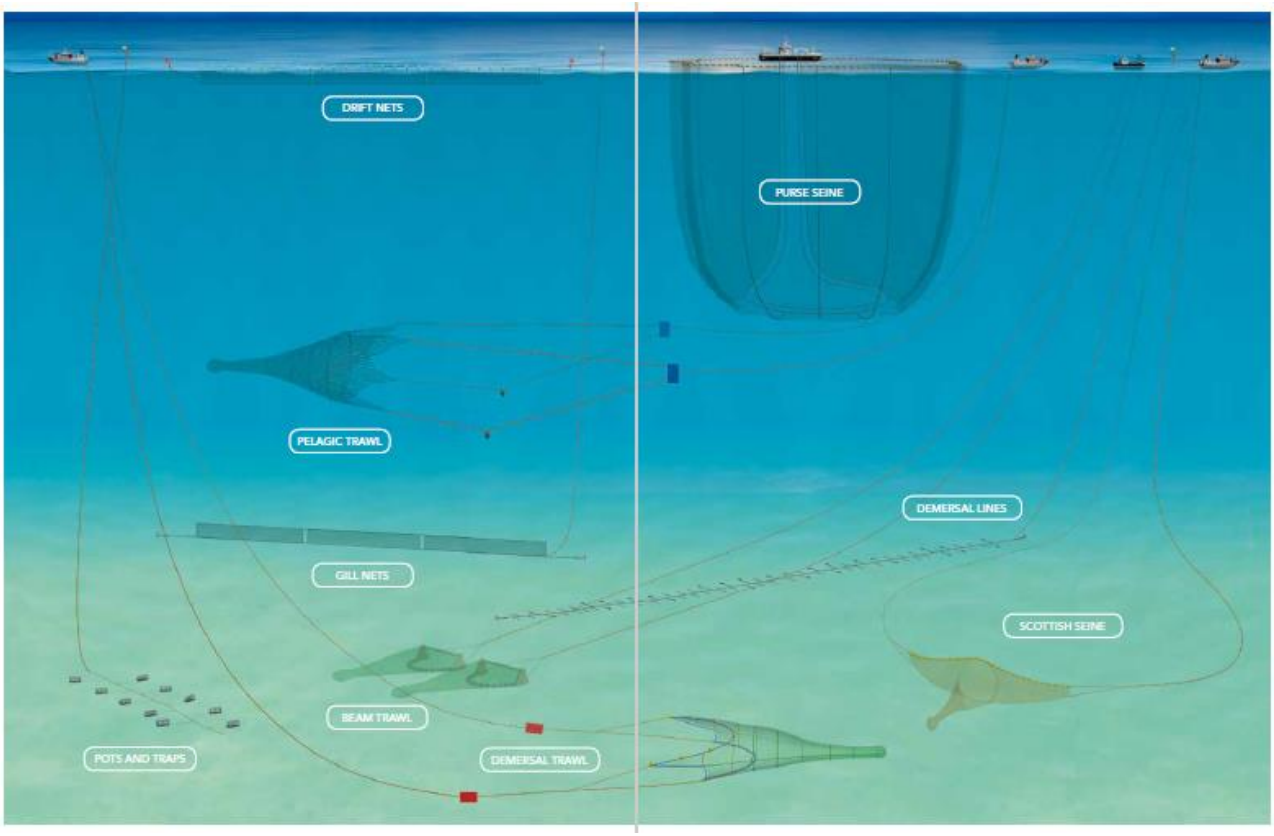
2.1 Product and trade information

2.1.1 Polymer types and % plastic in product

'Commercial fishing gear' is an umbrella term that covers a range of products, with different uses and made from multiple materials. There are 2,065 active Scottish based fishing vessels[40]. Different gear will be used in different waters dependent on specific fleet and species targeted. Fishing methods (and products) are outlined in Figure 1 below, although not all are applicable to Scottish fisheries.

[40] Scottish Sea Fisheries Statistics (2017) https://www.gov.scot/publications/scottish-sea-fisheries-statistics-2017/pages/4/

Figure 1: Types of commercial fishing gear, Seafish[41]



Plastic polymers are used in most conventional fishing equipment. The most common polymers are polyethylene (PE) and polypropylene (PP), which float, and nylon monofilament line, which sinks. Nets and ropes accounted for between 13% and 33% of marine litter in OSPAR beach surveys most representative of Scotland and surrounding maritime areas.[42]

Using Scottish Sea Fisheries Statistics 2017, the three tables below give an overview of the types of gear used by different fleets in Scotland.

Table 1 outlines typical fishing gear used by Scottish fleets targeting demersal species, which are the target species for 33% of total Scottish vessels[43].

[41] Seafish (2015) Basic fishing methods, p. 96-97
[42] 13% in the Celtic Sea and 33% in the Northern North Sea. https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities/marine-litter/beach-litter/
[43] Scottish Sea Fisheries Statistics (2017) https://www.gov.scot/publications/scottish-sea-fisheries-statistics-2017/pages/4/

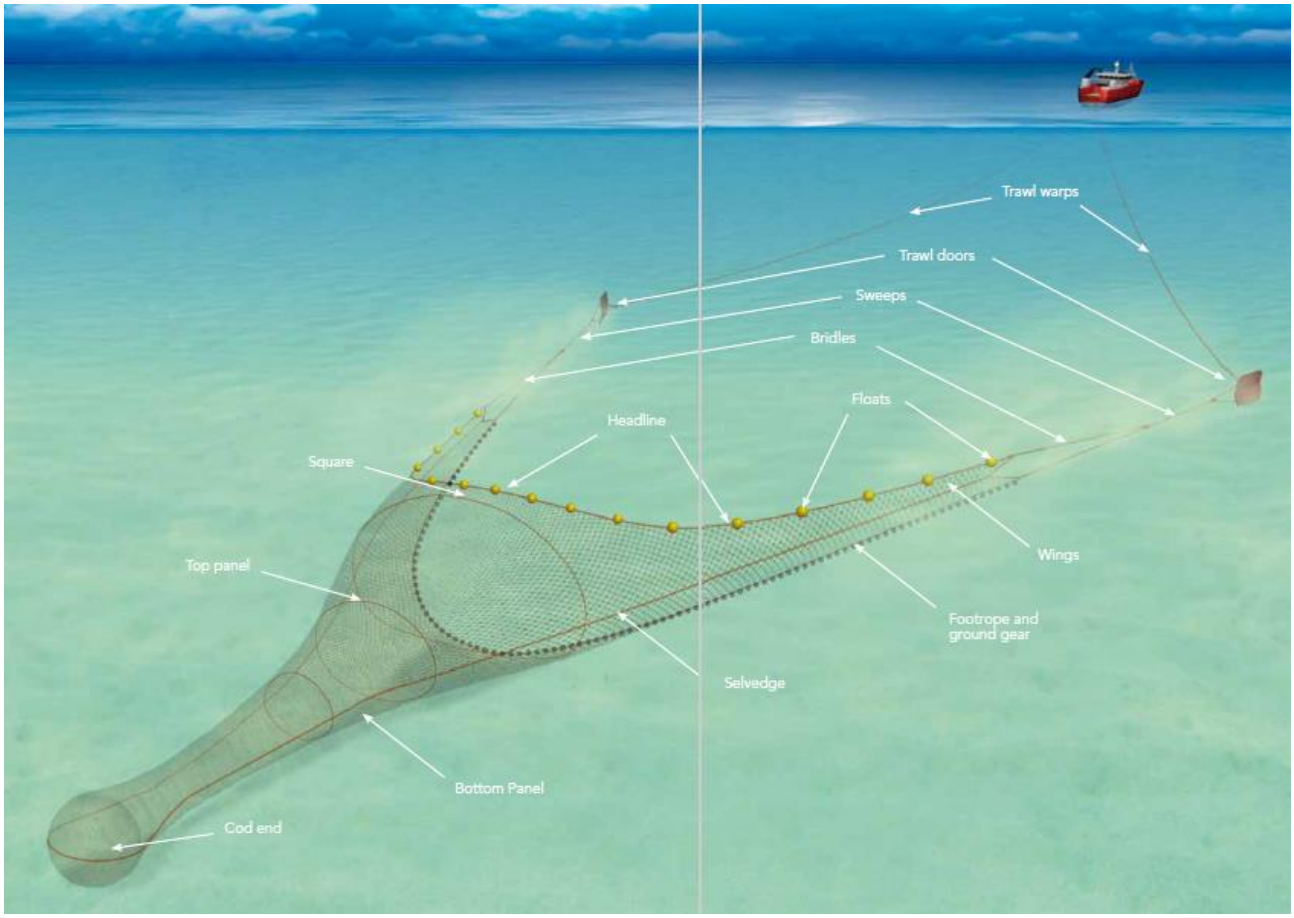
Table 1: Fishing methods for Demersal Species, Scottish Government Marine and Fisheries[44]

Trawling for Demersal Species	Material
Bottom Trawling (Single Boat)	• Two shaped panels of netting - twisted polyethylene twines – laced together to create a funnel shaped bag • Rope at upper edge – head line • Rope at lower edge – foot line • Rope at sides – wing lines
Seine Netting	• Net of twisted polyethylene twine or polypropylene ropes • Up to 14 coils of rope each side of net, each rope lead core, abrasion resistant
Twin Beam Trawling	• Cone-shaped net • Tubular steel beam supported with steel beam heads
Longlining	• Longline rope of nylon monofilament • Multiple branch lines of hooks
Set Nets or Gill Nets	• Single layer of fine netting, typically nylon monofilament or multi-monofilament • Weighted at bottom, with floats above

An example of the scale of the nets used by fleets trawling for demersal species is outlined below in Figure 2. This image provides an understanding of the scale and volume of materials used in commercial fishing gear, and the plastic polymers, as well as other materials, included in this product.

[44] https://www2.gov.scot/Topics/marine/Sea-Fisheries/sustainfish/fishcapture/FishingGears

Figure 2: Example of beam trawl, Seafish[45]

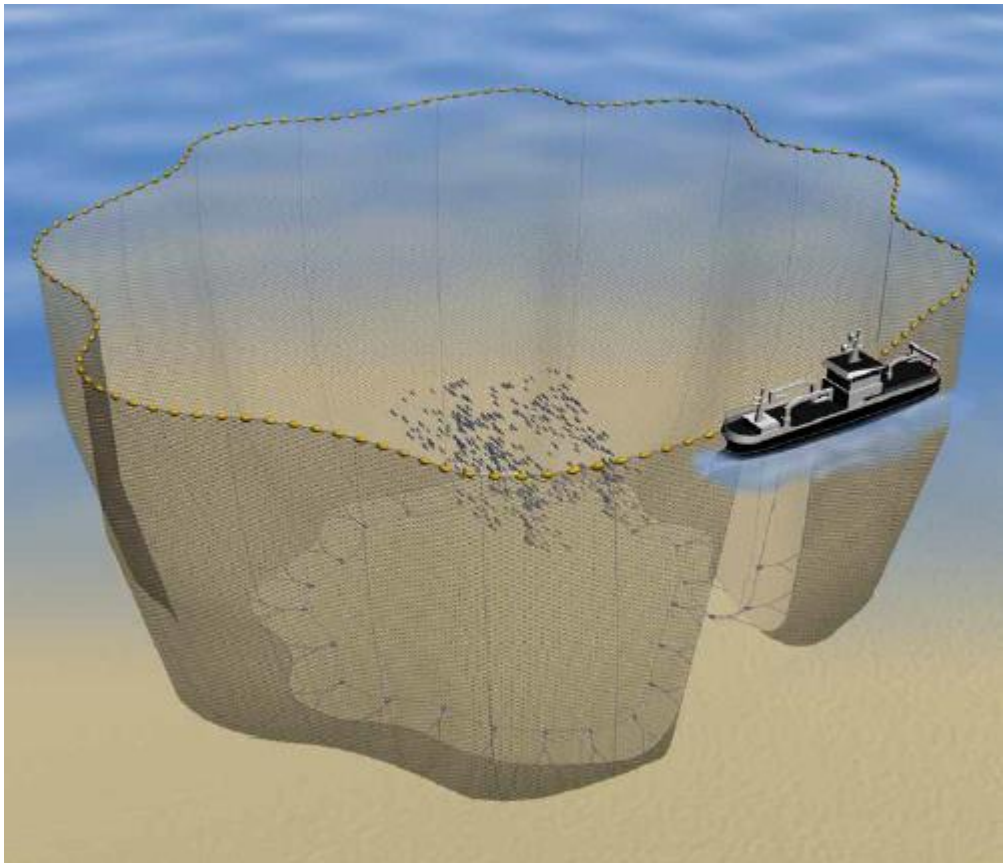


In 2017, 20 vessels targeted pelagic species, with 17 trawlers and 3 purse seining[46]. This method of fishing utilises expensive equipment and mixed materials in the manufacture of the gear. Figure 3 is included to show the scale of equipment used in the purse seining method.

[45] Seafish (2015) Basic Fishing Methods, p. 30-31

[46] https://www.gov.scot/publications/scottish-sea-fisheries-statistics-2017/pages/4/

Figure 3: Example of purse seining, Seafish[47]



In Scotland, the fleet is dominated by smaller vessels (ten metres and under in length). These smaller vessels – which commonly fish using creels, traps or baskets – make up 73% of the Scottish fleet[48]. Table 2 gives an overview of the materials used in the fishing equipment required for targeting shellfish species.

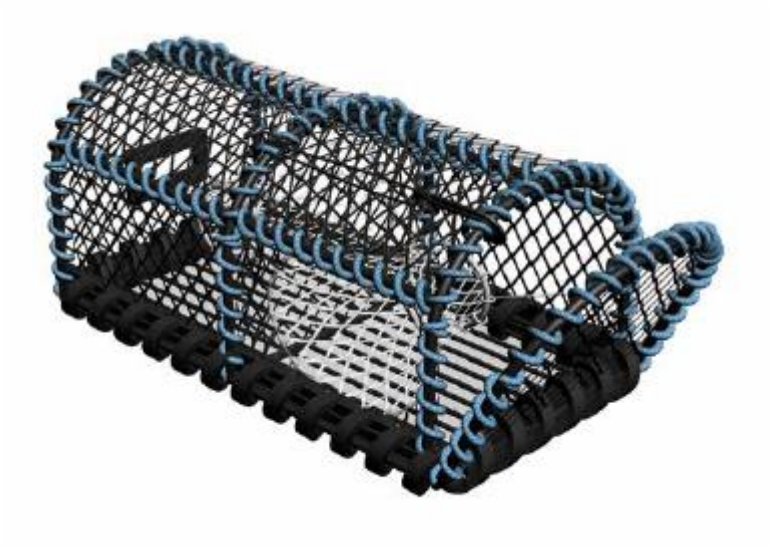
Table 2: Fishing methods for Shellfish Species, Scottish Government Marine and Fisheries[49]

Fishing for Shellfish Species	Material
Potting and Creeling	• Netting of nylon and polyethylene • Modern gear made from steel, wood, and plastic for the frame • Steel coated in plastic to reduce rusting
Scallop Dredging	• Solid, heavy, metal-toothed 'dredge' leading edge. • Underside of attached bag and sweep made from chain links and mesh. • Topside of bag contains chain and twine netting. •

[47] Seafish (2015) Basic Fishing Methods
[48] https://www.gov.scot/publications/scottish-sea-fisheries-statistics-2017/pages/4/
[49] https://www2.gov.scot/Topics/marine/Sea-Fisheries/sustainfish/fishcapture/FishingGears

Included in Figure 4 is an example of a typical pot / creel used in targeting shellfish species in Scottish fishing fleets. This provides an overview of the materials used: a mixture of plastic-coated steel frame and monofilament or multi monofilament netting.

Figure 4: Example of pot/creel, Seafish[50]



2.1.2 Role/function of plastic in product and reasons for choice

Fishing gear needs to maintain high performance in an environment with many destructive and abrasive forces, so durability is paramount. Synthetic fibres are preferable for commercial fishing equipment as they are cheaper to manufacture, more durable, lighter, stronger and maintain their form better than traditional fishing gear made from natural materials such as hemp, cotton and/or flax[51]. Commercial fishing gear is designed to be durable and hardwearing, and these requirements make plastic polymers attractive to net and line manufacturers.

In the manufacture of pots and creels, plastic is used to coat the steel frame in order to avoid rusting and degradation of the metal. This improves the quality and durability of the product. However, it is acknowledged anecdotally that whilst the plastic coating is very durable it does get cracked and degraded over time in the marine environment.

No product standards were found that related to quality of fishing gear. However, conversations with manufacturers would likely increase understanding of this topic. Nonetheless, Council Regulation (EC) No 850/98 prohibits fishing for multiple species using mesh sizes smaller than specified[52], and a number of other European technical measures also consider specifications for design and use of gears as well as minimum mesh size for nets and use of selective gears[53]. Scottish Statutory Instrument SSI 227/2000 provides requirements for mesh size and twine thickness, subsequently amended by SSI 250/2001 and SSI

[50] Seafish (2015) Basic Fishing Methods
[51] Jones, M. 1994. Fishing debris in the Australian marine environment, Bureau of Resource Sciences, Canberra.
[52] EC, 2015 (https://bit.ly/2WTglZD)
[53] EC (https://bit.ly/2WZkriM)

167/2003[54] [55]. Gear used is assessed when applying for MCS Sustainable Seafood Certification, including examination of fishing gears used by the client/fishery under assessment and all other vessels or fishers pursuing the stock of interest, although only MSC certified vessels can carry the MSC label in the marketplace[56].

2.1.3 Product volumes placed on market: import, export and domestic production

Public data on UK market of fishing gear can be found in Appendix A.1.

According to PRODCOM lists of production, import and export of commercial fishing gear, the UK market imports significantly more material than it exports. Moreover, the UK does not have a significant production market of commercial fishing gear products, though there are many smaller manufacturers and suppliers.

2.1.4 Key players in the market and indications of market share

There are only two companies registered on Companies House as rope and netting manufacturers, however manufacturers of these items may be classified instead under different products. Typically, UK net stockists import materials and products from Asia. The fishing gear supply chain is not localised. Table 3 provides an overview of key players operating in the manufacture and sale of commercial fishing gear within Scotland and provides insight to each company's role within the supply chain.

Table 3: Key players in manufacture of commercial fishing gear, focussing primarily on Scotland and UK companies

Key Players	Location	Role in the supply chain
Faithlee Trawl	Fraserburgh, Scotland	Manufacture of cordage, rope, twine and netting
Jackson Trawls	Peterhead, Scotland	Manufacture of nets, wire rope stockist
Euronete UK	Aberdeen, Scotland	Manufacture of netting, steel wire and fibre ropes
Tyson's Riggers	Grimsby, UK	Supplier of wire and synthetic ropes, and netting
Gael Force Group	Stornoway, Scotland	Manufacture of creels
Caithness Creels Ltd	Wick, Scotland	Manufacture of creels
Swan Net-Gundry Ltd	Killybegs, Ireland	Manufacture of trawling nets
KT Nets	Carnmore, Ireland	Manufacture of pelagic nets
Coastal Nets	Dorset, UK	Stockist of ready-made equipment, imported nets and rope
Advanced Netting Ltd	Essex, UK	Stockist of ready-made equipment, imported nets and rope

[54] https://www.legislation.gov.uk/ssi/2000/227/made
[55] Details of later amendments, https://www2.gov.scot/Topics/marine/Compliance/legislation/si
[56] MCS, 2019 (https://bit.ly/2w9S3ip)

Key Players	Location	Role in the supply chain
Renco Nets	Lincolnshire, UK	Import / export of netting and rope
Sicor International	Dorset, UK	Supplier of net and rope (worldwide)
Comfish Marine	Cornwall, UK	Stockist of commercial fishing equipment
Southern Ropes	South Africa	Synthetic rope manufacturer
Van Beelen	The Netherlands	Netting and rope manufacturer

2.2 Qualifying the problem in the marine environment

2.2.1 Abundance in marine environment

Unlike the other three products considered in this research (crisps, snack, and sweet wrappers, artificial grass pitch and menstrual products) which are generally included in marine litter surveys in larger categories during data collection, commercial fishing gear is generally covered within multiple categories. Analysing marine litter compositions is complicated by the inability to source many items of marine litter. For example, pieces of polystyrene foam could originate from fish boxes, or other non-fishing sector polystyrene uses. As such, all surveys represent items that can be identified to the categories used, and as such will likely represent the lower bound of these items.

In a comparison of beach litter studies from across Europe, nets and ropes; and string and cord <1cm diameter ranked in the top 10 most frequently occurring items [57]. In beach surveys in the Northern North Sea, nets and ropes represented 33.2% of total number of items found, and tangled nets/cord/rope and string 0.9%[58]. Looking at British beach litter, Table 4 and Figure 5 show that fishing gear made up 15% of items collected from 2005-2014, and reached a peak of almost 50 pieces of fishing related litter per 100m in 2017. Polystyrene pieces comprised 9% of items collected from 2005-2014[59], which is of some relevance to commercial fishing gear. In 2018, half of the top 10 collected products had at least some relevance to commercial fishing gear; string/cord (fifth), fishing net (small – eighth), fishing line (ninth), plastic/polystyrene pieces (0-50cm - first) and plastic/polystyrene (other-tenth)[60].

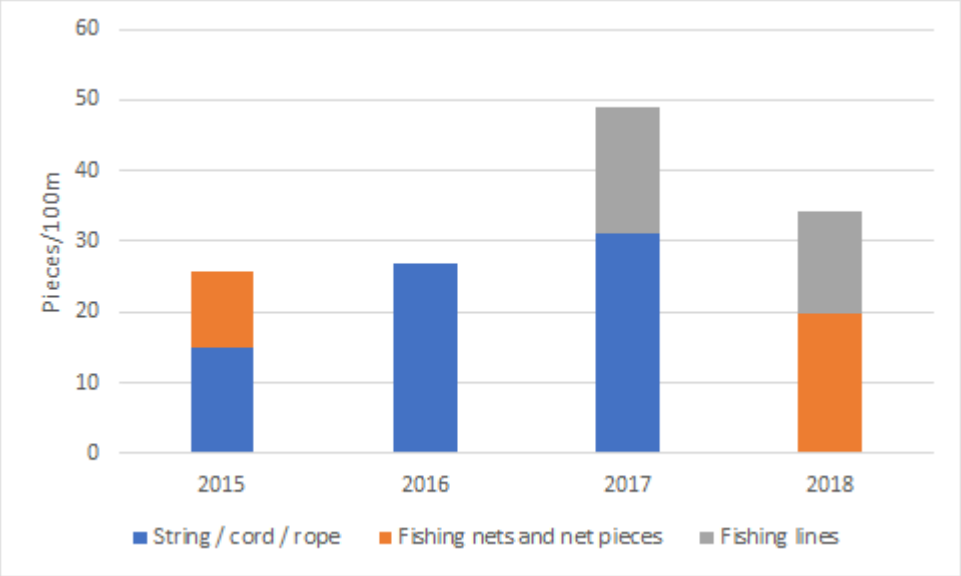
Table 4: Proportion of beach litter related to commercial fishing activity from Nelms et al. (2017), based on surveys on British beaches from 2005-2014 by Marine Conservation Society volunteers[61].

Item Category	Proportion
Fishing net (small; <50cm)	5%
Plastic string	5%
Fishing line	3%
Plastic rope	1%

[57] JRC, 2016 (https://bit.ly/2UWfyt5)
[58] OSPAR, 2017 (https://bit.ly/2UC7n62)
[59] Nelms et al., 2017 (https://bit.ly/2R6vO5t)
[60] MCS, 2018 (https://bit.ly/2rdV4vj)
[61] Nelms et al., 2017 (https://bit.ly/2R6vO5t)

Item Category	Proportion
Fishing net (large; <50cm)	1%

Figure 5: Fishing related litter collected on British beaches during the last four Great British Beach Clean Surveys[62]



The MCS beach survey is a valuable data set as one of the most consistent and long running surveys. However, it is reliant on volunteers survey sites are typically limited to beaches with public access within reach of population centers. The recent SCRAPbook project uses volunteer pilots to photograph litter around the Scottish coastline and provides a view of more remote coastal areas. The aerial photography means that results tend to reflect macro-litter, i.e. large items observable from a distance. The project suggests litter identified is generally around 10cm in size or greater. Figure 6 shows items typically associated with the fishing industry dominate the top ten most common litter types: fishboxes, rope, net, bouys, and 40% of litter items were inferred to be from 'marine' sources (Figure 7).

[62] MCS, 2018 (https://bit.ly/2rdV4vj); MCS, 2017 (https://bit.ly/2DhCJWS); MCS, 2016 (https://bit.ly/2GmTqAh); MCS, 2015 (https://bit.ly/1MlD75x)

Figure 6: Top ten most common litter type, SCRAPbook mainland survey 2018[63]

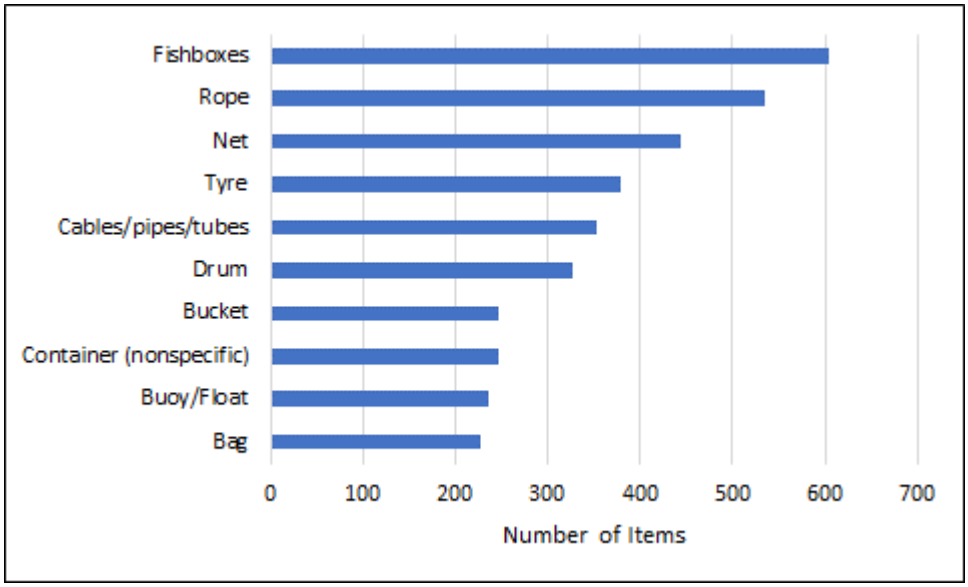
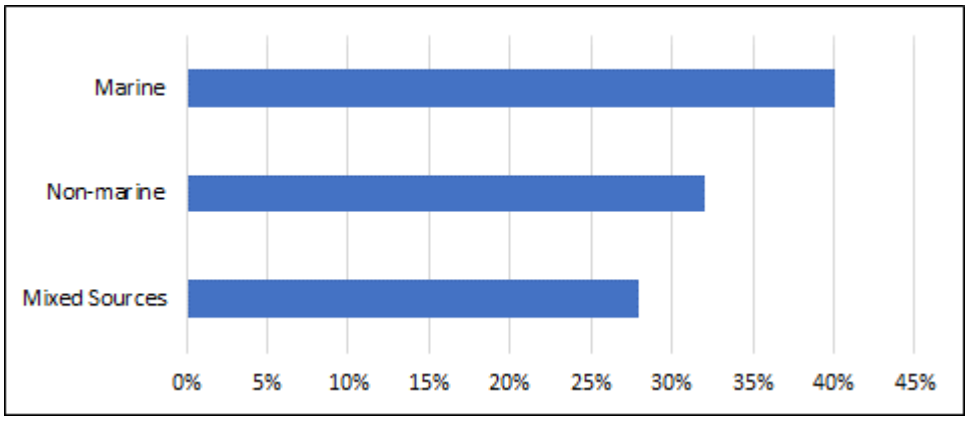


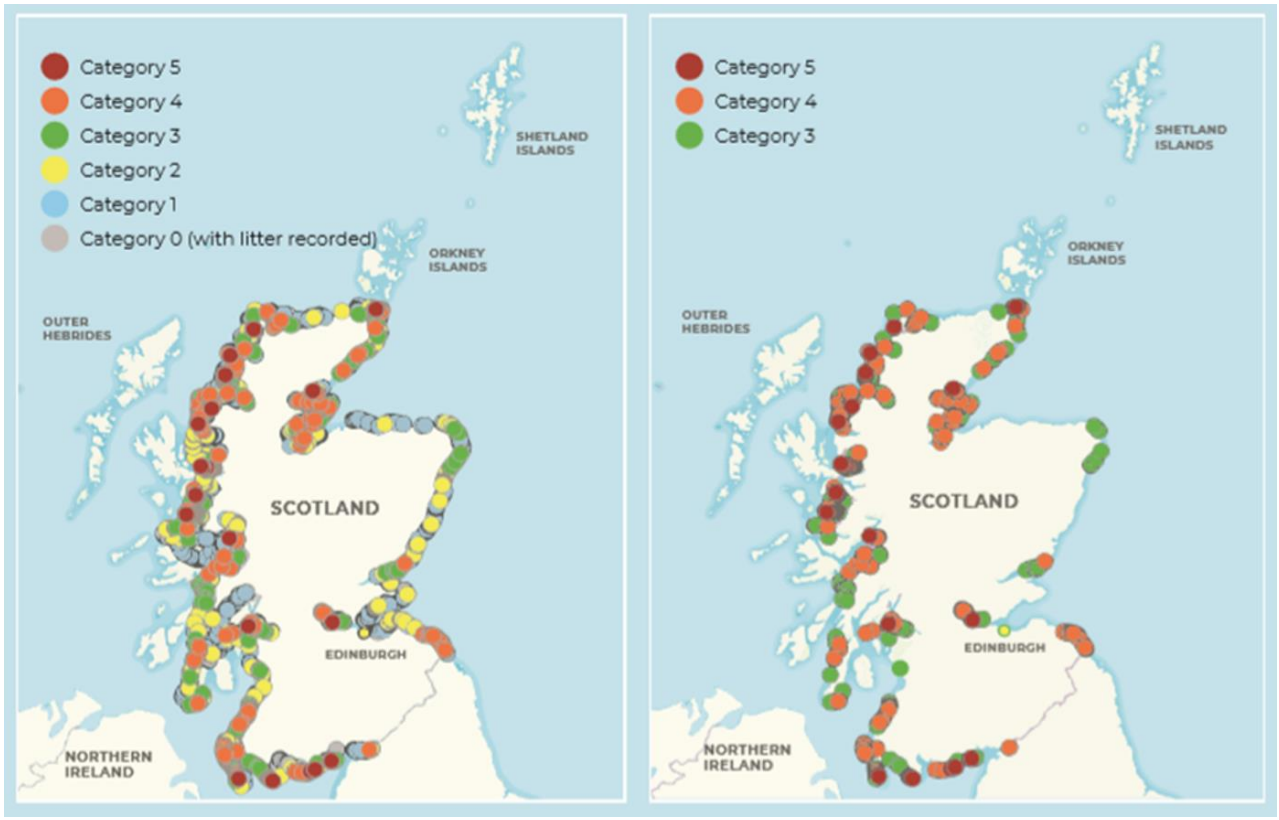
Figure 7: Inferred litter sources, SCRAPbook mainland survey 2018 [64]

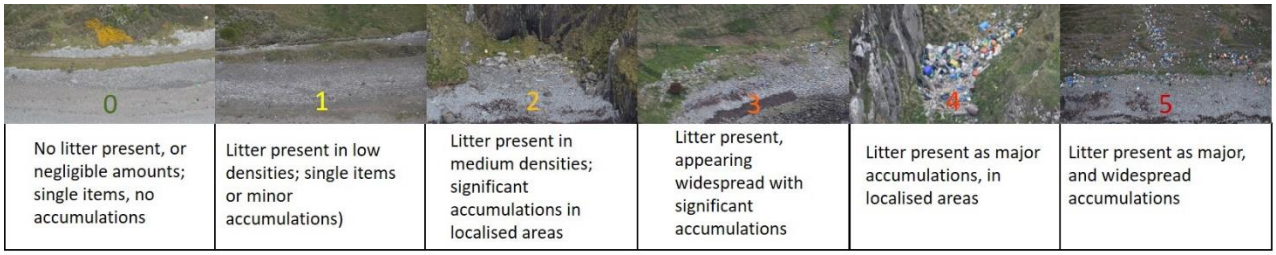


The distribution of coastal litter on beaches surveyed in the SCRAPbook survey is shown in Figure 8. The project website notes that many of the hotspots are found on the north and west coasts, often in less accessible areas with low population densities. Inaccessible areas are likely to be cleared less often by local authorities and volunteers (e.g. via the MCS beach survey) and so litter is likely to persist for longer and accumulate more over time. This is an interesting finding if fishing gear litter is one of the main sources of litter in these locations.

[63] https://scrapbook.org.uk/2018-results/
[64] https://scrapbook.org.uk/2018-results/

Figure 8: Distribution of coastal litter SCRAPbook mainland survey 2018 (left), results filtered to show hotspots (right), and category definitions (below) [65].





0	1	2	3	4	5
No litter present, or negligible amounts; single items, no accumulations	Litter present in low densities; single items or minor accumulations)	Litter present in medium densities; significant accumulations in localised areas	Litter present, appearing widespread with significant accumulations	Litter present as major accumulations, in localised areas	Litter present as major, and widespread accumulations

Please note that this survey did not cover all Scottish beaches, so beaches with no data represent beaches which weren't survey, not those which were free from litter.

In benthic (sea floor) surveys on the East Mingulay Marine Protected Area (MPA) conducted from 2003-2012, fishing related litter were the most frequently found items[66]. As all fishing is prohibited in this area, this gear must have been littered before 2010, or drifted in from other locations[67]. An assessment of 588 video and trawl surveys across 32 European seafloor locations showed plastic to be the most common item, with fishing gear particularly prevalent[68]. Table 5 shows the analysis from Scottish sites.

[65] https://scrapbook.org.uk/2018-results/
[66] La Beur et al., 2019 (https://bit.ly/2XScTOU)
[67] La Beur et al., 2019 (https://bit.ly/2XScTOU)
[68] Pham et al., 2014 (https://bit.ly/2GPP58F)

Table 5: Densities of marine litter from seabed locations around Scotland. Density categories: highest (>20 items ha^{-1}), intermediate (10-20 items ha^{-1}), low (2-10 items ha^{-1}), lowest (<2 items ha^{-1}) [69].

Location	Location type	Litter density	% fishing gear
Wyville-Thomson Ridge	Ocean ridge	Intermediate	86%
Darwin Mounds	Seamount/bank/mound	Low	10%
Rosemary Bank	Seamount/bank/mound	Low	67%
Anton Dohrn Seamount	Seamount/bank/mound	Lowest	0%
Hatton Bank	Seamount/bank/mound	Lowest	88%
Rockall Bank	Seamount/bank/mound	Lowest	33%
North-East Faroe-Shetland Channel	Continental slope	Lowest	100%
North Faroe-Shetland Channel	Continental slope	Lowest	100%

2.2.2 Indications of impact

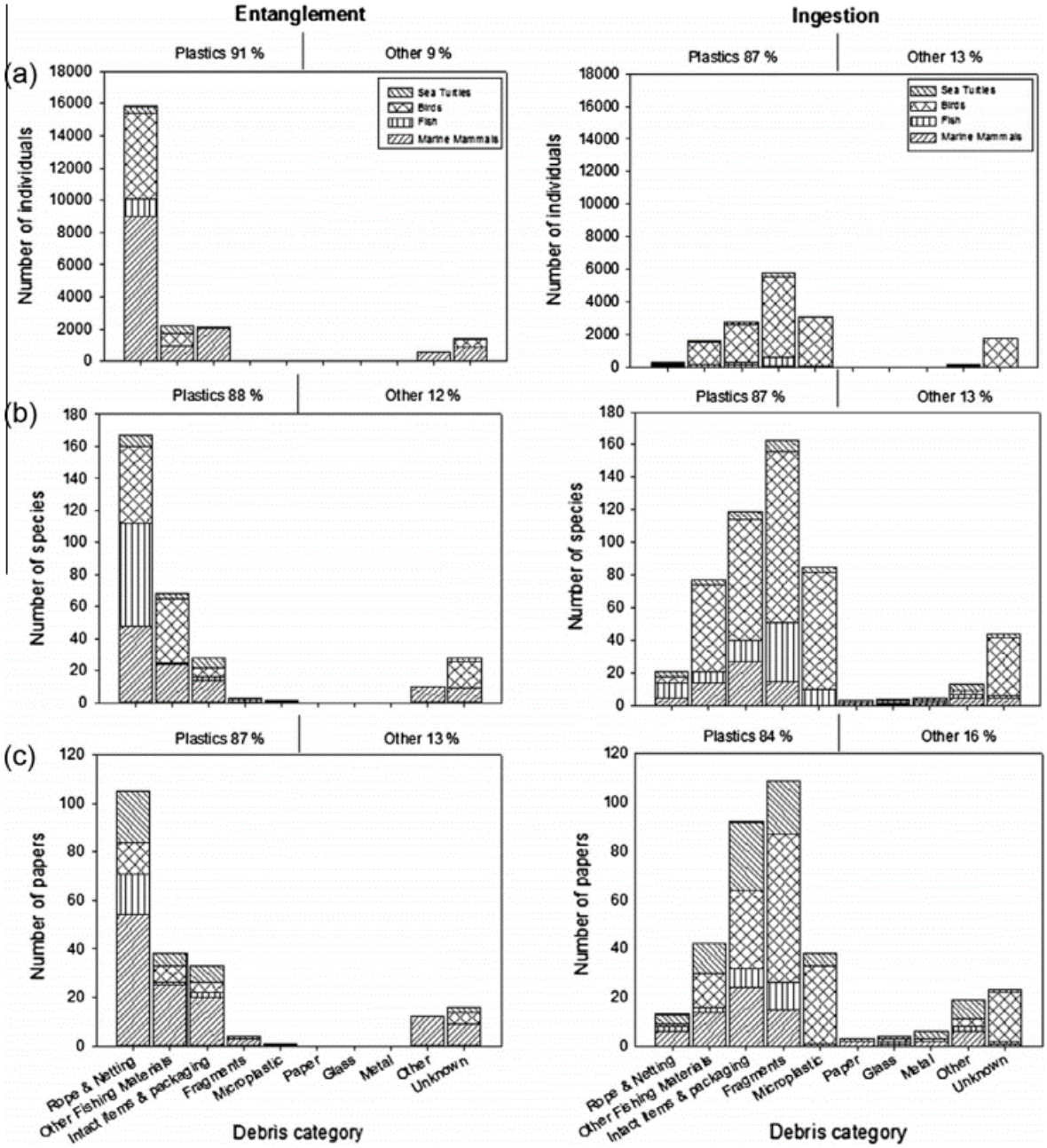
Regarding entanglement impacts, fishing related items (buoys, rope, monofilament line, nets) were ranked as the marine litter item which caused most damage in a survey sent to experts in major marine wildlife or marine debris[70]. Monofilament line was also ranked as having one of the greatest ingestion impacts[71]. No estimates are available for the number of animals entangled in fishing debris, and the time over which lost gear continues to entangle organisms varies with site and gear type[72]. However, of a population of photo-identified[73] right whales in the North Atlantic, 83% showed evidence of entanglement in ropes and nets[74]. The occurrence of entanglement can also be related to behavioural factors in specific organisms, such as seabirds using ropes in nest building, and young seals playing with floating objects[75]. Entanglement in fishing gear can either cause wounds and infection, prevent food acquisition and predator avoidance, cause deformation during growth, or prevent marine mammals or sea turtles reaching the surface, causing drowning[76].

A review of published literature addressing entanglement and ingestion risks from marine debris showed that almost 16,000 marine mammals, fish, birds and sea turtles had been entangled by rope and netting,

[69] Pham et al., 2014 (https://bit.ly/2GPP58F)
[70] Wilcox et al., 2016 (https://bit.ly/2HI2CNw)
[71] Wilcox et al., 2016 (https://bit.ly/2HI2CNw)
[72] Kühn et al., 2015 (https://bit.ly/2IxcDAp)
[73] Photo identification is the process of using photos to identify individuals in a population. It is a common method to estimate population size and monitor cetaceans in the wild.
[74] Knowlton et al., 2012 (https://bit.ly/2VKj2fw)
[75] Kühn et al., 2015 (https://bit.ly/2IxcDAp)
[76] Kühn et al., 2015 (https://bit.ly/2IxcDAp)

across over 160 species, and almost 2,000 individuals had ingested these materials across roughly 20 species (Figure 9)[77].

Figure 9: Reports of entanglement and ingestion caused by marine debris according to number of (a) individuals, (b) species, and (c) documents/papers per debris type[78]



[77] Gall and Thompson, 2015 (https://bit.ly/2GsKTeN)
[78] Gall and Thompson, 2015 (https://bit.ly/2GsKTeN)

The impact assessment for the EU Single-Use Plastics Directive identified that the highest impacts of fishing gear were entanglement, transport of invasive species, microbial contamination, and economic impacts on tourism and fisheries (Table 6) [79].

Table 6: Impact of the top 10 most commonly found single use items plus fishing gear[80]

	Entanglement of marine wildlife	Ingestion by marine animal	Pollution of marine waters (chemicals release, micro-plastics)	Transport of invasive species (rafting)	Microbial contamination	Economic impacts on tourism	Economic impacts on fisheries	Potential human health impacts
Drinks bottles & caps	+	++	+	+++	+++	+++	+	+
Cigarette butts	-	+++	+++	+++	+++	++	++	+
Cotton bud sticks	-	+++	+	+++	+++	++	+	+
Crisp packets	**+**	**+++**	**+**	**+++**	**+++**	**+++**	**++**	**+**
Sanitary applications	**+**	**++**	**++**	**+++**	**+++**	**+++**	**++**	**+**
Plastic bags	+++	+++	+	+++	+++	+++	+++	+
Cutlery, straws & stirrers	+	+++	+	+++	+++	++	+	+
Drinks cups & lids	+	++	+	+++	+++	+++	+	+
Balloons & sticks	+	+++	+	+++	+++	+	+	+
Food containers	++	++	+	+++	+++	+++	++	+
Fishing gear	**+++**	**++**	**++**	**+++**	**+++**	**+++**	**+++**	**+**

Environmental issues are not the only risks; marine litter of fishing gear causes serious problems in terms of navigation, with ship propellers becoming entangled in ALDFG, in one case reportedly leading to capsizing of a vessel in Korean waters with the loss of 292 lives[81].

2.3 Key points of leakage and pathways into the marine environment in Scotland

Estimates suggest that 10% of all marine litter is ALDFG[82] and nets and ropes accounted for between 13% and 33% of marine litter in OSPAR beach surveys most representative of Scotland and surrounding

[79] EC, 2018 (https://bit.ly/2GsEwbq)
[80] EC, 2018 (https://bit.ly/2GsEwbq)
[81] FAO, 2018 (https://bit.ly/2InnJJ4)
[82] FAO, 2018 (https://bit.ly/2InnJJ4)

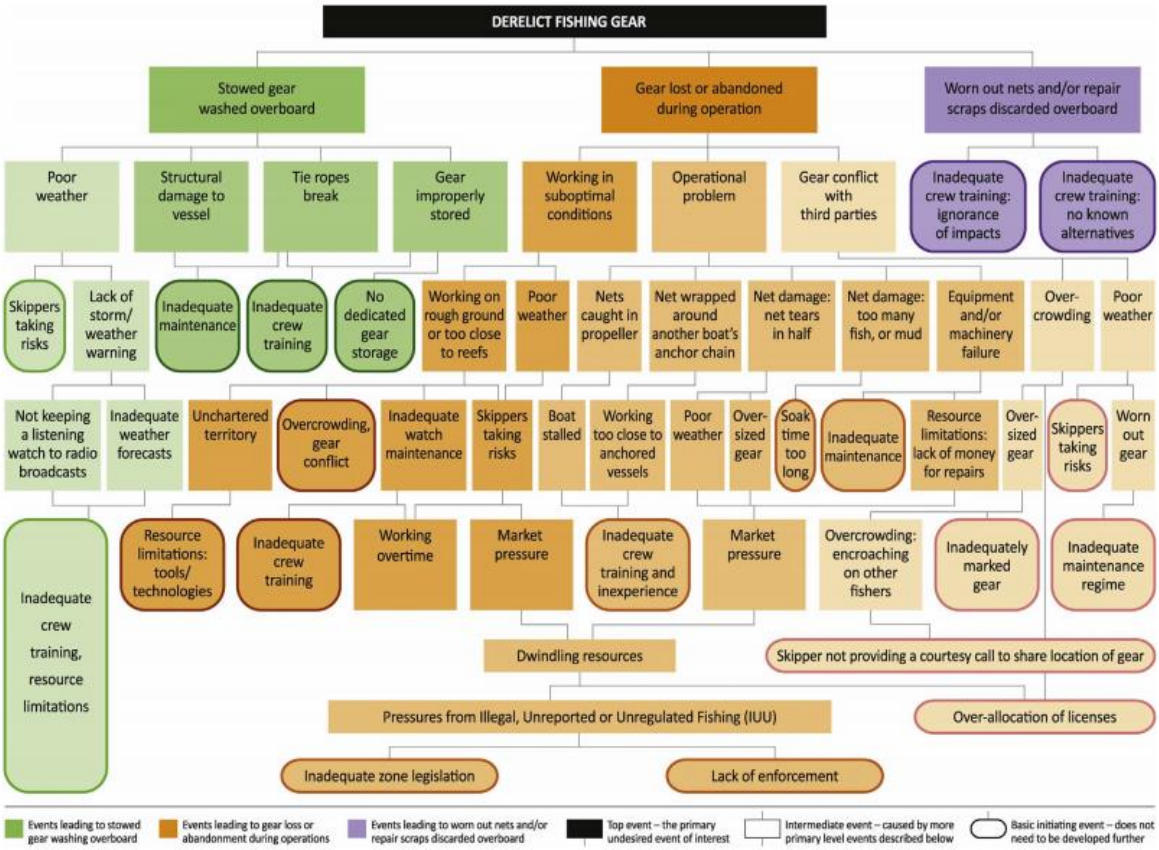
maritime areas.[83] Generally, likely due to the sensitivity of the topic, and bias which occurs when asking individuals to admit to illegal behaviour, it is not well understood how much ghost gear is caused by loss vs. abandonment. An analysis of the Fishing for Litter scheme in the South West of England has shown that around 35% of fishermen who were not involved in Fishing for Litter sometimes threw unwanted items overboard when at sea, compared to less than 10% of those who were involved with the scheme[84].

While legislation to prevent dumping of waste in the ocean is theoretically comprehensive, gaps still exist[85]. Of relevance to Scotland is that mandatory vessel monitoring is only applicable to vessels of 12m or more, a category which only 27% of the Scottish fleet falls into[86]. The 2017 guidelines for the implementation of MARPOL Annex V[87], which prohibits the dumping of waste at sea, concedes that direct enforcement of the Annex is difficult. It recommends that governments consider not only restrictive and punitive measures, but also the removal of disincentives, creation of incentives and initiatives to facilitate compliance, and the development of voluntary measures to ensure compliance. No fishing vessel has ever been prosecuted under MARPOL Annex V in the UK.

A recent study conducted in Australia and Indonesia concluded that 78% of fishers identified snagging of nets; 19% gear conflicts with third parties; and 2% poor weather as the main causes of gear loss[88]. The study also found a significant negative correlation between frequency of net repair/replacement and net loss, i.e. the more regularly nets are repaired, the less frequently they are lost, with 12% of Indonesian gillnet fishers discarding unusable nets overboard (no Australia fishers stated doing this)[89]. This data is self-reported, so may represent an underestimate if fishers do this, but are unwilling to admit to it. This study developed a graphical representation of the causes of derelict fishing gear (Figure 10), which shows that the main causes of gear loss can be traced back to inadequate training of crew, inadequate zone legislation, lack of enforcement and over-allocation of licenses; and the main ways gear is lost are via worn out nets being discarded overboard, loss or abandonment during operation, and stowed gear washing overboard. There is currently no such research which quantifies the causes and pathways of ALDFG in Scotland.

[83] 13% in the Celtic Sea and 33% in the Northern North Sea. https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities/marine-litter/beach-litter/
[84] DEFRA, 2014 (https://bit.ly/2XIBmGC)
[85] Brodbeck, 2016 (https://bit.ly/2IBLfRZ)
[86] Scottish Government, 2018 (https://bit.ly/2GfOHPh)
[87] MEPC, 2017 (https://bit.ly/2GKCLbb)
[88] Richardson et al., 2018 (https://bit.ly/2UAac7A)
[89] Richardson et al., 2018 (https://bit.ly/2UAac7A)

Figure 10: Graphical representation of causes of loss of derelict fishing gear from fishing vessels[90]



2.4 Why leakage happens – economic, behavioural and social factors (drivers and barriers)

2.4.1 Economic and competitive forces

The number of active Scottish based vessels has increased to 2,065 vessels in 2017, a two per cent increase (32 vessels) since 2016 and a six per cent decrease (135 vessels) since 2008. The Scottish fleet is dominated by vessels that are ten metres and under in length, with a total of 1,503 vessels falling into this category in 2017, accounting for 73 per cent of the Scottish fleet. 562 vessels are over ten metres in length[91]. Regulations differ depending on length of vessel, with lighter requirements on shorter vessels.

In the UK, fishing and fish processing employs 22,000 people. Fishing communities have been in gradual decline over the past 40 years[92]. Fishers experience considerable financial pressure due to the

[90] Richardson et al., 2018 (https://bit.ly/2UAac7A)
[91] https://www.gov.scot/publications/scottish-sea-fisheries-statistics-2017/pages/4/
[92] Seafarers UK (2018) 'Fishing for a Future', p. 1 https://www.seafarers.uk/wp-content/uploads/2018/01/Fishing-for-a-Future.pdf [Accessed 22 April 2019]

unpredictable nature of their earnings and 61% of port neighbourhoods are classed as deprived, as measured by the Index of Multiple Deprivation[93].

The use of plastics in the manufacture of fishing gear has reduced production costs for net/line manufacturers.. In some cases, the use of plastics improves quality and durability of fishing gear, e.g. pots are made from stainless steel, but the metal is coated in polypropylene to improve the durability of the steel and minimise rusting. Plastic materials also improve hygiene of products and minimise odours, improving quality of life for fishers and producers. Organic materials such as hemp can rot or become increasingly weighed-down and heavy during use. This can pose a risk to fishers operating heavy machinery, thus lighter plastic materials can improve health and safety for users.

There is often an economic disincentive to correctly dispose of used nets and fishing gear as the combined cost of handling, transport and disposal can be prohibitive when landfilled and is subject to the high rate of landfill tax. Moreover, the economic burden of waste disposal is placed solely on fishers when ports do not include waste management as part of port dues. Some synthetic equipment components are relatively inexpensive to purchase, costly and time consuming to repair, and correctly disposing of fishing gear is expensive, thus there is no economic incentive for fisherman to bring gear ashore to be disposed of. If a fisher chose to dispose of waste gear in the sea the likelihood of being caught in the act is extremely low. The externalities of plastics in the environment are not factored into the cost of plastic materials, which continue to be a cheap and abundant manufacturing material.

There are many factors that contribute to performance of fishing gear. Equipment performance can be influenced by towing speed, sea state, bottom type and condition of equipment. Moreover, catch rates can be dependent on weather conditions, fish abundance, time of year and other factors.[94] Costs associated with commercial fishing trips include fuel costs, labour costs, quota leasing, equipment, ice and boxes. Rising fuel costs have added additional economic pressures to fishers in Scotland and across EU.

The capacity of fishing fleets is dependent on licensing, limiting volume and power of fleet which is a measure of fishing effort.[95]. In Scotland's fishing zones, there is competition from EU fleets. The majority of fish and shellfish landed in UK's Exclusive Economic Zone (EEZ) by EU fishing boats is caught by non-UK boats[96]. It can be difficult to identify lost or abandoned fishing gear and trace it back to specific users due to the wide range of competitors operating in Scottish waters.

2.4.2 Social norms and behaviours at leakage points

The decision to litter is often linked to a 'commons dilemma', a situation that occurs when people choose options that are of personal benefit without considering the costs to others. This is exacerbated by people's impulsivity and influence of emotions along with competing pressures for attention and cognitive resources. Behaviour science indicates that people determine the benefit, or a cost, to themselves through

[93] Seafarers UK (2018) 'Fishing for a Future', p. 2 https://www.seafarers.uk/wp-content/uploads/2018/01/Fishing-for-a-Future.pdf [Accessed 22 April 2019]
[94] https://www.seafish.org/geardb/wp-content/uploads/2017/12/Industry-led-Best-Practice-Guidance-06122017-FINAL.pdf
[95] https://www.gov.scot/publications/scottish-sea-fisheries-statistics-2017/pages/4/
[96] Napier, I (2016) *Fish Landings from the United Kingdom's Exclusive Economic Zone, and UK Landings from European Union's EEZ*, p i https://www.nafc.uhi.ac.uk/t4-media/one-web/nafc/research/document/eez-reports/report-uk-eez-2016-10-11-final.pdf [Accessed 22 April 2019]

reference to their own personal rules, norms and/or arbitrary clues that arise from the situation context[97]. Commons dilemmas and personal cost/benefit analysis are considered the cause of most littering decisions so apply across all four product categories in this research and are particularly relevant to fishing gear littering. It is also worth noting that commons dilemmas can be influenced by small alterations in choices.

In the case of littering commercial fishing gear, more specific common drivers have been found to be poor crew training, resource limitations, and/or management of fishing zones – all common themes leading to the occurrence of ALDFG[98].

The Norwegian Directorate of Fisheries undertakes an annual clean-up of ALDFG and from 2018 started to return gear to relevant parties where ownership can be verified. This appears to increase motivation to self report lost gear.

It is reported that over-allocation of fishing licences, unregulated fishing and Illegal, unreported and unregulated fishing (IUU) fishing pressures[99] can result in overcrowding and overcapacity and so increasing competition[100] in a fishing zone. This competitive scenario can be a driver for skippers and crews to take risk-taking behaviours[101], including gear conflict and equipment dumping especially in relation to Scottish fishers.

A strong link between net repair and replacement was found by Richardson for Australian and Indonesian fishers, and better crew training[102] on the need for regular maintenance of nets and fishing gear can help reduce net losses and damage. A need for gear marking and/or identification was also raised[103].

A significant barrier to correct net and fishing gear disposal can be attributed to cost, especially where vessels are not making significant financial returns[104]. Increased pressure caused by poor economic circumstance make it more difficult to maintain a high level of crew training[105] so where budgets and time are short, the sea provides a quick and easy route for disposal.

Research with Taiwanese fishermen by Chen and Liu in 2013 highlighted a link between marine littering behaviour and both the presence of established household recycling practices and the provision of adequate collection facilities at ports[106]. Whilst the cultural situation and fishing industry in Taiwan is very different to Scotland, it could be inferred that ensuring recycling programmes are well established and

[97] Kolodko, Julia and Read, Daniel (2018) Using behavioural science to reduce littering. http://wrap.warwick.ac.uk/100201

[98] Mitchell (2019), Low hanging fruit? Action on single-use plastic to reduce marine plastic pollution. Marine Scotland.

[99] Richardson, K., Gunn, R., Wilcox, C. & Hardesty, B.D. (2018). 'Understanding the causes of gear loss provides a sound basis for fisheries management', Marine Policy, 96, pp. 278-284

[100] Amos. (2015) Fisherman call for action over equipment dumping. https://www.scotsman.com/news/environment/fishermen-call-for-action-over-equipment-dumping-1-3927631

[101] Richardson, K., Marine Policy (2018), Understanding causes of gear loss provides a sound basis for fisheries management. https://doi.org/10.1016/j.marpol.2018.02.021

[102] Mitchell (2019), Low hanging fruit? Action on single-use plastic to reduce marine plastic pollution. Marine Scotland

[103] Richardson, K., Marine Policy (2018), Understanding causes of gear loss provides a sound basis for fisheries management. https://doi.org/10.1016/j.marpol.2018.02.021

[104] Richardson, K., Marine Policy (2018), Understanding causes of gear loss provides a sound basis for fisheries management. https://doi.org/10.1016/j.marpol.2018.02.021

[105] Kolodko, Julia and Read, Daniel (2018) Using behavioural science to reduce littering. http://wrap.warwick.ac.uk/100201.

[106] Mitchell (2019), Low hanging fruit? Action on single-use plastic to reduce marine plastic pollution. Marine Scotland.

understood by Scottish crew members (both at their home and in Scottish ports encouraging a general culture of environmental awareness) could have an impact on improving behaviour at sea.

2.4.3 Where value is lost at each point in the chain

With all four products, value loss occurs in multiple ways:

- Value loss during use
- Economic damage caused by litter, for example:
    - ALDFG tangling in boat propellers
    - Economic damage to fishing industry – effects on fish stocks, perception by consumers of not just product, but irresponsible industry behaviour.
    - Increased road accidents due to litter or litter picking activities distracting drivers
- Environmental damage caused by litter:
    - Quality of land and marine environment
    - Resultant economic and social impact of devalued environment
        - Inward investment discouraged by poor quality environment, which has a negative effect on local economies and people's welfare, which in turn causes a downward economic spiral
- Opportunity costs
    - Loss of recycling value
    - Loss of value from failing to reuse items

Regarding commercial fishing gear, value is lost steadily with use as gear becomes worn and damaged. Its functionality can be replenished if gear is repaired. Damaged gear makes it more difficult to catch fish, leading to lost value in terms of lost earnings; and is also more likely to get caught and damaged further or lost completely.

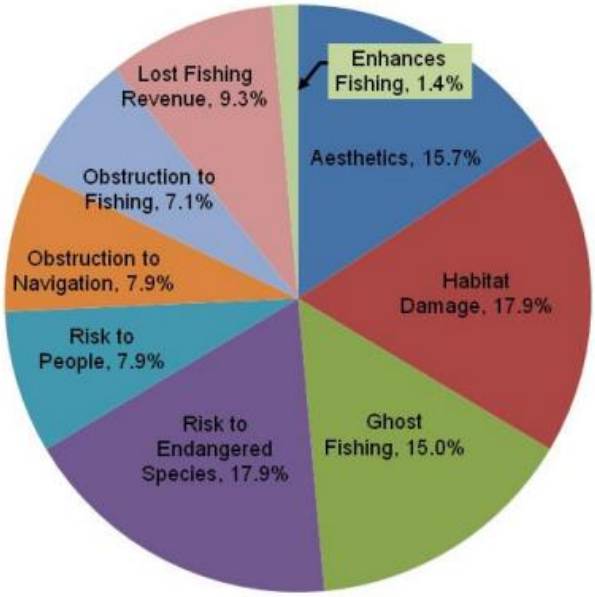
Value is also lost in terms of missed recycling opportunities. Organisations such as Fishy Filaments and Aquafil show there is value to be made from recycling this material. Fishy Filaments charges £400/10kg of their recycled nylon micro-pellet[107].

ALDFG also causes lost value in numerous ways due to its inappropriate disposal. Ghost fishing depletes potential catch, leading to lost value from lost income[108]. It entangles other gear and damages vessels, leading to lost value from reduced ability to work, as well as the cost of replacing gear and repairing vessels[109]. These externality damage costs are not currently represented in the sale price of fishing gear or accounted for in the product value chain.

Further value is lost in terms of reduced tourism value, as well as the cost of removing gear from beaches. A survey conducted in the Caribbean showed that participants more commonly stated the aesthetic impact than ghost fishing impacts when asked about the impact of ALDFG (Figure 11), reflecting the visual disamenity cost of beach litter.

[107] Fishy Filaments, 2019 (https://bit.ly/2Piqegu)
[108] Global Ghost Gear Initiative, 2018 (https://bit.ly/2PkcvWr)
[109] Global Ghost Gear Initiative, 2018 (https://bit.ly/2PkcvWr)

Figure 11: Effects of ALDFG reported by survey participants[110]



Fishing gear retrieval efforts can also be costly. The Norwegian Directorate of Fisheries conducts annual net retrieval surveys. In 2004, 103 hauls retrieved 589 nets, alongside other fishing gear (lines, dredges, etc.), at a total cost of 1.5 million NOK (around £121,000 in 2004)[111]. The majority of this cost, 1.1 million NOK, was spend on boat fire and fuel for one month, with 0.12 million NOK spent on a collecting information via a fishermen's survey, and 0.28 million spent on survey labour cost and expenses.

2.4.4 How market economics can affect behaviour change

Gilman et al. (2016)[112] reviewed ALDFG for the UN FAO and compiled a list of measures to prevent and remediate ALDFG and associated ghost fishing, both directly and indirectly. Preventative measures included gear marking, technology to avoid unwanted gear contact with the sea bed, technology to track gear position, gear design and materials which reduce risk of gear loss, economic incentives for proper disposal of unwanted gear and disincentives for creating ALDFG, among others[113]. Remedial actions included gear design and fishing practices which reduce ghost fishing catch and mortality rates of species of conservation concerns, using less-durable and degradable gear to reduce ghost fishing duration, among others[114]. At present, only half of 18 measures identified to prevent and remediate ALDFG were used by organisations with the competence to establish binding controls for marine capture fisheries[115].

[110] Matthews, 2017 (https://bit.ly/2Gnjt9a)
[111] https://ieep.eu/uploads/articles/attachments/4a24b509-013d-44ca-b26e-47c8f52e29c4/ghostfishing.pdf?v=63664509699
[112] Gilman et al., 2016 (https://bit.ly/2ISGtQ7)
[113] Gilman et al., 2016 (https://bit.ly/2ISGtQ7)
[114] Gilman et al., 2016 (https://bit.ly/2ISGtQ7)
[115] Gilman, 2015 (https://bit.ly/2IQdLiL)

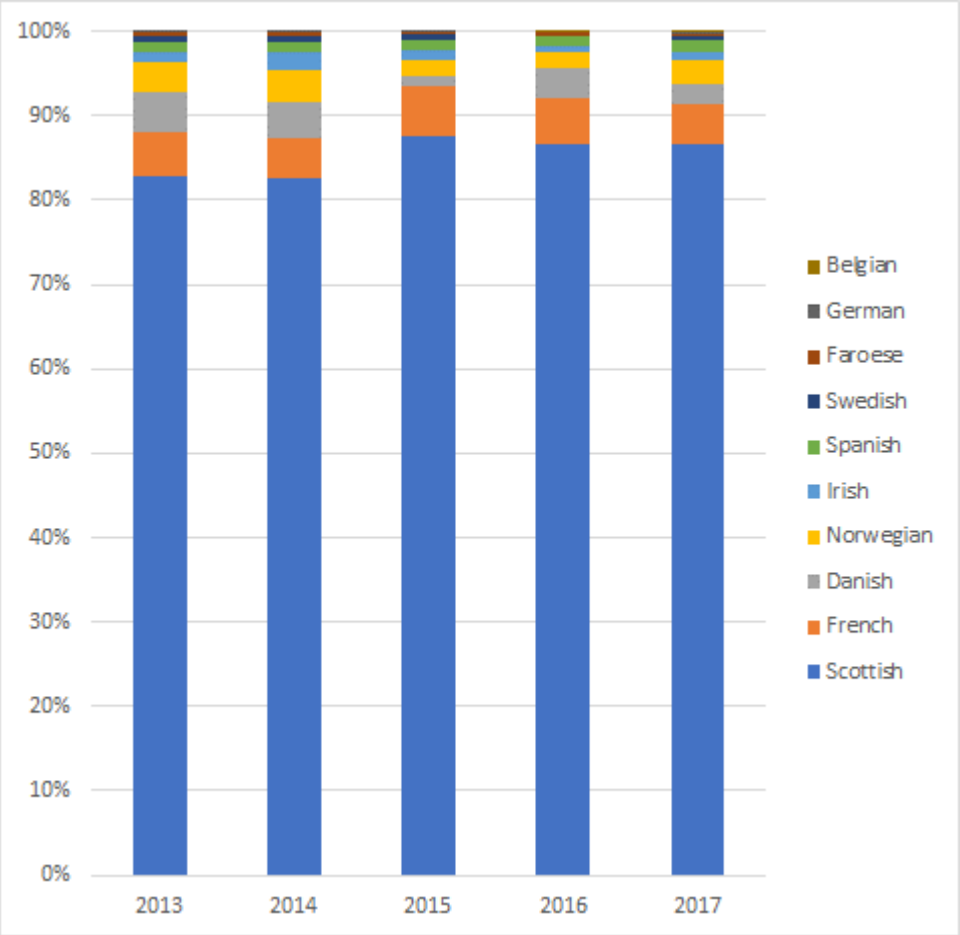
2.5 Decision points with opportunities to minimise marine plastics

2.5.1 Material and design alternatives, potential impacts these might have, barriers to uptake

The FAO convened a Technical Consultation on the Marking of Fishing Gear, during which the Voluntary Guidelines on the Marking of Fishing Gear were adopted[116]. The guidelines are voluntary and global in scope and apply to all fishing gear types used in all fishing activities in all oceans and seas[117]. Complexity of marking should be based upon necessity and practicality, and all interested parties should be involved in development, implementation and regulation of a marking system[118]. The Guidelines are considered to be an important tool in minimising the impact of ALDFG and in illegal fishing, and pilot projects have been conducted to demonstrate feasibility[119], however fishermen are likely to be resistant to any measures which increase cost or effort. Gear marking will likely be difficult to regulate, particularly when many nationalities fish in Scottish waters (Figure 12), and the situation following Brexit is as yet unknown. Gear tagging is also being considered as part of the Marine Litter Action Plan by OSPAR[120].

[116] FAO, 2018 (https://bit.ly/2IohyVi)
[117] FAO, 2018 (https://bit.ly/2IohyVi)
[118] FAO, 2018 (https://bit.ly/2IohyVi)
[119] ICES-FAO, 2018 (https://bit.ly/2UCwuFP)
[120] OSPAR, 2014 (https://bit.ly/2YduTHg)

Figure 12: Percentage of total landings in Scotland made by nationality[121]



Discussions around alternative materials for fishing gear are also ongoing, however even when they show catch rates similar to conventional nets, it is clear that there are many uncertainties, challenges and knowledge gaps to be filled before conclusions can be drawn around their benefits[122].

2.5.2 Alternative products and circular economy business models

Plastic used for fishing gear is generally high quality, but only 1.5% is effectively recycled[123]. As such, the European Commission is looking at schemes to provide tools and incentives which facilitate recovery, re-use and recycling including EPR schemes[124]. The suggested EPR scheme would remove the financial disincentive from bringing retrieved gear ashore, by passing the cost from fishermen to producers, which should also accelerate the development of a dedicated waste stream for fishing gear waste[125].

[121] Scottish Government, 2018 (https://bit.ly/2GfOHPh)
[122] Kim et al., 2016 (https://bit.ly/2VnvZyR)
[123] EC, 2018 (https://bit.ly/2xirnPV)
[124] EC, 2018 (https://bit.ly/2xirnPV)
[125] EC, 2018 (https://bit.ly/2xirnPV)

If EPR is introduced for commercial fishing gear, decisions will need to be made to confirm a variety of aspects:

- Centralisation vs localisation of recycling and re-use schemes;
- Review points and performance indicators;
- Full net cost recovery or an alternative;
- Overseeing body to set targets;
- Collection standards;
- Point of obligation; and
- Basis of fees paid (specific materials, weight, etc.).

At present, major fishing net recycling schemes are centralised, such as Aquafil in Slovenia[126]. However, material has to travel great distances to reach the recycling plant, with associated carbon impacts. Arguments have been raised for the localisation of net recycling as a more appropriate means of dealing with resources from a local industry whilst benefitting local economies and reducing costs associated with transport[127]. The degree of localisation applied must ensure economies of scale and avoid duplication of resources – the British Irish Council (BIC) decided this year to collaborate to establish a recycling facility for fishing gear within the BIC region to encourage better waste management whilst managing economies of scale[128].

2.6 Levers available to the Scottish Government (intervention and support)

Various levers are available to the Scottish Government to reduce marine plastics, both regulatory and non-regulatory, which can broadly be categorised as:

1. **Command and control measures** – such as product or material bans, product design requirements, licensing and prohibition of specific activities,
2. **Market based measures** - such as subsidies, taxes and charges, and
3. **Communicative, persuasive measures** - such as stakeholder co-ordination, voluntary agreements, consumer campaigns, labelling, innovation and challenge funds.

These categories and measures are explored in the following paragraphs in general terms as applying to all products not just commercial fishing gear. Fishing gear specific levers are then explored in the subsequent report sections.

Command and control measures

Product bans can remove specific harmful products from the market, as was recently exercised with respect to the manufacture and sale of rinse-off personal care products containing plastic microbeads, and planned for plastic-stemmed cotton buds[129]. In the context of fishing gear and other 'necessary' products, proposed bans should consider if functional alternatives exist or provide sufficient lead-in time for manufacturers to create them. The UK Government can also specify requirements for product design, labelling and use in the way that other potentially harmful products/services are controlled such as guns,

[126] Recycling Today, 2019 (https://bit.ly/2Fyi55p)
[127] Fishy Filaments, 2017 (https://bit.ly/2GzX0pc)
[128] BIC, 2019 (https://bit.ly/2Y2zDj6)
[129] https://www2.gov.scot/Topics/marine/marine-environment/litter/Initiatives

tobacco and gambling. Licensing and regulation can be used to control of prohibit specific high-risk activities.

Market based measures

The Government has power to influence markets and encourage innovation with guidance, targets and support. Whilst not the focus of this research, consumer behaviour and consumption can be influenced through economic levies, as demonstrated with the 5p single-use carrier bag charge, while more sophisticated economic measures, such as EPR, can link manufacturers to end-of-life impacts. The private sector would also react to such levers and incentives. Subsidies can also be used to address market failures in favour of environmental outcomes. Fines and criminal charges can be used to deter and penalise illegal activities.

Communicative, persuasive measures

The Government can play an important role to facilitate information exchange and collaboration amongst stakeholders across the value chain. This can help to explore issues in detail and from every angle, aid understanding of how decisions affect others in the value chain and collaborate on solutions. Once a preferred direction is established, Government can assist in disseminating information and guidance to a wider audience than those already actively engaged on the issue, for example through strategy documents and workshops. Voluntary agreements can be encouraged and supported by government to provide a co-ordinated approach to an issue and recognition of efforts made by industry. A voluntary approach is often favoured where coordination and legislative cost are high (e.g. monitoring and enforcement) as recognition for voluntary parties acts as an incentive to act. Consumer campaigns and voluntary product labelling are often used to inform and influence consumer and producer behaviour, and can stimulate innovation in product design to meet emerging preferences. Government can also direct and stimulate innovation within the market through innovation and challenge funds as well as more traditional forms of investment and business support.

In the following section, regulatory measures for commercial fishing gear are explored first in terms of levers available to the Government, the existing legislative framework and proposed legislation that could be adopted or used to tackle marine plastics. Non-regulatory measures are then discussed in the context of behavioural research and case study examples, government support for initiatives and relevant technological and market developments. Some examples of the measures listed above were identified in the literature review, whilst some recent developments are not yet publicised. Details of further measures and initiatives gathered from stakeholder engagement will be reported in subsequent stages of this project.

It is worth noting that for commercial fishing gear, much of the regulation discussed is derived from EU Directives and adopted in UK or Scottish law. Whilst general uncertainty around Brexit continues, the UK Government position on environmental legislation is clear: the EU (Withdrawal) Act will ensure existing EU environmental law continues to have effect in UK law after exit[130]. All EU-derived waste legislation will be

[130] https://www.gov.uk/government/publications/upholding-environmental-standards-if-theres-no-brexit-deal/upholding-environmental-standards-if-theres-no-brexit-deal

retained, and new legislation introduced as necessary to meet ambitions[131]. However, it is not clear how new Directives and revisions to existing Directives will be treated in the UK in the event of leaving the EU.

2.6.1 Regulatory measures

The fishing industry is one of the most tightly controlled industries in Scotland, with detailed regulation, management and reporting systems to ensure a healthy and productive environment for future generations. Whilst the majority relates to protecting fish stocks through quotas and operational guidelines there are also many complementing regulations and activities designed to tackle fishing gear waste and marine plastics. Key policies and the levers they employ are discussed below.

MARPOL (the International Convention for the Prevention of Pollution from Ships) Annex V expressly prohibits the discharge of all plastics to sea[132]. 153 states have signed this agreement accounting for 99% of world fishing capture[133] including the UK and all EU Member states. However, under the UK transposition of the MARPOL Annex V smaller vessels do not have the same waste management requirements, and no vessel has been prosecuted under Annex V in the UK[134]. There are no laws in Scotland specifically prohibiting and penalising the discharge of waste to sea, although The Future of Fisheries Management in Scotland (2019)[135] discussion paper states that the Scottish Government will explore the mechanisms to establish this as an offence.

Fishermen are obligated to attempt to retrieve lost gear under EU regulations[136] and UK law[137], but no such legislation was found in Scotland. UK law also sets out gear marking requirements, managed and enforced by the Marine Management Organisation, but no such legislation exists in Scotland[138]. Instead, the Scottish Government published best practice guidance on marking static fishing gear in 2018 that "recognises and responds to concerns of some fishermen who operate in a variety of conditions, allowing those fishermen to responsibly apply their judgment to safely mark gear"[139]. The Scottish Government plans to introduce gear marking legislation to improve gear marking by banning the use of inappropriate items and requires fishers to mark gear so that the owner can easily be identified – including licensed fishermen to mark their gear with the PLN of their vessel.

Clean-up and end-of-pipe solutions are often considered a last resort as most prefer preventative measures for marine litter. The Environmental Protection Act (1990) sets requirements of 'duty bodies' held responsible for keeping public places clear of litter, mainly local authorities and statutory undertakers such as Network Rail, but also academic institutions such as schools, colleges and universities[140]. In Scotland, a

[131] HM Government (2018), Our waste, our resources: A Strategy for England, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/765914/resources-waste-strategy-dec-2018.pdf
[132] http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Marine-Environment-Protection-Committee-(MEPC)/Documents/MEPC.295(71).pdf
[133] http://www.imo.org/en/About/Conventions/StatusOfConventions/Documents/StatusOfTreaties.pdf
[134] Comments from Marine Scotland
[135] https://www.gov.scot/publications/national-discussion-paper-future-fisheries-management-scotland/
[136] Council Regulation (EC) No 1224/2009 establishing a Community control system for ensuring compliance with the rules of the common fisheries policy, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009R1224
[137] https://www.gov.uk/guidance/marking-of-fishing-gear-retrieval-and-notification-of-lost-gear
[138] https://www.gov.uk/guidance/marking-of-fishing-gear-retrieval-and-notification-of-lost-gear
[139] https://www2.gov.scot/Topics/marine/Sea-Fisheries/InshoreFisheries/static-gear-marking
[140] https://www2.gov.scot/Publications/2006/12/13125718/29

large proportion of the coastline is privately owned by Crown Estate Scotland, and beach cleans are typically organised by NGOs and local community groups. The cost and ease of using port reception facilities to deliver waste from fishing vessels is thought to be a significant factor in how end-of-life gear and retrieved derelict gear is handled. How waste is received on shore is dictated by the EU Port Reception Facilities (PRF) Directive[141], implemented in UK law through the Merchant Shipping and Fishing Vessels (Port Waste Reception Facilities) Regulations 2003. The Directive aligns with MARPOL Annex V, which requires Governments to ensure adequate port reception facilities to reduce solid waste pollution from ships. The PRF Directive requires vessels to deliver all ship-generated waste to a port reception facility and for ports to develop Waste Handling Plans. Most ships are required to notify ports in advance of the waste they wish to deliver and pay a mandatory fee to significantly contribute towards the costs of waste management – meaning at least 30% of the costs should be covered by a direct fee[142]. Intriguingly, while the fee is required to cover 30% of waste costs, somewhat paradoxically, it must simultaneously "provide no incentive to discharge their waste into the sea" [143]. However, fishing vessels are exempt from the requirements of waste notification and mandatory fee under the Directive. Fishing vessels are exempt from specific inspection requirements set in the Directive, but Member States are given the broad requirement to 'establish control procedures' for fishing vessels to the extent required to comply with the requirements of the Directive.

In implementing the PRF Directive, ports have chosen different cost recovery systems to charge vessels for their waste. Some cost recovery systems are criticised as providing an incentive to discharge waste at sea. In many ports the fee charged increases for greater quantities of waste creating an economic disincentive to deliver all waste to port[144] [145]. Outside of fishing for litter schemes, there are insufficient free facilities for vessels bringing retrieved fishing gear ashore, even though they are not the waste producer. Calls for harmonisation of best practice from port users and environmental groups have led the European Commission to address these concerns in a proposed revised PRF Directive. The proposed revisions require vessels to deliver their waste before departure from the port, and for a 'no special fee' (also called the '100% indirect fee') cost recovery system whereby vessels, including fishing vessels, pay a flat fee for port reception facilities irrespective of the delivery of waste and without any additional direct charges[146]. A 'green ship' concept is also to be adopted whereby ships that demonstrate sustainable on-board waste management pay reduced fees[147].

The EU recognises that whilst the '100% indirect fee' system will remove direct economic disincentives to deliver fishing waste, the costs of expanding port reception facilities will most probably lead to increased

[141] European Directive on Port Reception Facilities for Ship-generated Waste and Cargo Residues
[142] https://eur-lex.europa.eu/resource.html?uri=cellar:15945efb-a7e8-4840-ab4d-0535f12692a8.0004.02/DOC_2&format=PDF
[143] European Directive on Port Reception Facilities for Ship-generated Waste and Cargo Residues
[144] https://seas-at-risk.org/17-marine-litter/834-new-port-reception-facilities-proposal-what-does-it-mean-for-sea-sourced-marine-litter.html
[145] http://www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities/download/445/235/23.html
[146] https://ec.europa.eu/fisheries/new-proposal-will-tackle-marine-litter-and-%E2%80%9Cghost-fishing%E2%80%9D_en
[147] http://www.europarl.europa.eu/RegData/etudes/BRIE/2019/633180/EPRS_BRI(2019)633180_EN.pdf

port fees and therefore, indirectly, increase costs for fishing vessels[148]. The EU proposes EPR and other measures to address this. Outlined in the EU Strategy on Plastic, the Commission sets aims to develop targeted measures for reducing the loss or abandonment of fishing gear at sea, including deposit schemes, EPR and recycling targets[149]. EPR for fishing gear is also one of the measures set out in the proposed Single-use Plastic and Fishing Gear Directive[150]. The aim of introducing these measures is to create a positive economic incentive for fishing vessels to bring waste to shore and to ease the cost burden for small scale ports and fishing operators by sharing costs amongst producers. The wider aims of EPR include to internalise the environmental cost of marine litter, attract innovation for more sustainable materials, stimulate the recycling market, help our fishermen and offer further protection of our ocean[151].

EPR costs will fall primarily on producers of fishing gear containing plastics, and fishermen and artisanal makers of fishing gear containing plastic will be exempt from EPR. The EU estimates the cost to fishermen will be 0.16% of revenue[152]. The Circular Economy Package revisions to the Waste Framework Directive include setting general minimum requirements for EPR schemes (article 8a). This states that producers will cover costs of waste collection, transport and treatment necessary to meet EU targets, costs of providing adequate information to waste holders, and costs of data gathering and reporting, amounting to at least 80% of necessary costs. However, fees can be modulated for products, notably by taking into account their durability, reparability, re-usability and recyclability and the presence of hazardous substances[153]. It also requires waste management targets to be set, in line with the waste hierarchy, ensure data gathering and reporting systems are in place, and ensure a regular dialogue between stakeholders (including producers and distributors, waste operators, local authorities, civil society organisations and, where applicable, social economy actors and the re-use and repair sector). EPR therefore represents a powerful mechanism to link producers to end of life impacts and to create an economic incentive to use product design to minimise unwanted environmental impacts.

A '100% indirect fee' system combined with measures such as EPR and deposit-return aims to replace the significant economic disincentives for fishing vessels to deliver waste to shore with positive incentives that lead to behaviour change. This could dramatically increase the amount of end-of-life and derelict gear entering the waste system whilst reducing plastic marine litter. There is opportunity for The Scottish Government in choosing what measures it adopts, how they are designed and when they are implemented, and in the case of EPR, how it will adhere to a single EPR framework for all product types as proposed in the 2016 Circular Economy Strategy for Scotland[154]. Support would be needed to create a large-scale fishing industry waste and recycling system, and there is opportunity to design local or centralised processing and decide the level of Government and industry governance or to establish the conditions for a well-functioning private market to fulfil this need. Such considerations will no doubt form part of discussion with

[148] https://ec.europa.eu/fisheries/sites/fisheries/files/lost-fishing-gear_en.pdf
[149] http://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy-brochure.pdf
[150] http://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf
[151] https://ec.europa.eu/fisheries/sites/fisheries/files/lost-fishing-gear_en.pdf
[152] https://ec.europa.eu/fisheries/new-proposal-will-tackle-marine-litter-and-%E2%80%9Cghost-fishing%E2%80%9D_en
[153] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0851&rid=1
[154] https://www.gov.scot/publications/making-things-last-circular-economy-strategy-scotland/

British Irish Council (BIC) members in developing a recycling system for fishing gear, as intentions to establish such as system were announced in February 2019[155].

It should also be noted that many commercial fishing activities are licensed and controlled by UK Fisheries Administrations (including the Scottish Administration) to keep fishing within the quotas set in the EU Common Fisheries Policy[156]. Licenses are registered on the UK Ship Register, and advice given by local Marine Scotland Fishery Offices[157]. Controls include specific conditions and requirements, particularly what species a vessel is prohibited from fishing and prohibited or restricted fishing grounds. Penalties include prosecution with fines up to £50,000 for each offence and/or the forfeit of gear and/or fish on board. As different fishing gear is used for different target species the license effectively controls gear use (albeit indirectly).

Overarching strategies around the marine environment and fishing industry will dictate the direction of travel in tackling marine litter. Future measures are expected to align with the aims and principles of these strategies. The primary strategy document in Scotland is the Scottish Marine Litter Strategy (2014)[158], which outlines the vision for a clean, healthy and sustainable marine environment, the strategic direction set to achieve those aims, and specific actions to take, often focussing on co-operation and co-ordination across stakeholder groups. The Strategy outlined actions taken and new actions proposed. It is a long list of actions, including research activities for reuse and recycling of fishing nets at ports, expanding KIMO Fishing for Litter activities, encouraging innovation in product design, improving monitoring and enforcement, incentivising recycling, engagement and training activities with the fishing industry, and collaboration with OSPAR and other countries.

The EU Marine Strategy Framework Directive (MSFD) is also of overarching importance in improving the marine environment and reducing marine litter across the EU. The MSFD requires member states to achieve Good Environmental Status (GES), as defined by 11 descriptors, by 2020. Descriptor 10 relates to litter, requiring that "Properties and quantities of marine litter do not cause harm to the coastal and marine environment". The UK has set a target for marine litter on coastlines “Overall reduction in the number of visible litter items within specific categories/types on coastlines from 2010 levels by 2020” and is establishing programmes of monitoring and measures to achieve GES. A monitoring programme has also been established in Scotland[159].

The Scottish Marine Litter Strategy recognises that many activities would benefit from sharing best practice and a co-ordinated effort across nations. OSPAR is a key vehicle to achieve this as it is the mechanism under which 15 Governments and the EU cooperate to protect the marine environment of the North-East Atlantic. The OSPAR Regional Action Plan for Marine Litter (RAP ML) [160] was established to significantly reduce marine litter, and sets out actions for litter from sea-based and land-based sources, removing existing litter from the marine environment, and education and outreach on the topic of marine litter.

[155] BIC, 2019 (https://bit.ly/2Y2zDj6)
[156] https://www2.gov.scot/Publications/2006/10/30105313/2
[157] https://www2.gov.scot/Topics/marine/Licensing/FVLS/11285
[158] https://www.gov.scot/publications/marine-litter-strategy-scotland/
[159] Comment from Marine Scotland
[160] https://www.ospar.org/documents?v=34422

OSPAR also coordinates and standardises monitoring and assessment activities, which aligns with the MCS beach litter survey methodology, allowing comparison of results.

Specific measures have been proposed to tackle marine litter from fishing gear, including stricter gear marking requirements. The Food and Agriculture Organization of the United Nations (FAO) has developed voluntary guidelines on gear marking with the aim of eliminating Illegal, Unreported and Unregulated (IUU) fishing, commercial traceability of fishing gear marking so it can be traced back to its owner, and reporting and recovery of ALDFG[161].

2.6.2 Non-regulatory measures

Behavioural science indicates a range of tactics suitable to address littering behaviour that could be deemed as relevant to the fishing gear scenario. The following behavioural drivers were identified in the report 'Using behavioural science to reduce littering'[162]:

- **Monetary penalties.** Voluntary penalty schemes run by ports could influence behaviour especially as behavioural science shows that imposing fines on those who litter is the most direct way to increase the personal costs of littering[163]. However, littering behaviour at sea would be difficult (or practically impossible) to monitor, and a balance of gear used and sent for waste management is likely to be too onerous and imprecise to track responsible waste management behaviour. Furthermore, Ports view vessels as customers so may not wish to enforce fines, and penalties will be limited in effectiveness if people doubt they will be enforced. Administration and enforcement resources would be needed to implement voluntary penalties. Waste deposit information is not easily accessible or harmonized with other ports.
- **Incentives.** Incentives, monetary or otherwise, are another good way to encourage people to adopt difficult new behaviours. Whilst monetary markets are very sensitive to the value of the financial offer available (higher values generally illicit increased effort), social markets, more commonly result in higher effort based on altruism so can be more affordable – and so sustainable – incentive options. Social markets include personal and social rewards for efforts, such as the satisfaction of working to benefit others and social recognition of efforts made.
- **Timely prompts.** People often don't think about their actions so a simple verbal prompt may nudge people to hold on to litter until they reach a suitable disposal point. Making the prompt personal and specific will make it more powerful.
- **Communicating consequences through education.** While it is true that people often act automatically and follow the design of the environment they are in, in some cases understanding why a certain behaviour is preferred or undesired can help people understand the broader context and may increase their motivation to change behaviour.

[161] http://www.fao.org/3/CA0196EN/ca0196en.pdf
[162] Using behavioural science to reduce littering (The University of Warwick)
[163] Kolodko, Julia and Read, Daniel (2018) Using behavioural science to reduce littering. http://wrap.warwick.ac.uk/100201

- **Promoting Cooperation.** Communication between group members was found[164] to be one of the more influential factors to address commons dilemmas. Communication between community members allows for education, sharing of common values and the establishment and enforcement of policies aimed at bringing back order.

The Marine Litter Regional Action Plan[165] advises supporting and initiating community or business-based producer responsibility schemes or deposit systems, for example on recycling fishing nets. Research by Richardson et al[166] also raised the issue of gear marking and identification and how unmarked gear increases the chance of eventual gear losses.

Engaging with Scottish fishermen is also seen as a strong behaviour intervention opportunity, as illustrated in examples below.

- The Low Hanging Fruit[167] report recommended **updating training requirements** for new fishers. This would provide opportunity to increase awareness of economic and environmental impacts of gear loss or abandonment within the industry. It would also provide an opportunity to disseminate details on best practices for disposal and recovery. Interviews and workshops with Scottish fishers would also add value to discuss results and identify root causes of gear loss.
- The Marine Litter Regional Action Plan lists a range of opportunities for **increased education,** promoting curricula for marine-related education, promoting or adopting environmental awareness courses for fishermen and the fishery sector and encouraging participation in International, EU and National Litter Clean-up Campaigns.
- Engaging with fishers would also help establish a database on good practice examples of marine litter measures and initiatives which could be shared with other Regional Seas Conventions in order to make action more visible to the public.

Existing voluntary campaigns include:

- Fishing for Litter (FFL) scheme which encourages fishers to responsibly dispose of passively fished litter in the marine environment and to highlight good waste management. It also monitors passively fished litter coming ashore and investigates recycling opportunities. This voluntary scheme has shown significant positive results in reducing the occurrence of marine littering amongst its members whilst also increasing the frequency of litter collection by members[168].
- The "Adopt a beach" system[169] was recommended as a suitable education and outreach option to be undertaken at a national level as a way to implement OSPAR's Regional Action Plan for Prevention and Management of Marine Litter in the North-East Atlantic.

[164] Gifford, R., & Hine, D. W. (1997). Toward cooperation in commons dilemmas. Canadian Journal of Behavioural Science, 29(3), 167–17
[165] OSPAR Commission (2014), Marine Litter Regional Action Plan. https://www.ospar.org/documents?v=34422
[166] Richardson, K., Marine Policy (2018), Understanding causes of gear loss provides a sound basis for fisheries management. https://doi.org/10.1016/j.marpol.2018.02.021
[167] Mitchell (2019), Low hanging fruit? Action on single-use plastic to reduce marine plastic pollution. Marine Scotland
[168] Defra (2014), An evaluation of the Fishing for Litter (FFL) scheme. www.fishingforlitter.org.uk/assets/file/Report%20FFL%202011%20-%2014.pdf
[169] OSPAR Commission (2014), Marine Litter Regional Action Plan. https://www.ospar.org/documents?v=34422 – Adopt a Beach System

Government support for initiatives to reduce marine plastics can enable new ideas and scale-up of innovative approaches or long-term backing where there are insufficient commercial markets for the work. Examples include financial support from the European Maritime and Fisheries Fund for the recovery of litter and gear from the sea as well as the improvement of waste handling infrastructure and management processes on vessels and at ports. For the period 2014-2020, €53 million has been allocated to such projects[170]. Similarly, the KIMO Fishing for Litter scheme is supported by OSPAR and the Scottish Government with further plans to support expansion set out in the Scottish Marine Litter Strategy (see section 2.6.1 above).

Chemical recycling may also provide a waste treatment route that would reduce the cost of managing end-of-life fishing gear, and so potentially diminish the disincentive to dispose of the waste responsibly. Pilots such as Project Beacon in Perthshire[171] can process difficult to recycle plastic products such as fishing gear. However, chemical recycling is a relatively new technology and there is currently only limited treatment capacity available.

2.7 Summary

Fishing gear is a technical product group. Fishing nets in particular can be constructed from many components and materials. Netting, ropes and coatings used in the sector use plastics to provide product strength, low weight, and flexibility. Fishing gear needs to maintain high performance in an environment with many destructive and abrasive forces and so durability is paramount. There are many fishing gear companies based in Scotland and the UK, but the majority of products are imported.

Fishing gear is a significant marine litter issue, as demonstrated by beach surveys, aerial coastline surveys and benthic surveys in the ecologically active sediment layers of oceans and estuaries. Nets and ropes accounted for between 13% and 33% of marine litter in OSPAR beach surveys most representative of Scotland and surrounding maritime areas.[172] In addition to ingestion and other issues associated with marine litter, fishing gear is particularly dangerous in entanglement of wildlife.

The EU estimates that 20% of fishing gear is lost at sea due to either accidents, storms, entanglement or intentional abandonment[173], and in a recent study conducted in Australia and Indonesia fishers identified snagging of nets to be the main cause, followed by gear conflict and poor weather[174]. There is currently no such research which quantifies the causes and pathways of Abandoned, Lost or Discarded Fishing Gear (ALDFG) in Scotland.

The decision to litter is often linked to a 'commons dilemma', a situation that occurs when people choose options that are of personal benefit without considering the costs to others. Commons dilemmas and personal cost/benefit analysis are considered the cause of most littering decisions which apply across all four product categories in this research and are particularly relevant to fishing gear littering.

[170] https://ec.europa.eu/fisheries/new-proposal-will-tackle-marine-litter-and-%E2%80%9Cghost-fishing%E2%80%9D_en
[171] https://www.zerowastescotland.org.uk/case-study/project-beacon
[172] 13% in the Celtic Sea and 33% in the Northern North Sea. https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/pressures-human-activities/marine-litter/beach-litter/
[173] EC, 2018 (https://bit.ly/2xirnPV)
[174] Richardson et al., 2018 (https://bit.ly/2UAac7A)

In the UK, fishing and fish processing employs 22,000 people and there were 2,065 active Scottish based fishing vessels in 2017[175]. The fishing industry is highly competitive and actors are under considerable financial pressure, with many port neighbourhoods offering limited alternative employment opportunities. Large fishing gear items, such as nets, are typically landfilled at end of life at high cost, incurring UK Landfill Tax. Costs can be prohibitive[176], which has been cited as a factor leading to illegal discard at sea internationally[177]. However, many fishers demonstrate pro-environmental behaviour, actively fishing for litter and bringing recovered items to shore for safe waste disposal. Recycling opportunities are being explored by small companies and at government level[178] and aim to reduce the financial burden on fishers for waste management. The EU has proposed Extended Producer Responsibility (EPR) for fishing gear[179] [180] which would move the majority of the financial burden onto producers, reducing disposal costs for fishermen and ports and potentially encouraging a national collection and recycling scheme.

There are no legal requirements for gear marking in Scotland, although Government guidance exists and plans to introduce legislation have been announced. There are also gaps around discharge of waste at sea which is prohibited under international agreement, but with less strict requirements for small vessels in the UK transposition of the agreement and not yet criminalised under Scottish law. Furthermore, the requirements for port reception facilities for waste from fishing vessels are not as comprehensive as they should be. Current revisions to EU Directives could be designed to bridge this gap and remove the economic disincentive to deliver waste to port (i.e. the high cost of managing waste gear).

Non-regulatory interventions can be effective in encouraging pro-environmental behaviour through localised penalty systems, financial or social incentives, timely prompts, communicating consequences and promoting cooperation. Training requirements and education in particular have been highlighted as effective measures for the fishing industry. The KIMO 'Fishing for Litter' initiative has shown significant positive results in reducing the occurrence of marine littering amongst its members whilst also increasing the frequency of litter collection by members[181].

3 Crisps, snack and sweet wrappers

3.1 Product and trade information

3.1.1 Polymer types and % plastic in product

Crisps, snack and sweet packets and wrappers are typically made from aluminium-coated polypropylene (PP) or polyethylene (PE). The product can have three or more separate layers of different plastics plus a

[175] Scottish Sea Fisheries Statistics (2017) https://www.gov.scot/publications/scottish-sea-fisheries-statistics-2017/pages/4/

[176] As landfill costs typically exceed £100 per tonne and fishing nets can weigh several tonnes.

[177] http://www.fao.org/3/a-i5051e.pdf

[178] https://www.britishirishcouncil.org/sites/default/files/BIC%20-%20Marine%20Litter%20Symposium%202019%20%20-%20Communique%20-%20Final.pdf

[179] http://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy-brochure.pdf

[180] http://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf

[181] Defra (2014), An evaluation of the Fishing for Litter (FFL) scheme. www.fishingforlitter.org.uk/assets/file/Report%20FFL%202011%20-%2014.pdf

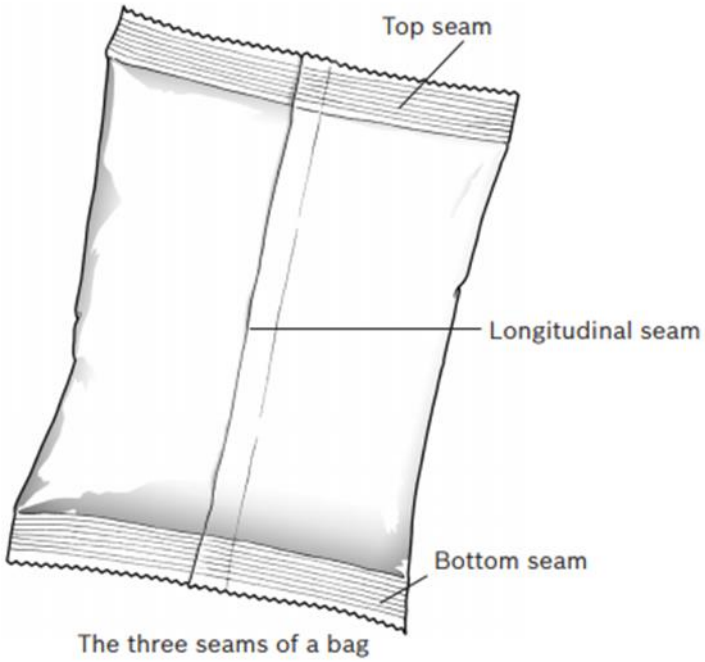
very thin coating of aluminium, usually sprayed onto the plastic[182]. Coextruded biaxially oriented polypropylene (BOPP) or oriented polypropylene films (OPP) is typically included in the manufacture of crisps, snack and sweet wrappers. This material is commonly the inner most layer of the packaging, in contact with the food product. Low-density polyethylene (LDPE) is also present as an additional polymer to strength packaging. Ionomer resin, such as Surlyn, is used as a coating or outer packaging material. The combination of these polymers gives the packaging thermoplastic qualities and allow products to be heat-sealable or peel-able. Producers add a 'protective atmosphere of nitrogen gas'[183], commonly known as Modified Atmosphere Packaging (MAP) which is designed to reduce the fragility of the crisps or sweets within the wrapper and preserve the product for longer, thus extending shelf life.

Example wrappers are shown in Figure 13 and Figure 14.

Figure 13: Example of typical crisps, snack and sweet confectionery packaging [184]

[182] https://friendsoftheearth.uk/plastics/walkers-crisp-packet
[183] https://www.walkers.co.uk/faq/quality-control/do-you-put-nitrogen-gas-in-the-bag-of-crisps-to-keep-them-fresh
[184] https://www.mirror.co.uk/news/uk-news/sweets-through-ages-timeline-shows-6882741

Figure 14: Example of crisp bag packaging[185]



Some manufacturers have tried alternative materials such as polylactic acid (PLA) for their crisps, snack and sweet wrappers in response to the negative environmental impacts of oil-based plastics. The market for bioplastic polymers is growing but still represents approximately 1% of global plastic production[186]. Oil-based plastics remain cheaper than bioplastics[187], however bioplastics are becoming more competitive as demand grows, driven by multinational brands[188]. Using PLA rather than OPP or BOPP could allow wrappers to be certified compostable and have the potential to be composted alongside organic waste, however this is dependant on access to processing facilities. At present, in the UK there is not sufficient infrastructure to ensure that these materials are processed at industrial composting facilities thus switching to this material could result in negative environmental impacts. One unintended consequence of using PLA in the production of crisp packaging is that the rustle of the packaging when used is noisier than oil-based plastic packaging[189]. Figure 15 shows Frito-Lays' SunChips brand, which used PLA to ensure their packaging is compostable, but the product was withdrawn due to negative feedback from customers and a drop in sales of more than 11%[190].

[185] https://www.boschpackaging.com/media/pa/product/cf/paud/sve_3800_ab/bosch_guide_to_vffs-web.pdf, p. 6
[186] Ricardo Energy and Environment (2019), Plastics in the Bioeconomy, https://bbia.org.uk/wp-content/uploads/2019/05/Plastics-in-the-Bioeconomy-report-1.pdf
[187] https://www.european-bioplastics.org/faq-items/how-are-costs-for-bioplastics-developing/
[188] https://qz.com/796603/dropping-cost-of-bioplastics/
[189] https://www.theguardian.com/sustainable-business/blog/eco-crisp-packet-too-noisy
[190] https://www.packagingdigest.com/smart-packaging/frito-lay-withdraws-noisy-compostable-sunchips-bag

Figure 15: Polylactic acid (PLA) used in manufacture of food packaging[191]

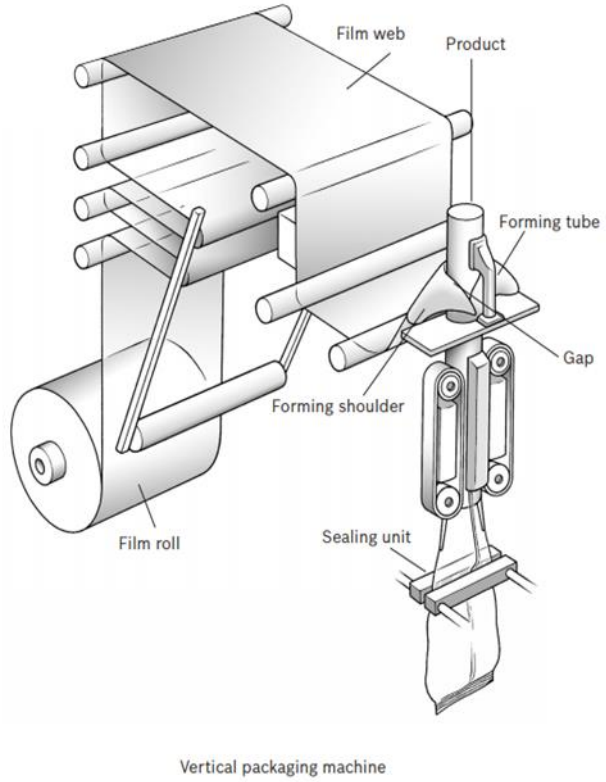
3.1.2 Role/function of plastic in product and reasons for choice

Crisps, snack and sweet wrappers are designed to keep perishable contents fresh. Mixed materials are used to ensure freshness but also to make products lightweight and flexible[192]. Crisps, snack and sweet packaging require robustness, so the material used must have strength to endure handling and transport without damage or contamination to the perishable product. Crisps are packaged in a protective atmosphere, and as such multi-layered plastic packaging is generally required to prevent the added atmosphere leaking[193]. Polypropylene film provides this strength of material whilst also allows user to open the packaging easily when required.

A key reason for choosing BOPP film, to manufacture packaging for both crisps, snack and sweets, is due to the proprieties of the material, e.g. light weighting, strength, printability, and non-porous properties. High-speed and high-performance production technologies such as vertical form fill sealing (VFFS) or horizonal form fill sealing (HFFS) are designed to produced quality packaged products without requirements of human labour. VFFS and HFFS machinery can produce between 30 and 300 products per minute dependent on the type of machinery used[194]. This technology, coupled with OPP / BOPP film material, makes the manufacturing process profitable and efficient. Film roll, referred to as 'rollstock' is fed through the machine either continuously or intermittently dependent on speed of production. An illustration of VFFS technology is outlined in Figure 16, showing how the layered plastic-based film is fed through the machine before being sealed into a packet.

[191] https://www.packagingdigest.com/smart-packaging/frito-lay-withdraws-noisy-compostable-sunchips-bag
[192] https://www.huffingtonpost.co.uk/entry/why-is-there-plastic-in-crisp-packets_uk_5acc79d0e4b07a3485e7f0a6
[193] Interempresas, 2010 (https://bit.ly/2Jbe4G5)
[194] https://vikingmasek.com/packaging-machine-resources/packaging-machine-blog/a-guide-to-vertical-form-fill-seal-machines

Figure 16: Vertical packaging machine, Bosch, Guide to Vertical Form-Fill-Seal Baggers[195]



Product and packaging design requirements are likely to dictate the material choice and product design to some extent. Crisps and other snacks such as nuts are packaged in a 'protective atmosphere'. For these types of items, the recommended gas mixture is 100% nitrogen for bulk products, and either 100% nitrogen or 30% carbon dioxide, 70% oxygen for retail[196]. This prevents the food spoiling and protects the product from damage[197]. EU Directive No. 95/2/EC requires packaging labels of products packaged in protective atmosphere to include the appropriate E number[198]. There are also EU regulations that state that all manufacturers producing products with reduced oxygen content or protective atmosphere have to set up control points for gas content and seal integrity[199].

Packaged goods such as crisps, sweets and snacks are regulated under the Weights and Measures (Packaged Goods) Regulations 2006 which regulate the nominal compared to actual quantities of the package[200]. Businesses must also comply with Regulation (EU) No 1169/2011 – the main law relating to food labelling in the European Union[201]. This Regulation requires mandatory country of origin labelling for a number of products and the European Snacks Association (ESA) suggested that extending this legislation to

[195] https://www.boschpackaging.com/media/pa/product/cf/paud/sve_3800_ab/bosch_guide_to_vffs-web.pdf, p. 5
[196] Modified Atmosphere Packaging, 2018 (https://bit.ly/2YEVr0J)
[197] Witt Gas (https://bit.ly/2EqL3Ch)
[198] Modified Atmosphere Packaging, 2012 (https://bit.ly/2WnID1c)
[199] Modified Atmosphere Packaging, 2012 (https://bit.ly/2WnID1c)
[200] Gov.uk (https://bit.ly/1QVrfp6)
[201] EC, 2011 (https://bit.ly/2HxE5x9)

crisps and snacks would be burdensome for industry with little to no benefit[202]. Loose sweets also have requirements for labelling of allergens and the name of the product[203]. Commission Regulation (EC) No 450/2009 regulates food contact materials including packaging to ensure they are sufficiently inert that they impact neither consumer health nor food quality[204].

3.1.3 Product volumes placed on market: import, export and domestic production

Detailed information on crisps, snack and confectionery market in the UK can be found in Appendix A.1

According to PRODCOM lists of production, import and export of crisps, snack and confectionery, the UK has a significant production market and a healthy export market of these UK brands. Across product types identified in the dataset, production equalled 480,000 tonnes, with 260,000 tonnes imported and 119,000 tonnes exported. The UK imports more confectionary products from both EU and non-EU markets, rather it produces and exports. In contrast, the UK manufactures and exports more crisp products than is imported.

3.1.4 Key players in the market and indications of market share

Some of the key players in the Scottish market for crisps, snack and sweets are shown in Table 7

Table 7: Key players in the Scottish market for crisps, snack and sweets, with identified presence in Scotland or the UK

Key Players	Location	Market share
Walkers Crisps (owned by PepsiCo)	UK manufacture - Leicester	47% of UK crisp market[205]
Mackie's of Scotland	Scottish manufacture - Errol, Perthshire	15% market share for snacks manufactured in Scotland[206]
Tunnocks	Scottish manufacture - Uddingston, UK	Annual turnover of £58.1 million, employing 570 people[207]
Maynard Bassetts (owned by Mondelez International)	n/a	18.4% share of confectionery market in UK[208]
Mars-Wrigley	UK manufacture - Berkshire, UK	Owned by US confectionery company Mars, £60m pre-tax profit in UK arm of company[209]
Rowntree (part of Nestle)	See below	See below

[202] ESA, 2014 (https://bit.ly/30F18O0)
[203] Gov.uk, 2017 (https://bit.ly/2VItvao)
[204] EC (https://bit.ly/2FxNMtc)
[205] https://www.packaging-gateway.com/projects/walkerscrisps/
[206] https://www.pressandjournal.co.uk/fp/business/farming/828707/plough-pack-behind-scenes-scotlands-crisp-maker/
[207] https://www.glasgowchamberofcommerce.com/news-media/news/2019/january/30/tunnock-s-announces-25-rise-in-overseas-sales/
[208] https://www.marketingweek.com/2016/01/22/mondelez-relaunches-maynards-bassetts-as-one-brand-in-adult-candy-push/
[209] https://www.insidermedia.com/insider/southwest/wrigley-uk-profits-near-60m-ahead-of-anniversary

Key Players	Location	Market share
Nestle	Scottish manufacture – Girvan, Ayrshire	90% of products produced for home market manufactured in the UK[210]
Haribo	UK manufacture – Pontefract, UK	World's biggest manufacturer of fruit gums and liquorice products entered the UK market in 1972, when it acquired a majority stake in the English firm Dunhills (Pontefract)[211]
Kettle Foods	UK manufacture – Norfolk, UK	Declined to provide market share data due to "very intense" UK snack market competition[212]
Cadbury (owned by Kraft)	UK manufacture – Birmingham, UK	10.3% of global confectionery market share[213]
Tayto Group (Tayto, Golden Wonder, REAL Crisps)	Northern Ireland manufacture	Annual sales of around £250 million[214]
KP Snacks	UK manufacture – range of locations across UK	Part of InterSnack Group, Europe's 2nd largest snack manufacturer
Pipers Crisps Ltd	UK manufacture – Lincolnshire, UK	One of the fastest growing brands in UK[215]
Tyrrells Potato Crisps	UK manufacture - Herefordshire, UK	In top ten brands for growth in UK snacks[216]
SEALPAC	Poole, UK	SEALPAC is a key player in global tray sealing machine manufacturing
National Flexible	Bradford, UK	The UK's largest distributor of polypropylene, laminates and special films
Accrued Plastic Ltd	Burnley, UK	One of the UK's largest stockists, distributors and suppliers of biaxially oriented polypropylene (BOPP)
Line Equipment (VFFS & HFFS Machines)	Nottingham, UK	n/a

[210] https://www.confectionerynews.com/Article/2016/10/25/Nestle-confectionery-division-remains-under-pressure
[211] https://www.haribo.com/enGB/company/haribo-united-kingdom.html
[212] https://www.edp24.co.uk/business/campbell-s-soup-kettle-foods-refuses-comment-sale-1-6037021
[213] https://www.theguardian.com/news/datablog/2010/jan/05/cadbury-kraft-brands-takeover-chocolate-data
[214] https://www.thegrocer.co.uk/movers/paul-allen-steps-down-as-tayto-group-ceo/576648.article
[215] https://www.bbc.co.uk/news/business-46107734
[216] http://www.nivogroup.co.uk/wp-content/uploads/2017/03/Tyrrells-Introduction.pdf

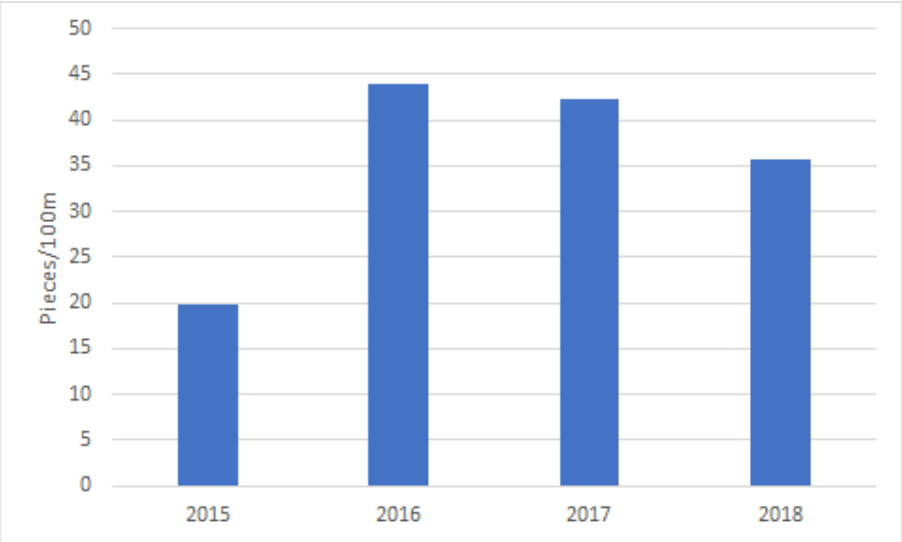
Key Players	Location	Market share
Two Farmers Ltd	Herefordshire, UK	n/a

3.2 Qualifying the problem in the marine environment

3.2.1 Abundance in marine environment

In a comparison of marine litter studies from across Europe; crisps, snack and sweet wrappers ranked in the top 10 most frequently occurring items [217], and in 2018 crisp packets were the fourth most collected item in MCS beach surveys in the UK[218]. In beach surveys in the Northern North Sea, crisp/sweet packets and lolly sticks represented 1.8% of total number of items found[219], considerably lower than the proportion found during British beach surveys from 2005-2014 (6%)[220]. Number of packets collected per 100m on British beach cleans has decreased between 2016 and 2018, but still remains higher than 2015 (Figure 17). In street litter surveys in 2014 in England, confectionary packaging comprised 13% of items found, and snack packaging comprised 2% (both excl. chewing gum staining)[221].

Figure 17: Packets (crisp, sweet, lolly, sandwich) collected on British beaches during the last four Great British Beach Clean Surveys[222]



To demonstrate the variability of data year on year, Table 8 shows that the number of food wrappers collected in the UK during International Coastal Cleanup events decreased between 2016 and 2017. In 2016, the UK collected 2.6% of the total number of food wrappers across all participating countries, despite representing smaller proportions of people involved and km covered (Table 8). 17.9 food wrappers were

[217] JRC, 2016 (https://bit.ly/2UWfyt5)
[218] MCS, 2018 (https://bit.ly/2rdV4vj)
[219] OSPAR, 2017 (https://bit.ly/2UC7n62)
[220] Nelms et al., 2017 (https://bit.ly/2R6vO5t)
[221] INCPEN, 2014 (https://bit.ly/2GPB3Ee)
[222] MCS, 2018 (https://bit.ly/2rdV4vj); MCS, 2017 (https://bit.ly/2DhCJWS); MCS, 2016 (https://bit.ly/2GmTqAh); MCS, 2015 (https://bit.ly/1MlD75x)

collected per 100m in the UK, compared to 3.2 wrappers/100m worldwide. In 2017, number of wrappers collected in the UK decreased whilst globally the figure increased. This led to the UK collecting 0.9% of food wrappers, in line with it representing 0.9% of people and km surveyed. As such in 2017 food wrappers collected per 100m in the UK and across all countries involved were similar (5.8 food wrappers/100m in the UK, 5.7 across all countries).

Table 8: Number of food wrappers collected in Ocean Conservancy International Coastal Cleanups in 2017[223] and 2016[224]

	2016			2017		
	UK	**Total**	**%**	**UK**	**Total**	%
People	5,993	504,583	1.19	7,325	789,138	0.93
km	111.4	24,136	0.46	275	30,472	0.90
Total Items	186,850	13,840,398	1.35	166,892	20,824,689	0.80
Wrappers	19,907	762,353	2.61	15,996	1,739,743	0.92

3.2.2 Indications of impact

Regarding ingestion impacts, food wrappers were ranked highly as marine litter items which caused most damage in a survey sent to experts in major marine taxa or marine debris[225]. A review of published literature addressing entanglement and ingestion risks from marine debris showed that roughly 2,000 marine mammals, fish, birds and sea turtles had been entangled by food packaging, across over 20 species, and over 2,000 individuals had ingested these materials across roughly 120 species (Figure 9 above)[226]. It is not clear how many of these incidents relate specifically to crisps, snack and sweet wrappers.

No recordings of ingestion of crisps, snack and sweet wrappers specifically have been found in the scientific literature. However, there are numerous reports of ingestion of sweet and crisp wrappers in newspaper articles. In early 2019, a dead loggerhead turtle was found with a large array of plastic products in its stomach, including an M&Ms sweet wrapper[227]. A young Arctic harp seal was also found washed up in poor condition with a sweet wrapper in its stomach[228]. Most of these reports cannot directly state that the plastic was responsible for the death of the organisms, however a coelacanth (known as a 'living fossil' fish) was found killed by a crisp packet which had become wrapped around its intestines[229].

The impact assessment for the EU Single-Use Plastics Directive identified that the highest impacts of crisp packets were ingestion, transport of invasive species, microbial contamination, and economic impacts on tourism (Table 6, above).

[223] Ocean Conservancy, 2018 (https://bit.ly/2FZpDz7)
[224] Ocean Conservancy, 2017 (https://bit.ly/2rKZFa8)
[225] Wilcox et al., 2016 (https://bit.ly/2HI2CNw)
[226] Gall and Thompson, 2015 (https://bit.ly/2GsKTeN)
[227] Telegraph, 2019 (https://bit.ly/2E9i4Tz)
[228] Evening Express, 2018 (https://bit.ly/2UyOIYA)
[229] Daily Mail, 2018 (https://dailym.ai/2UTe82J)

3.3 Key points of leakage and pathways into the marine environment in Scotland

It is estimated that in the UK, of 8.3 billion packets of crisps eaten annually, 0.3 billion (3.5%) end up as litter[230]. In Scotland, surveys suggest roughly half the population have littered at some point[231], and this is thought to be the primary source by which crisp, snack and sweet wrappers reach the marine environment. This is particularly the case when these items are littered from cars or reach road drains when they are dropped while walking along roads. Road drains which do not merge with the combined sewer network discharge unscreened and untreated into nearby watercourses, releasing all collected litter on a direct pathway to the marine environment. There are 40 litter hotspots on south west Scotland's roads alone[232], with almost seven tonnes of rubbish removed from the sides of the M8 and M9 each month[233], again highlighting the importance of this pathway into the marine environment. Across Scotland, 50 tonnes of litter are removed from the roads every month, 54% of which comes from eating and drinking on the go[234]. Food packaging is among the most commonly littered items in Scotland[235], with confectionary wrappers present in over 1/3 of sites surveyed in Scotland, with higher prevalence in areas with high footfall[236]. While confectionary packaging reduced across 120 surveyed locations between 2014 and 2016, snack packaging more than doubled[237]

Crisp, snack and sweet packets can also reach the marine environment as windblown litter, with the potential to be blown, either once they have been littered, out of public litter bins or from municipal waste management such as landfill. There are also 'tidy littering' habits such as leaving litter next to bins or placing items on a wall or other surface which are also highly likely to reach the marine environment as windblown litter[238].

3.4 Why leakage happens – economic, behavioural and social factors (drivers and barriers)

3.4.1 Economic and competitive forces

The 'on-the-go' food and drink market is rapidly growing in the UK. In 2017, 95% of people in the UK engaged with food on-the-go, spending £580 on average per person[239]. It is estimated that this market is set to grow by £2bn in the next three years[240]. The crisps and savoury snacks market have grown by 10% over the past five years[241]. In 2018, it was reported that the value of the sugary confectionery market in the UK grew by 4.3% to £897m[242]. Sales of chocolate and sugar confectionery is worth an estimated £1.1bn to

[230] EarthWatch Institute, 2019 (https://bit.ly/2U4XBUT)
[231] Zero Waste Scotland, 2013 (https://bit.ly/2Dk1FuH)
[232] Scotland Transerv, 2015 (https://bit.ly/1Wi3R5Q)
[233] Scottish Government, 2019 (https://www.gov.scot/news/littering-from-vehicles/)
[234] Keep Scotland Beautiful, Give your litter a lift, https://www.keepscotlandbeautiful.org/roadside-litter-campaign/
[235] Zero Waste Scotland (2019), 11 facts about litter, https://www.zerowastescotland.org.uk/litter-flytipping/facts
[236] Keep Scotland Beautiful (2017), National Benchmarking Report 2016-17, https://www.keepscotlandbeautiful.org/media/1561096/16_17-leams-benchmarking-report.pdf
[237] INCPEN (2016), Composition of litter in Scotland, https://www.incpen.org/composition-of-litter-in-scotland/
[238] Restorick, Hubbub (https://bit.ly/2ZkkB5S)
[239] https://www.thecaterer.com/articles/532081/instant-gratification-the-latest-trends-in-grab-and-go
[240] https://www.mca-insight.com/market-reports/uk-food-to-go-market-report-2019/576350.article
[241] http://reports.mintel.com/display/878229/
[242] https://www.confectionerynews.com/Article/2018/10/02/Top-10-UK-sugar-confectionery-brands

the UK economy[243]. In this competitive environment, retailers and producers are seeking more innovative ways to stand out in this saturated market, which can result in brands adopting more multi-material and multi-functional packaging making product packaging more complicated to recycle. Lightweighting of product packaging, which provides improved product quality, reduces cost for the producer and reduces plastic usage in the design phase[244], could result in more littering as packaging may be more likely to be blown away or lost.

This growth in crisps, snack and sweets consumption has increased the volume of non-recyclable waste. Walkers, the largest UK crisp manufacturer in the UK, produces approximately 4bn non-recyclable crisp packets per year[245]. Plastic crisp, snack and confectionary wrappers have no recycling value after use and are treated as general waste, with the exception of recycling trials, e.g. Walkers Crisps recycling scheme in partnership with Terracycle.

The production of food products must meet health, safety and quality standards. Modern crisp, snack and sweet packaging, which includes plastics, not only protects food from microbial and chemical contamination, but it also protects from oxygen, light and water[246]. Protecting food products from contamination allows the products a longer shelf-life, thus improving their economic competitiveness. However, it is arguably unnecessary to protect food products with a short production and consumption timescale using materials that take decades to degrade. Using VFFS or HFFS packaging technology improves competitiveness of products due to guaranteed protection of the product's quality as well as meeting BRC, IOP and/or HACCP hygiene and food safety standards. However, there are also growing economic costs associated with growing convenience food and drink trends. In the UK, 20% of plastic found on UK beaches is single-use material associated with on-the-go food and drink markets[247]. Due to the robust nature of plastic packaging, it does not degrade and is easily identifiable as litter in the marine environment. This litter has a detrimental economic impact, with Scotland spending £53 million on cleaning up and minimising litter and flytipping[248].

3.4.2 Social norms and behaviours at leakage points

The key leakage for this type of packaging intrinsically sits with the consumer at point of disposal and this forms the main points for discussion below. Little evidence of case studies showcasing cultural or behavioural factors in the extended value chain relating to marine litter were found.

The Keep Scotland Beautiful website reports that 54% of litter found on roads comes from people eating and drinking on the go and cites crisp packets[249] as a common element of roadside litter. The Keep Britain

[243] https://www.confectionerynews.com/Article/2018/04/04/Cocoa-chocolate-and-sugar-confectionery-worth-1.1bn-to-UK-economy
[244] https://www.packagingdigest.com/sustainable-packaging/solving-the-problems-of-lightweighting-in-consumer-product-packaging-2017-03-17
[245] https://www.theguardian.com/environment/2018/aug/05/walkers-plastic-crisp-packet-non-recyclable
[246] Sanches Silva, A *et al* (2004) 'Modified atmosphere packaging and temperature effect on potato crisps oxidation during storage', Analytica Chimica Acta 524, p. 185
[247] https://www.theguardian.com/environment/2017/nov/30/shocking-rise-in-rubbish-washing-up-on-uk-beaches
[248] https://www.zerowastescotland.org.uk/sites/default/files/Scotland%27s%20Litter%20Problem%20-%20Full%20Final%20Report.pdf
[249] https://www.keepscotlandbeautiful.org/roadside-litter-campaign/

Tidy 'Little Book of Litter'[250] also highlights an increasing number of people admitting to dropping litter from vehicles: rising from 13% in 2006, to 31% in 2010. Keep Britain Tidy also points out that there is a gap between the proportion of people who admit to littering and the proportion that actually litter, therefore it is likely that the proportion of people who actually drop litter from vehicles will be higher than this; and that people admitted to littering out of their vehicles because they believed they were much more anonymous than dropping litter elsewhere.

As outlined in previous sections, most littering behaviour can be attributed to the classic 'commons dilemma'[251] – where the cost of littering to an individual is perceived to be more important than the cost to other. Dropping litter in shared spaces – such as a park or beach – is an example of the commons dilemma. Keep Britain Tidy reintroduced the Tidy Man logo (Figure 18) in 2016 for use on packaging to encourage correct disposal behaviours[252]. However, this is often not a prominent feature of packaging design and no evidence of a decrease in littering behaviour was found following the logo reintroduction.

Figure 18: The Tidy Man logo, often featured on packaging to encourage correct disposal behaviour

The Recycle for Scotland website claims that some crisp wrappers are recyclable and encourages consumers to do the scrunch test to assess recyclability[253]; and manufacturer of Walkers crisps claim that packets are technically recyclable[254] but it is the absence of a separate collection system that has prevented this from occurring in the mainstream.

In terms of social norms and behaviours at leakage points, the design and maintenance of litter bins appears to be a clear factor affecting people's littering behaviour[255]. The Keep Britain Tidy research 'The

[250] Keep Britain Tidy (2012). The little book of litter. https://www.keepbritaintidy.org/sites/default/files/resources/KBT_Little_Book_of_Litter_2012.pdf
[251] Using behavioural science to reduce littering (The University of Warwick)
[252] Resource Magazine online (2017), https://resource.co/article/keep-britain-tidy-re-launches-tidyman-symbol-11653
[253] https://www.recycleforscotland.com/what-to-do-with/crisp-packets
[254] https://www.bbc.co.uk/news/uk-england-leicestershire-46483411
[255] Keep Britain Tidy (2012). The little book of litter. https://www.keepbritaintidy.org/sites/default/files/resources/KBT_Little_Book_of_Litter_2012.pdf

Little Book of Litter' reports that seven out of 20 people admit they would feel guilty for dropping some litter, but also highlights that people will often blame a lack of bins in the right place or say they are full.

There are increasingly examples of littering behaviour campaigns initiated across the value chain – for example, manufacturer Coca Cola recently launched a campaign encouraging consumers to responsibly dispose of drinks packaging[256] (Figure 19); and waste management company Bristol Waste released a campaign to encourage people not to litter[257] (Figure 20).

Figure 19: Coca Cola campaign to reduce littering

Figure 20: Bristol Waste Company litter reduction campaign

Keep Britain Tidy also pick up on the acceptability of litter and its ease of cleansing as key factors[258]. Foil and paper, which relates to crisps, snack and sweet wrappers, are generally considered 'acceptable' and 'clean or easy to pick up', which could explain people's higher propensity to litter these items. For example, people may consider it acceptable to leave litter at a public gathering where they think that the mess will be cleared up by event organisers. And the report suggests that the public are more likely to drop items of litter such as small pieces of paper that they consider to be easy to clean up.

The Attenborough effect, highlighted in the GlobalWebIndex report 'Sustainable Packaging Unwrapped'[259], is another important factor in terms of people's behaviour around littering. Occurrence of supply chain interventions as outlined above could indicate that organisations are increasingly feeling pressured to provide solutions in order to protect their brand reputation. The recent public campaign against the non-

[256] https://www.creativebloq.com/news/coca-cola-billboards
[257] https://www.bristolwastecompany.co.uk/learn-more-home/litterhurts/
[258] Keep Britain Tidy (2012). The little book of litter. https://www.keepbritaintidy.org/sites/default/files/resources/KBT_Little_Book_of_Litter_2012.pdf
[259] GlobalWebIndex - Sustainable Packaging Unwrapped

recyclability of Walkers crisp packets is an interesting example of public pressure resulting in the manufacturer initiating a publicly available and free recycling system as an alternative point of disposal.

However, even though the public consciousness of the impact of plastics on the environment is higher than ever, it highlights that their ambitions go only as far as their budgets and what's laid out in front of them. In other words, consumers are still making their purchasing decisions primarily based on price and convenience. At the moment this means that crisps, snack and sweets are often the cheapest and most convenient items available. With public pressure on brands growing, those that do provide an alternative at a competitive price point and manage to position them in the right way with retailers will likely reap the rewards.

3.4.3 Where value is lost at each point in the chain

95% of plastic packaging material value ($80-$120 billion annually) is lost to the economy after first use[260]. This value loss results as only 14% of plastic packaging is collected for recycling, and subsequent value losses in sorting and reprocessing result in only 5% of material value being retained for future use[261]. With crisp, snack and sweet wrappers, this figure has the potential to be even smaller. Recent consumer backlash saw Walkers partner with Terracycle to set up a crisp packet recycling scheme[262], which has now recycled just over 10 tonnes of crisp packets[263]. There are no known similar schemes for sweet wrappers.

Economic value is lost through the direct and indirect impacts of littering (clean-up costs, litter disamenity and pollution externalities costs). Research conducted by Zero Waste Scotland in 2013 calculated that at least £46 million of public money gets spent clearing litter annually (the bulk of the £53m total spend, which also included education and enforcement)[264]. Street litter such as crisp, snack and sweet wrappers also impacts the popularity of local tourist spots, can increase crime rates (£22.5 million cost[265]), contribute to mental illness (£53 million cost[266]) and reduce house prices in the vicinity[267]. A recent study calculated that if 1% of Scotland's housing stock was devalued by 2.7% due to litter it would equate to £100 million value loss[268]. The same report calculated that the local disamenity cost of litter at between £73-770 million and beach litter disamenity between £50-100 million[269].

3.4.4 How market economics can affect behaviour change

Marine litter from single-use plastics originates from two distinct actions: the purchase of plastic items, and littering; which both require different policy responses – market interventions for the former and behavioural for the latter[270]. Market interventions in terms of the design of packaging or deposit return schemes is required for these products, as few alternatives are readily available. Options include the rise of

[260] World Economic Forum, 2016 (https://bit.ly/1Ou5wDU)
[261] World Economic Forum, 2016 (https://bit.ly/1Ou5wDU)
[262] The Guardian, 2018 (https://bit.ly/2Gb8xyu)
[263] Terracycle (https://bit.ly/2DteJhk). Terracycle reports 1 unit of waste = 5g of crisp wrappers
[264] Zero Waste Scotland (https://bit.ly/2H6dxop)
[265] Eunomia (https://bit.ly/2Zu7mQ7)
[266] Eunomia (https://bit.ly/2Zu7mQ7)
[267] Zero Waste Scotland (https://bit.ly/2H6dxop)
[268] Eunomia (https://bit.ly/2Zu7mQ7)
[269] Eunomia (https://bit.ly/2Zu7mQ7)
[270] EC, 2018 (https://bit.ly/2GsEwbq)

plastic free shops, or packaging in cans as opposed to bags[271]. Public campaigns and the associated reputational loss have already been shown to impact recycling schemes for these products[272].

Increased enforcement of littering fines may also lead to behaviour change. At present, it appears that the likelihood of a fine is not high enough to deter people from littering, especially when many people who receive a fine do not pay it, and do not suffer resulting recrimination[273].

3.5 Decision points with opportunities to minimise marine plastics

3.5.1 Material and design alternatives, potential impacts these might have, barriers to uptake

A potentially simple design change for crisp, snack and sweet wrappers is light-weighting. When comparing packaging to product, for a number of sweet and chocolate products there is (or may be) an excessive amount of packaging[274]. There are already examples of this approach being applied successfully[275] and light-weighting provides significant cost advantages in the supply chain and reduces environmental impact in the supply chain. However, there are also trade-offs. Light-weighting can cause issues in terms of recycling as lighter materials can be blown off of recycling belts easily and get lost from the system[276]. Recycling may also be impaired as light-weighted materials can be difficult to separate, or as light-weighting can involve use of multilayer materials which are inherently difficult to recycle[277].

Compostable confectionary packaging is being launched, however there have been occasions of corn-starch based products being withdrawn from shelves[278]. The products are promoted as quicker to degrade in the environment[279], but are more difficult to compost and recycle in conventional recycling systems. There is currently a lack of suitable disposal facilities and of consumer understanding leading to high levels of contamination – this has resulted in none of the compostable packaging being used by UK Parliament being composted[280]. Established brands also seem unlikely to change their packaging, particularly when it is distinctive and designed to protect delicate products[281].

3.5.2 Alternative products and circular economy business models

Circular economy business models do not immediately seem appropriate for crisp, snack and sweet wrappers, due to the single use status of the product. Previous work undertaken by Resource Futures developed a use phase-based approach to eliminating avoidable plastic proposing a novel approach which categorises plastics by the length of the use-phase[282]. There is a strong correlation between the lifetime of a product, the way it is discarded and the actions which can be taken to reduce the negative impacts of

[271] Yappah Crisps (https://bit.ly/2W0a79W)
[272] The Guardian, 2018 (https://bit.ly/2Gb8xyu)
[273] The Ferret, 2018 (https://bit.ly/2vjEtZj)
[274] ALPHR, 2018 (https://bit.ly/2UWV1ok)
[275] Packaging News, 2017 (https://bit.ly/2tfdjQu)
[276] CNN, 2019 (https://cnn.it/2S9inWe)
[277] Geueke et al., 2018 (https://bit.ly/2IEsUo3)
[278] Packaging News, 2015 (https://bit.ly/2GuYm4J)
[279] Fast Company, 2015 (https://bit.ly/2xTP9z7)
[280] Footprint (2019), https://www.foodservicefootprint.com/footprint-investigation-parliament-burnt-by-compostable-pledge/
[281] Munchies, 2018 (https://bit.ly/2ISdrAg)
[282] Resource Futures and Nextek, 2018 (https://bit.ly/2XNq0Ft)

plastics throughout the life-cycle[283]. A use phase based approach to eliminating avoidable plastic supports elimination or substitution of plastics for alternative materials for products with a short use-phase[284], but the market would need to produce functional alternatives for the specific requirements of crisps, snacks and sweets. Such alternatives must undergo a full life-cycle assessment (LCA) to ensure they are a more sustainable alternative[285]. Traditional pick-and-mix style sweet sales use less packaging and often only use paper bags, but not all sweets are available in this format. These items (particularly sweets) may be more appropriate for plastic free shops and aisles which are opening[286, 287], particularly as reuse is only commercially feasible for refillable and cleanable containers[288]. However, there are now multiple take-back schemes being offered for food packaging in general, such as the Terracycle/Walkers scheme mentioned previously. M&S, as part of efforts towards a circular economy, is rolling out bins across all of its stores for non-recyclable plastic, which will be recycled into store fittings, furniture and school playground equipment[289]. However, this is down-cycling, and likely hinders repeat recycling, and as such it is necessary to clarify whether this is in line with circular economy goals[290].

Loop by TerraCycle[291] is a pilot scheme with high-quality packaging which can be returned and refilled repeatedly, with corporate partners including Procter & Gamble, PepsiCo, Mars and Coca-Cola, among others. It will trial in two locations with 300 products in durable, reusable containers, some of which have been made especially for Loop. Consumers will order online, paying a deposit for containers designed to be reusable[292]. When they have finished the product, they can arrange for collection or take it to the retailer, choosing whether to have it refilled, or their deposit refunded. Empties are sent for washing and refilling. TerraCycle envision that in time, Loop will come in three models:

- Consumers shop through the Loop website for products and Loop arranges the delivery and pick-up;
- Products are ordered through a partner retailer's website, delivered in the usual way and the same driver picks up the empty container; and
- The consumer buys the products in store and drops off empty containers[293].

In each model, the package remains property of the brand. While some have cited this as a paradigm shift, others have concerns about the practicalities and overall environmental impacts of the scheme, including difficulties in rural areas, feasibility across the number of products covered, difficulties in predicting consumer behaviour and issues such as damage to packaging during use cycles[294]. There are clear concerns

[283] Resource Futures and Nextek, 2018 (https://bit.ly/2XNq0Ft)
[284] Resource Futures and Nextek, 2018 (https://bit.ly/2XNq0Ft)
[285] UN (2018), https://www.lifecycleinitiative.org/starting-life-cycle-thinking/life-cycle-approaches/
[286] The Zero Waster (https://bit.ly/2EZeWIx)
[287] The Guardian (2019), Waitrose launches packaging free trial, https://www.theguardian.com/business/2019/jun/04/waitrose-launches-packaging-free-trial
[288] Geueke et al., 2018 (https://bit.ly/2IEsUo3)
[289] The Grocer, 2019 (https://bit.ly/2GGXPOC)
[290] Geueke et al., 2018 (https://bit.ly/2IEsUo3)
[291] GreenBiz, 2019 (https://bit.ly/2WgsXKr)
[292] CNN, 2019 (https://cnn.it/2S9inWe)
[293] Inside Packaging (2019), Closing the Loop, https://inside-packaging.nridigital.com/packaging_may19/closing_the_loop_terracycle_s_circular_economy_and_its_impact_on_packaging#popup-3
[294] Packaging Digest, 2019 (https://bit.ly/2Tpk2Ux)

over the carbon impact of the trial, to which Terracycle have responded that their courier partner for the UK will be UPS who will schedule collections geographically on routes where other local deliveries are happening to ensure there are no 'extra' vans on the road, as well as collecting empty containers at the same time as delivering new products[295]. However, to our knowledge there is no publicly available LCA of the pilot.

3.6 Levers available to the Scottish Government (intervention and support)

The lever categories of bans, penalties, levies, product regulation, support and influence outlined for Commercial Fishing Gear in Section 2.6 are available to tackle marine litter from crisps, snack and sweet wrappers, as they are for all products, where suitable. The regulatory and non-regulatory measures available to the Government are explored in the sections below in the context of existing legislative powers, proposed legislation, behavioural science and case studies.

3.6.1 Regulatory measures

Food labelling and packaging is currently strictly regulated through Food Standards Scotland in accordance with Regulation (EU) No 1169/2011 and The Food Information (Scotland) Regulations 2014, with the primary focus being on food safety, consumer information and traceability. Litter legislation is focussed on terrestrial litter as this is the primary location that crisps, snack and sweets are consumed and littered. There is no legal requirement to place anti-littering information on food packaging, although the Tidyman logo is used voluntarily by many manufacturers of on-the-go food and drinks products.

This study does not cover public littering behaviour directly, as this is covered in other research and the focus of this work is on the value chain. However, a rudimentary understanding of litter and flytipping regulation is presented below for context.

Littering is a criminal offence defined in The Environmental Protection Act (EPA) 1990 section 87. On the spot fixed penalties for litter and flytipping can be issued by police, local authorities and duty bodies such as Loch Lomond and the Trossachs National Park. The powers to issue fixed penalty notices (FPNs) are given under Section 88 (litter) and Section 33A (flytipping) of the EPA 1990. The penalties are £80 for littering and if unpaid the case can go to court with fines of up to £2,500[296]. The National Litter Strategy[297] strengthened enforcement powers by, amongst other things, increasing the fixed penalties to the current level and creating a requirement for alleged offenders to provide their name and address to enforcement officers.

The FPNs can act as a deterrent to littering behaviour, however effectiveness is likely to be influenced by the public's awareness of the risk and consequences of being caught. The enforcement regime is dependent on monitoring activities – officers and other authorised persons patrolling streets to witness offenses and issue penalties. Where significant resources are invested in enforcement many offenders can be caught. It was recently reported that 36,360 fixed penalty notices were issued in the Glasgow City area for litter offences over a three year period, accounting for 86 per cent of all litter fines in Scotland[298].

[295] Inside Packaging (2019), Closing the Loop, https://inside-packaging.nridigital.com/packaging_may19/closing_the_loop_terracycle_s_circular_economy_and_its_impact_on_packaging#popup-3
[296] https://www.gov.scot/policies/managing-waste/litter-and-flytipping/#penalties
[297] https://www2.gov.scot/Resource/0045/00452542.pdf
[298] https://theferret.scot/glasgow-litter-fine-unpaid/

However, the same news report, informed by FOI requests and information from authorities, highlights that only 46% of fines were paid and none were followed up with legal action following non-payment. Such gaps in the system are likely to undermine the deterrent factor of litter penalties, especially when reported in the public press.

New rules making it an offence to litter from vehicles are set to be included in a new circular economy bill in Scotland[299]. As discussed previously, such measures would likely need much higher levels of monitoring and enforcement than seen at present to be effective.

The University of Warwick study 'Using behavioural science to reduce littering'[300] emphasises the need for visible and high levels of enforcement so that people know the cost of littering can become real to them personally. The study states:

> *The most direct way to increase the personal cost of littering is to impose fines on those who do it. Loss aversion is a strong motivating force – people don't like losing what they already have. Actually, they don't even like the risk of losing money. If people knew that there was a real chance of getting a fine when they dropped litter, they would not do it as often.*

The Code of Practice on Litter and Refuse (Scotland) 2018 (COPLAR) provides guidance on fulfilling duties set out in the Environmental Protection Act 1990 to keep land clear of litter and refuse and to keep certain roads clean[301]. The regulations apply to 'duty bodies' held responsible for keeping public places clear of litter, mainly local authorities and statutory undertakers such as Network Rail, but also academic institutions such as schools, colleges and universities[302]. COPLAR sets standards, prioritisation and timescales to follow, and was revised in 2018 to align with the National Litter Strategy with an emphasis on preventative action. Preventative actions can include engagement, education, partnership working and infrastructure provision (such as bins)[303].

Future action will be aligned with the National Litter Strategy[304] which sets out principles for intervention based around the structure of information (including data collection and communications messaging), infrastructure and enforcement, and outlines planned interventions in each category. Roles and responsibilities are outlined for key stakeholder groups The Scottish Government, landowners, businesses, and third sector and local groups.

Further opportunities to reduce litter may be sought through deposit return schemes (DRS) and EPR. Whilst crisps, snack and sweets are not currently products considered for the DRS in Scotland it is possible that that scope of the scheme could be expanded to include such items in the future, particularly if the litter prevention benefits of the system are proven. EPR may also be considered for crisps, snack and sweet wrappers and is promoted in the Single-use Plastic and Fishing Gear Directive[305]. EPR for these products

[299] BBC, 2019 (https://bbc.in/2VeJVYE)
[300] Using behavioural science to reduce littering (The University of Warwick)
[301] https://www.gov.scot/publications/code-practice-litter-refuse-scotland-2018/
[302] https://www2.gov.scot/Publications/2006/12/13125718/29
[303] https://www.zerowastescotland.org.uk/sites/default/files/1.3%20Preventative%20Actions%20final.pdf
[304] https://www.gov.scot/binaries/content/documents/govscot/publications/strategy-plan/2014/06/towards-litter-free-scotland-strategic-approach-higher-quality-local-environments/documents/00452542-pdf/00452542-pdf/govscot%3Adocument
[305] http://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf

could be delivered under a single EPR framework that covers all obligated product types, as proposed in 'Marking Things Last', the 2016 Circular Economy Strategy for Scotland[306].

3.6.2 Non-regulatory measures

The majority of literature on crisps, snack and sweet wrappers and other street litter items focusses on how to impact public littering behaviour.

The research paper from The University of Warwick, 'Using behavioural science to reduce littering'[307] provides a comprehensive overview of non-regulatory interventions that could be considered. Techniques are discussed below in relation to consumer impact and how other members of the value chain can also engage.

Monetary incentives are less suited to engage bin use due to logistical and financial reasons[308] but other incentives such as use of **fun and positive nudges** can encourage pro-social and pro-environmental behaviour e.g. unusually shaped bins (such as sharks or coffee cups), voting bins, or bins that make noises when used. The examples shown in Figure 21 show how varying members of product value chains are already using these tools – from brands, waste management collectors and material reprocessors to engage with consumers to influence disposal behaviour

Figure 21: Bins using nudge techniques to engage consumers – left to right: Coca cola bottle shaped bin, cigarette voting bin and Hubbub talking bin.

Social incentives are also effective – be they shaming or celebratory in nature (e.g. encouraging posting pictures of litterers / litter pickers on social media channels with a unique hashtag). This is an area where monetary incentives could be utilised to good effect to impact consumer behaviour by the value chain – for example offering financial or other rewards to those tagged doing great work in their local community.

There is evidence that **community clean-up activities** can increase motivation not to litter and to promote a long-term reduction in litter (also highlighted in 'Leverage Points for Reducing Single-use Plastics'[309]. This

[306] https://www.gov.scot/publications/making-things-last-circular-economy-strategy-scotland/
[307] Kolodko, Julia and Read, Daniel (2018) Using behavioural science to reduce littering. http://wrap.warwick.ac.uk/100201
[308] http://www.nudgeathon.com/wp-content/uploads/2016/01/CLUB-REPORT.pdf
[309] Eunomia (2017) Leverage Points for Reducing Single-use Plastics. https://www.eunomia.co.uk/reports-tools/leverage-points-for-reducing-single-use-plastics-background-research

also increases **Local pride identity** – where research indicates that removing litter can serve as a morale builder in deprived areas through building community pride and community strength.

Mimicry is also a useful tool, especially amongst younger groups, e.g through use of appropriate ambassadors (e.g. popular YouTubers influencers). Also highlighted in 'Leverage Points for Reducing Single-use Plastics'[310] and 'Low hanging fruit'[311].

The report also discusses the importance of the **use and placement** of visible litter bins and the importance of making these bins **appealing and easy to use**. This is commonly seen as a key driver to reducing littering behaviour and is also highlighted in 'Leverage Points for Reducing Single-use Plastics'[312] and 'Low hanging fruit'[313]. Again this is an opportunity for the value chain to engage, with examples from Coca Cola and Bristol Waste Company (waste management company) showcasing existing good practice (Figure 19 and Figure 20 shown previously). However, conversely, removing litter bins has also been shown to have positive litter reduction impact around the world, with examples including Japan[314] and Taipei[315]. However, in both instances the reduction of litter bins was implemented alongside highly efficient waste and recycling programmes and in cities where food on the go is a less common phenomena that across Scotland and the UK.

There have been prolonged efforts to engage and educate the public in attempts to affect public littering behaviour, as outlined above, with innovative methods trialled more recently by organisations such as Hubbub and the Neat Streets project[316]. However, there are very few suggestions or case studies focussed on the value chain for crisps, snack and sweet wrappers. No examples were found of product design and material choice specifically used to reduce litter and marine litter, nor was this promoted as a measure in the EU Single-use Plastic and Fishing Gear Directive[317]. There is currently very little variation in packaging design across different products, and further engagement with brands and product designers would be required to understand the performance requirements and opportunities for addressing litter issues.

However, broader measures may be adopted that address consumption patterns. The Marine Scotland report, 'Low hanging fruit?', highlights that simply substituting materials is not always the answer. For example, use of compostable or biodegradable plastics, whilst a popular solution with the public, is often a misnomer due to current restrictions in waste infrastructure to process such materials. Opportunities to utilise new materials and public education will be key in this area[318].

Instead, a strategy to cut plastic overconsumption should eventually reduce our environmental, social and economic impact, rather than merely transferring negative externalities to other materials and

[310] Eunomia (2017) Leverage Points for Reducing Single-use Plastics. https://www.eunomia.co.uk/reports-tools/leverage-points-for-reducing-single-use-plastics-background-research

[311] Mitchell (2019), Low hanging fruit? Action on single-use plastic to reduce marine plastic pollution. Marine Scotland

[312] Leverage Points for Reducing Single-use Plastics (Eunomia 2017, 81pp)

[313] Mitchell (2019), Low hanging fruit? Action on single-use plastic to reduce marine plastic pollution. Marine Scotland

[314] https://www.forgerecycling.co.uk/blog/japan-waste-litter/

[315] https://www.smithsonianmag.com/innovation/how-taiwan-has-achieved-one-highest-recycling-rates-world-180971150/

[316] https://www.hubbub.org.uk/neat-streets

[317] http://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf

[318] Understanding plastic packaging and the language we use to describe it (2018). Wrap. http://www.wrap.org.uk/sites/files/wrap/Understanding%20plastic%20packaging%20FINAL.pdf

communities[319]. One mechanism to deliver change might be the Courtauld Commitment, a successful voluntary agreement within the UK grocery sector with signatories of major brands and retailers[320]. It is currently in its third phase and has focussed on reducing food and packaging waste both in terms of weight and carbon impacts. Whilst not directly focussed on litter, measures to reduce packaging could impact in this area and litter impacts could potentially be incorporated in future phases of the agreement. The UK Plastics Pact[321] and the preceding work on A UK Plastics Roadmap to 2025[322] provide a framework for businesses to deliver ambitious targets and seek to transform the way that the UK makes, uses and disposes of plastic.

There have also been recent developments in end-of-life treatment options. As mentioned above, Walkers has established a takeback scheme in partnership with Terracycle, with network of collection points and subsequent recycling[323]. New technologies may also make it easier and cheaper to process difficult to recycle items. For example, chemical recycling converts plastic waste into chemicals that can either be used as fuel or converted into new plastics. This is relatively new technology, with pilots such as Project Beacon in Perthshire[324], which could potentially process crisps, snack and sweet wrappers. However, the impact of improving recycling infrastructure on marine litter is not known.

3.7 Summary

Crisps, snacks and sweet packets and wrappers are typically made from aluminium-coated polypropylene (PP) or polyethylene (PE). Other polymers and aluminium are also commonly used in multiple layers, and some packets are filled with a protective atmosphere of nitrogen gas[325], commonly known as Modified Atmosphere Packaging to protect the contents. The wrappers are designed for food contact safety, to reduce the fragility of the crisps, snacks or sweets within the wrapper and preserve the product for longer, thus extending shelf life. There are Scottish brands, with presence of bigger companies in the UK, whilst many products are imported from abroad.

It is estimated that in the UK, of 8.3 billion packets of crisps eaten annually, 0.3 billion (3.5%) end up as litter[326]. In Scotland, surveys suggest roughly half the population have littered at some point[327]. Crisps, snack and sweet wrappers are typically very common marine litter items, as seen in beach surveys[328] [329], and experts rank food wrappers highly in marine litter items which cause most damage [330]. Whilst no cases of ingestion by marine life were found in the scientific literature, there were over 2,000 recorded incidents of ingestion of 'food packaging' in general, many are reported in newspaper articles. The sources and

[319] Mitchell (2019), Low hanging fruit? Action on single-use plastic to reduce marine plastic pollution. Marine Scotland
[320] http://www.wrap.org.uk/content/what-is-courtauld
[321] UK Plastics Pact (2019). Wrap. http://www.wrap.org.uk/sites/files/wrap/The-UK-Plastics-Pact-Member-progress-report-May-2019_0.pdf
[322] A Roadmap to 2025 - The UK Plastics Pact (2018). Wrap. http://www.wrap.org.uk/content/the-uk-plastics-pact-roadmap-2025
[323] https://www.walkers.co.uk/recycle
[324] https://www.zerowastescotland.org.uk/case-study/project-beacon
[325] https://www.walkers.co.uk/faq/quality-control/do-you-put-nitrogen-gas-in-the-bag-of-crisps-to-keep-them-fresh
[326] EarthWatch Institute, 2019 (https://bit.ly/2U4XBUT)
[327] Zero Waste Scotland, 2013 (https://bit.ly/2Dk1FuH)
[328] JRC, 2016 (https://bit.ly/2UWfyt5)
[329] MCS, 2018 (https://bit.ly/2rdV4vj)
[330] Wilcox et al., 2016 (https://bit.ly/2HI2CNw)

pathways to the marine environment are clear. Crisps, snack and sweet wrappers that are consumed outdoors are dropped on land, blown from bins or skips and littered from cars, a proportion of which are then washed down surface water drains and discharged to the marine environment. Some are directly littered on beaches or blown in from the coastal environment.

This study scope focusses on the supply chain rather than public littering behaviour which is the subject of other ongoing research and policy development. However, it is important to gain an overview in order to understand how the solutions can be targeted across the supply chain. Having carried crisps, snacks and sweets to eat in public spaces and cars, some are then consciously or unconsciously dropped as litter . Research reveals a cultural dependency on bin infrastructure and government street cleansing services that cannot meet the public's propensity to drop litter. The issue is further compounded by public conceptions of 'acceptable' littering for certain products or littering where people think the items will later be cleaned up. There are very few propositions or case studies focussed on the value chain for crisps, snack and sweet wrappers, with the exception of the recent Walkers crisps takeback scheme and new recycling technologies but the impact on litter is not clear.

Packets and wrappers have negative economic value after the contents have been consumed as recycling options are scarce and likely to be uneconomic/unsustainable. Furthermore, economic value is lost through the direct and indirect impacts of littering (clean-up costs, litter disamenity and pollution externalities costs), estimated to amount to many millions of pounds of damage each year. Arguably, a product that is designed to last a matter of months does not need to be packaged in materials that will take hundreds of years to degrade and have negative economic value to society and the economy after the contents are eaten.

Key market players are exploring alternative materials and product designs, but have not yet developed alternative product designs that reduce marine litter beyond traditional pick-and-mix style sweet sales and potential opportunities with niche plastic-free shops/aisles. Many alternative materials (e.g. bioplastics) are more expensive than conventional plastics, do not provide the same use qualities, and are still in R&D phase of development. Examples of recycling exist but are product specific and/or relatively small scale. Moreover, although there is growing awareness of the issues caused by plastics packaging in the marine environment, it has not yet had a significant impact on consumer behaviour as the crisps, sweets and snacks market in the UK continues to grow[331].

A lifecycle based approach can be taken to tackling plastic issues, whereby products are categorised by how long they are in use as this typically indicates which solutions are most applicable. This approach supports elimination or substitution of plastics for small products with a short use-phase [332], but the market would need to produce functional alternatives for the specific requirements of crisps, snacks and sweets. The current product and delivery systems are optimised for single-use products, making it potentially difficult for new product designs and business models that are incompatible with existing systems. Exploration of alternatives could benefit from innovation funding to explore R&D opportunities.

Legislation has been enforced to issue strong and immediate penalties for people caught littering. However, issuing penalties and the deterrent effect they create are dependent on the scale of resources allocated to monitoring and enforcement, which varies across Scotland. If non-payment of penalties is not

[331] https://ahdb.org.uk/news/consumer-insight-continued-innovation-key-to-a-healthy-future-for-crisp-sales
[332] https://ciwm-journal.co.uk/wordpress/wp-content/uploads/2018/06/Eliminating-avoidable-plastic-waste-by-2042-a-use-based-approach-to-decision-and-policy-making.pdf

backed up with legal action, as has been recently publicised, the deterrent effect is reduced. EPR is one regulatory solution that could engage the supply chain in shared responsibility and finding solutions. Recent research reveals insight into littering behaviour that could be used to target future non-regulatory measures.

4 Artificial grass pitch

4.1 Product and trade information

4.1.1 Polymer types and % plastic in product

First developed in 1960s, the engineering of artificial grass pitch (AGP) has improved and the product is now in its third generation (3G). AGP includes small plastic blades of artificial grass – known as 'yarn' or 'pile' – which are attached to a carpet-like base. The base is typically manufactured from a mix of polypropylene (PP), polyamide 6, polyolefin, and/or polyurethane (PUR)[333]. There is a distinction between filled and non-filled AGP. In 3G AGP, which is a filled system, the product requires 'performance infill', which is regularly replaced. The materials used as 'infill' are typically either virgin polymer, natural material (such as cork or coconut husk), or styrene butadiene rubber (SBR). The most common infill in the UK is SBR, manufactured from recycled car tyres[334]. Although SBR is the most common infill, both EPDM (Ethylene propylene dienemonomer) and TPE (thermoplastic elastomer) are alternative synthetic rubber compounds that can also be used as a virgin material infill[335]. Below, Figure 22 shows the different components that make up a typical, filled artificial sports pitch.

Figure 22: Components used in the manufacture of artificial grass pitches[336]

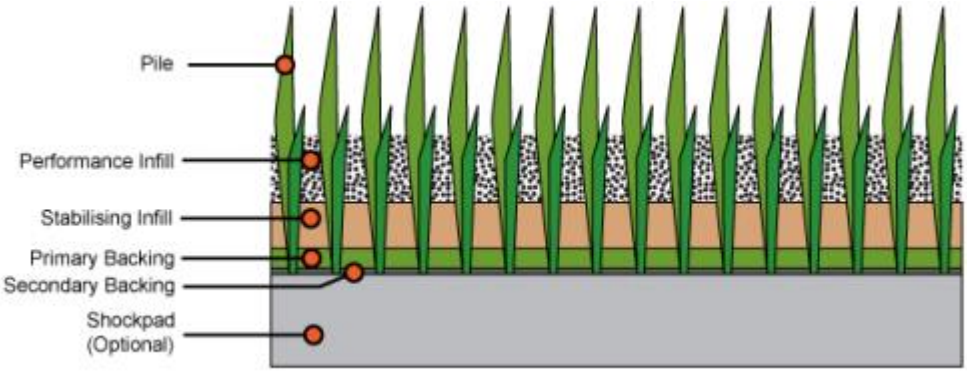


Table 9 shows components and typical materials used in AGP and Figure 23 shows the ratio of polymers used.

[333] https://www.ivl.se/webdav/files/Rapporter/C183.pdf
[334] https://www.fidra.org.uk/turf-tyres-and-health/
[335] https://football-technology.fifa.com/media/1230/artificial_turf_recycling.pdf, p. 9
[336] Eunomia (2018) *Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products*, p. 23

Table 9: Components of artificial grass pitch[337]

Artificial 3G pitch components	Material commonly used	Reason for use
Primary backing material	Polypropylene (PP)	Provides structure and spacing that the pile is woven into.
Secondary backing material	Liquid polyurethane (PU) or latex	Applied and set in order to bind the pile to the backing.
Stabilising infill	Sand	Used to keep the PE fibres vertical during use.
Performance infill	Virgin polymer infill Styrene butadiene rubber (SBR) Organic infill (e.g. cork or coconut husk)	Provides the correct level of impact resistance to reduce injuries and provide a similar feeling to natural grass.
Pile	Polyethylene (PE)	Replicates blades of grass.
Shockpad	PE, PU & SBR, Textile, PU, PP	Reduces the amount of performance infill.

Figure 23: Polymers used in manufacturing artificial pitch[338]

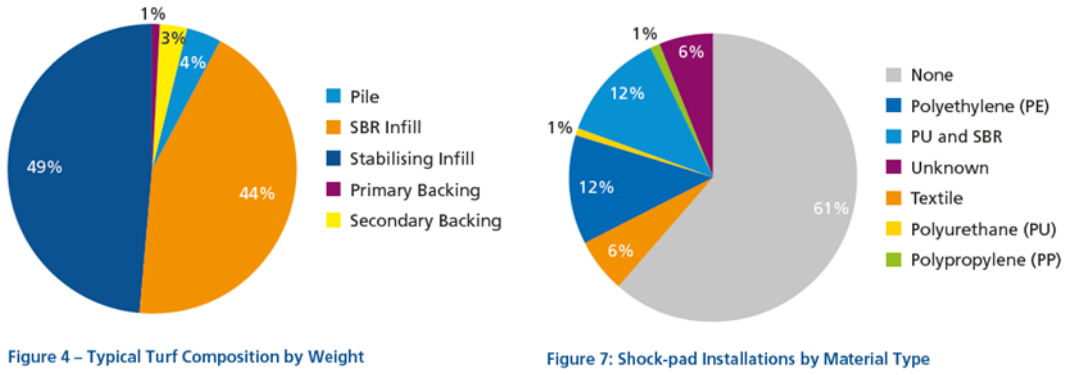


Figure 4 – Typical Turf Composition by Weight

Figure 7: Shock-pad Installations by Material Type

There are some artificial pitches which come without infill, which are promoted for use on small pitches (up to five-a-side)[339]. These operate using a shock absorbing underlay and shorter turf with a special yarn and tuft design – curled fibres to support the synthetic 'grass' stems in staying upright (Figure 24).

[337] Eunomia-Fifa (2017) Environmental Impact Study of Artificial Football Turf
[338] Eunomia-Fifa (2017) Environmental Impact Study of Artificial Football Turf
[339] Arturf (https://bit.ly/2JbjEbm)

Figure 24: Non-infill football grass[340]

4.1.2 Role/function of plastic in product and reasons for choice

AGP must meet high performance standards. It is required to absorb physical body impacts with the surface and mimic natural grass pitch. Using a range of plastic polymers provides performance related benefits such as durability, as well as removing the risk of waterlogging or other weather-related issues.

With on-going improvements to the quality of AGP, 3G technology requires performance infill, which is added to the synthetic pile. This infill is deemed by manufacturers to be essential to improve the performance of the surface and to reduce injury to the sports players. Not all artificial sports pitches have a rubber shockpad beneath the primary and secondary backing. Including a shockpad within the design of artificial pitch minimises the need for SBR (or alternative) crumb infill by approximately 50%[341].

There is an array of relevant standards for use of artificial pitch in outdoor sports, including varied levels of football, rugby and hockey, with some sports requiring compliance with standards in order to compete[342]. The Sports and Play Construction Association (SAPCA) has also produced Codes of Practice relating to installation, maintenance and construction of synthetic sports pitches[343], although this does not contain any information on leakage of infill or guidance on limiting emissions.

FIFA requires artificial pitches to be accredited by their FIFA Quality Programme, however artificial pitch is not allowed in League 2 or above. There are two quality standards – FIFA Quality for community and

[340] Arturf (https://bit.ly/2JbjEbm)
[341] https://www.ivl.se/webdav/files/Rapporter/C183.pdf
[342] Sport England, 2013, page 19 (https://bit.ly/2WiTytk)
[343] SAPCA (https://bit.ly/2EtwEFc)

amateur pitches, and FIFA Quality PRO for professional level football[344]. The approval process includes lab testing, installation review, and repeat field testing even after approval[345].

These standards test[346]:

- Interaction between the player and the surface
- Interaction between the ball and the surface
- Product composition
- Weather resistance
- Seam strength
- Service life

World Rugby Regulation 22 provides standards relating to the use of artificial pitch in rugby[347]. The Rugby Turf Performance Specification requires manufacturers and others involved in installation test and playing surfaces to ensure they comply before they are approved for use in rugby, with no games allowed to be played on artificial surfaces which do not meet the Specification[348].

4.1.3 Product volumes placed on market: import, export and domestic production

Information relating to imports, exports and domestic production of artificial grass turf were not found in the literature.

4.1.4 Key players in the market and indications of market share

Sports and Play Construction Association (SAPCA) is the trade association representing UK sports construction companies. SAPCA provide a list of artificial turf contractors on their website. Some key players are outlined below but full list and contact details can be found on SAPCA website.

Table 10: Some key players relevant to the AGP market in Scotland

Key Players	Location	Role within the supply chain
Synthetic Grass Solutions	Glasgow, Scotland	Surfacing contractor
Ecosse Sports	Midlothian, Scotland	Surfacing contractor
Sports Labs	Livingston, Scotland	Testing/Research
Replay Maintenance	Midlothian, Scotland	Pitch maintenance contractor
Slatter Sports Construction	Berkshire, UK	Surfacing design
TigerTurf	Hartlebury, UK	Surfacing manufacturer
McArdle Sport Tec	Oxfordshire, UK	Surfacing contractor
Genan	Germany, EU	Tyre / Rubber crumb manufacturer

[344] FIFA (https://bit.ly/30GgDoQ)
[345] FIFA, 2018 (https://bit.ly/2HxDL1u)
[346] FIFA (https://bit.ly/30GgDoQ)
[347] World Rugby, 2017 (https://bit.ly/2wd2XUB)
[348] World Rugby, 2017 (https://bit.ly/2wd2XUB)

Key Players	Location	Role within the supply chain
Fieldturf, Tarkett	France, EU	Pitch manufacturer (yarn)
Amorim	Portugal, EU	Pitch manufacturer (Natural Infill)
Trocellen	Germany, EU	Pitch manufacturer (Shockpad)
FIFA	n/a	Football association
Sports and Play Construction Association (SAPCA)	n/a	Trade body for artificial sports pitch
Re-match Turf Recycling	Denmark, EU	End-of-life / Waste management & recycling
Loughborough University, Sports Surface Research	Loughborough, UK	Academia

4.2 Qualifying the problem in the marine environment

4.2.1 Abundance in marine environment

While styrene-butadiene rubber infill from artificial pitches is a comparatively small contributor of microplastics to the aquatic environment, estimated at between 18,000 to 72,000 tonnes per year in Europe, it is also the source expected to grow most in percentage terms to 2035[349]. Based on calculations used to estimate infill loss across Europe in which infill density is estimated at 16.1kg/m^2 and loss rates are between 1% and 4%[350]; the UK is estimated to release between 1,200 tonnes and 4,900 tonnes of microplastic from artificial sports pitches per year. Just considering the 296 full size synthetic pitches used by football clubs in Scotland[351] represents between 359 tonnes and 1,435 tonnes lost per year.

It is highly unlikely that artificial pitch infill will be separately identified as such during marine litter surveys. However, there are larger categories which this material may comprise part of, for example plastic/polystyrene pieces (0-50cm) was the most collected item during MCS beach surveys in 2018[352]. Small (<2.5cm) plastic fragments also comprised 10% of beach litter collected in MCS beach surveys from 2005-2014[353].

4.2.2 Indications of impact

The environmental impacts of artificial pitch in terms of microplastic release are only recently eliciting research interest. This is such that a review of the environmental and health impacts of artificial turf published in 2014 made no mention of microplastics, or loss of crumb to the environment[354]. While this is an emerging science, it has been recognised that microplastics are ingested by marine organisms and can

[349] Eunomia, 2018 (https://bit.ly/2OZDLt9)
[350] Eunomia, 2018 (https://bit.ly/2OZDLt9)
[351] ESTC (https://bit.ly/2WhHRzS)
[352] MCS, 2018 (https://bit.ly/2rdV4vj)
[353] Nelms et al., 2017 (https://bit.ly/2R6vO5t)
[354] Cheng et al., 2014 (https://bit.ly/2UClEQ8)

pass up the food chain[355]. While studies on the impact of microplastics in the marine environment do not specifically refer to infill crumb from artificial turf, it can be assumed that this material would act in the same manner as other microplastics of a similar size.

Crabs have been shown to be vulnerable to uptake of microplastics both through ingestion of pre-exposed food, and following inspiration through the gills, with microplastics retained for longer following inspiration than ingestion[356]. Ingested microplastics still take 6 times longer to leave the body than food waste, giving a period of up to 3 weeks where trophic transfer could occur[357]. Trophic transfer is the transfer of compounds up the food chain as species at each level are consumed by species in the level above. Biomagnification can occur when organisms at higher trophic levels accumulate higher concentrations of compounds, sometimes with negative impacts[358]. Trophic transfer has been shown to represent an indirect but possibly major pathway of microplastic ingestion for species which consume whole prey[359]. Microplastic ingestion has been shown to cause multiple detrimental impacts including reduction in feeding capacity, energy reserves, and reproductive output in organisms at low trophic levels[360]. At present, there is not a clear understanding of whether microplastics bioaccumulate up trophic levels, or act as a mechanism to allow the bioaccumulation or absorption of chemicals into organisms[361, 362].

A review of published literature addressing ingestion risks from marine debris showed that over 2,000 sea turtles, birds and fish had ingested microplastics, across over 80 species (Figure 9 above).

4.3 Key points of leakage and pathways into the marine environment in Scotland

Artificial turf is a relatively small source of microplastics in the environment, however the emissions come from a small number of point sources, each estimated to release 1-5 tonnes of infill per year[363]. This equates to between 1% and 4% of the total infill installed and matches the infill top-up reported as required by turf manufacturers[364]. In the UK in 2012 there was approximately 7,664,337m^2 worth of artificial pitches[365], and using the infill density used by Eunomia research suggests 123,395 tonnes of infill in the UK, 1,233 - 4,935 tonnes of which is lost annually.

The infill material is periodically reapplied indicating there are direct losses of the infill material, a proportion of which is thought to enter watercourses and transferred to the sea. Infill loss occurs during use – the material is walked out of pitches on players' shoes, or becomes attached to players or their clothes, and lost down drains either during clothes washing or showering. In rainstorms infill is washed into drains and sewers. It is also likely that there is some material lost during installation and at end of life. Estimates suggest that 45% of infill is lost during waste disposal, 45% to soil/grass, 5% to internal drains

[355] Eunomia & FIFA, 2017 (https://bit.ly/2GmfECk)
[356] Watts et al., 2014 (https://bit.ly/2v2wXBJ)
[357] Watts et al., 2014 (https://bit.ly/2v2wXBJ)
[358] Desta et al., 2006 (https://bit.ly/2XU7BT0)
[359] Nelms et al., 2018 (https://bit.ly/2Pe7Cyg)
[360] Nelms et al., 2018 (https://bit.ly/2Pe7Cyg)
[361] Carbery et al., 2018 (https://bit.ly/2UYXu1E)
[362] Bonnano and Orlando-Bonaca, 2018 (https://bit.ly/2P9ie1b)
[363] Eunomia, 2018 (https://bit.ly/2OZDLt9)
[364] Eunomia, 2018 (https://bit.ly/2OZDLt9)
[365] Eunomia, 2018 (https://bit.ly/2OZDLt9)

(showers, washing machines) and 5% to surface water drains[366]. Table 11 shows upper and lower estimates of losses from artificial pitches in the UK based on these figures.

Table 11: Lower and upper estimates of infill loss from artificial pitches in the UK

	Lower (tonnes/year)	Upper (tonnes/year)
Waste disposal	555.28	2,221.12
Soil/grass	555.28	2,221.12
Internal drains	61.70	246.79
Surface water drains	61.70	246.79

If infill from artificial pitches reaches surface water drains which are not part of a combined sewer network, these will be discharged straight to a watercourse without any treatment.

Infill entering internal drains can escape to the aquatic environment either through combined sewer overflow (CSO) spills, or if they reach the wastewater treatment works (WWTW), may be removed in treatment and be sent to landfill or spread to land in sludge or in land reclamation (with the potential to be blown into the marine environment from these destinations, or washed back into sewer networks). As all WWTW are unique and no processes currently used in the EU are designed specifically to capture microplastics, the rate of microplastic retention at WWTW is highly variable[367]. The highest retention rates are in those works with tertiary treatment[368], however only 20% of treatment works in Scotland have tertiary treatment[369].

Tonnages lost during waste disposal and to soil/grass also have the potential to be washed or blown into sewers, watercourses or the marine environment.

4.4 Why leakage happens – economic, behavioural and social factors (drivers and barriers)

4.4.1 Economic and competitive forces

First generation AGP was very expensive to install and did not meet the same quality and performance standards as natural turf. The introduction of mixed materials and shock pads has improved the quality of this product. Moreover, the rise in manufacturers and access to low cost materials has driven the growth of this market.

Despite remaining a significant expense, installation of 3G AGPs has experienced significant growth throughout Europe, in both competitive and amateur capacities, allowing sports to be played in all weathers and decreasing maintenance. There is currently an estimated 120 full-size AGPs in Scotland[370]. Bad weather is a determining factor in the move away from natural turf towards an increase in artificial

[366] Eunomia, 2018 (https://bit.ly/2OZDLt9)
[367] Eunomia, 2018 (https://bit.ly/2OZDLt9)
[368] Eunomia, 2018 (https://bit.ly/2OZDLt9)
[369] Scottish Water, 2018 (https://bit.ly/2GEkvPg)
[370] SportScotland, National Audit of Scotland's Outdoor Sports Facilities

pitches in Scotland. Moving from natural pitch to AGP is more suited to high intensity use with reduced maintenance. This provides economic benefits in the form of increased revenue, attracting increased participation and usage.

An audit of 46 full size artificial grass pitches in Scotland[371] concluded that 59% were owned by Local Authorities. 15% were owned by secondary schools, 9% by colleges and universities, and 2% each by primary schools and voluntary clubs. The remaining 16% were assigned to 'other operators' which can be assumed to include professional pitches among others.

In Scottish football, much of the debate around synthetic turf is focused on the quality of the surface, rather than on the leakage of microplastics. Professional footballers prefer to play on natural turf, and it is argued that the introduction of synthetic turf into the professional sport is having a negative impact on how Scottish football is viewed[372]. Professional Footballers' Association (PFA) Scotland has called for a ban on artificial pitch in the Scottish Premiership due to the surface quality impacting the play[373].

There are currently no financial or regulatory incentives for designers and maintenance teams to actively design for the minimisation of infill leakage[374]. Sportscotland highlights that only 45% of Scotland's AGPs meet 'Grade 3 Satisfactory Standard' and estimate a cost of approximately £4.8m to bring these facilities up to an adequate standard[375].

In the design and implementation of artificial sports pitch, there are currently no requirements to include barriers around the perimeter of the pitch. In their recent guidelines 'Pitch In: Guidelines for Owners and Maintenance Teams', Fidra recommends a 'ground-up barrier' be added to the perimeter of artificial pitch and filters be added to drainage systems in order to reduce volume of loose rubber granules being lost from the pitch[376]. There are also recommendations to add a tarmac boundary around artificial pitch to allow maintenance staff to collect and retain crumb or introduce a sloping gradient. However, these recommendations would be at the expense of the pitch owners, which could prove to be a barrier to implementation.

There is an economic incentive to minimising leakage of rubber crumb from artificial sports pitch. At present, it is estimated that a well-maintained, average sized AGP requires between 1 to 5 tonnes of replacement infill each year, which is estimated to be between 1-4% of the total infill[377]. Better planning and design of pitches could reduce the amount of crumb lifted from the pitch during use. Better handling and distribution of infill could minimise leakage of microplastics, whilst also reducing cost to the pitch owners in the purchase of replacement performance infill.

[371] SportScotland (2017), National audit of Scotland's outdoor sports facilities, https://sportscotland.org.uk/documents/resources/nationalauditofscotlandsoutdoorsportsfacilities.pdf
[372] https://www.bbc.co.uk/sport/football/45903364
[373] https://www.skysports.com/football/news/11781/11637153/pfa-scotland-call-for-artificial-pitches-ban-in-scottish-premiership
[374] http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/microplastics_final_report_v5_full.pdf
[375] SportScotland (2006) National Audit of Scotland's Sports Facilities
[376] https://www.fidra.org.uk/wp-content/uploads/Fidra-Pitch-Fact-Sheet-Owners-and-Maintenance-Teams_v1.pdf
[377] https://www.fidra.org.uk/artificial-pitches/

4.4.2 Social norms and behaviours at leakage points

The Fidra report 'Plastic Pitches'[378] recognises that there are practical reasons for choosing artificial turf, especially for playing sports: they can be used much more regularly than natural grass pitches, and they don't need as much water, pesticide or fertiliser as grass. As these artificial turfs become more of the norm, the Eunomia ICF Microplastics report[379] raises as an emerging issue that there is a lack of awareness to date amongst pitch operators that loss of infill can contribute to marine microplastics. Regulators, pitch users and the public, are also unaware of the issue, and thus there is no regulatory or reputational driver for pitches to prevent loss of polymeric infill, or use alternatives. Furthermore, in the absence of 'design, build, and maintain' contracts installers do not have an incentive to minimise lifetime costs through avoiding purchase of 'top-up' infill to replace that which is lost.

It is interesting to note that in media coverage[380] around this issue, the media and commentators seem to focus on the playability of the surface and the revenue implications of not being able to play on the pitches year-round. In general, it does appear that people making purchase and installation decisions are not using player advice as their main driver, but perhaps cost and ease of maintenance instead.

A FIFA report on the Environmental Impacts of Artificial Turf[381] also highlights that recycling of artificial football turf is not widespread. The majority of the manufacturers interviewed for this study claimed their products are 'recyclable', but none are taking significant steps to make sure this happens in practice.

4.4.3 Where value is lost at each point in the chain

Similarly to fishing gear, value of artificial pitch is lost steadily with use as infill is lost from pitches or becomes compressed due to lack of maintenance. In 2009, the cost of providing the correct level of maintenance for a full-size facility (7,500m^2) was up to £10,000 per year – including cleaning, brushing, maintaining uniform infill and conditioning the carpet pile[382]. The cost of replacing infill material is direct value lost.

Compared to items such as fishing gear, it is understood that microplastics have potential to affect productivity and biodiversity of marine ecosystems, thus degrading their value, but quantifying the extent of this has proved difficult[383]. Laboratory studies have shown that health, feeding, growth and survival of organisms at lower trophic levels are impacted by microplastics, however at a higher concentration of particles than would be found in the natural environment[384]. There are concerns about the potential of microplastics absorbed by organisms in the human food chain could allow for transfer of harmful chemicals into the human body when consumed, which would lead to costs in terms of health care, however the

[378] FIDRA (accessed 2019). Plastic Pitches. https://www.fidra.org.uk/artificial-pitches/
[379] Eunomia, 2018). Investigating options for reducing releases in the aquatic environment of microplastics emitted by (but not intentionally added in) products. https://bmbf-plastik.de/sites/default/files/2018-04/microplastics_final_report_v5_full.pdf
[380] BBC Sport (accessed 2910). Artificial pitches in Scotland: Views of managers and players https://www.bbc.co.uk/sport/football/35551542
[381] Eunomia (2017). Environmental Impact Study on artificial football turf Eunomia-FIFA (2017) Environmental Impacts of Artificial Turf
[382] Pitchcare, 2009 (https://bit.ly/2IAet4r)
[383] SEAFISH, 2018 (https://bit.ly/2W10h7L)
[384] SEAFISH, 2018 (https://bit.ly/2W10h7L)

likelihood and severity of this risk is yet to be determined[385]. Despite public concern, research on the health risk of playing on artificial sports pitches have shown that there is no elevated health risk from playing on pitches with rubber infill[386], which could be used to infer that loss of this material to the environment has only low risk in terms of chemical leaching.

4.4.4 How market economics can affect behaviour change

Market economics can impact behaviour change regarding infill loss from artificial pitches via maintenance, changes in infill material, or end of life disposal. Regulations requiring best practice capture techniques at pitches, best practice end of life management or producer responsibility could be implemented[387]. As public awareness of infill loss grows, public pressure may encourage pitch owners away from artificial turf back to natural grass[388], thereby causing a loss of income. Recommended actions are already available for manufacturers, suppliers, installers and pitch owners to take to mitigate risk of infill loss, including switching to organic substitutes and installing measures to mitigate loss of infill to the environment[389].

4.5 Decision points with opportunities to minimise marine plastics

4.5.1 Material and design alternatives, potential impacts these might have, barriers to uptake

The European Synthetic Turf Organisation (ESTO) has suggested a number of design alternatives to reduce infill loss[390]:

- Raised perimeter edging (this should have no impact on pitch drainage as artificial pitches drain through drainage holes in the turf and do not rely on runoff towards the edge of the pitch[391])
- Entrance mats and foot grills to capture infill on shoes
- Slit traps/filter areas in drainage devices around field boundaries and changing rooms
- Artificial pitch with lower potential for infill movement (alter yarn profiles and stitch rates)
- Artificial pitch with lower infill requirements
- Use of infill less prone to movement

There are also a number of non-plastic infill materials available[392], with cork alternatives appearing as the preferred option due the additional benefits environmentally and socially for Mediterranean countries that farm cork[393].

Likely the key barriers for uptake of any of these options is lack of awareness of the issue, lack of public pressure driving change and lack of financial or regulatory incentives[394].

[385] SEAFISH, 2018 (https://bit.ly/2W10h7L)
[386] Pronk et al., 2018 (https://go.nature.com/2IC3o2Y)
[387] Eunomia and Earthwatch Institute, 2019 (https://bit.ly/2GBZIMf)
[388] Eunomia and Earthwatch Institute, 2019 (https://bit.ly/2GBZIMf)
[389] Eunomia and Earthwatch Institute, 2019 (https://bit.ly/2GBZIMf)
[390] ESTO, 2018 (https://bit.ly/2Gox9BO)
[391] Fleming et al. (2016), Drainage behaviour of sport pitches (https://dspace.lboro.ac.uk/dspace-jspui/bitstream/2134/22478/1/Sports%20Pitch%20Drainage%20Final%20Research%20Report%2023-08-2016%20Loughborough%20University.pdf)
[392] KIMO & FIDRA (https://bit.ly/2W6p0aO)
[393] Eunomia & FIFA, 2017 (https://bit.ly/2GmfECk)
[394] Eunomia, 2018 (https://bit.ly/2OZDLt9)

4.5.2 Alternative products and circular economy business models

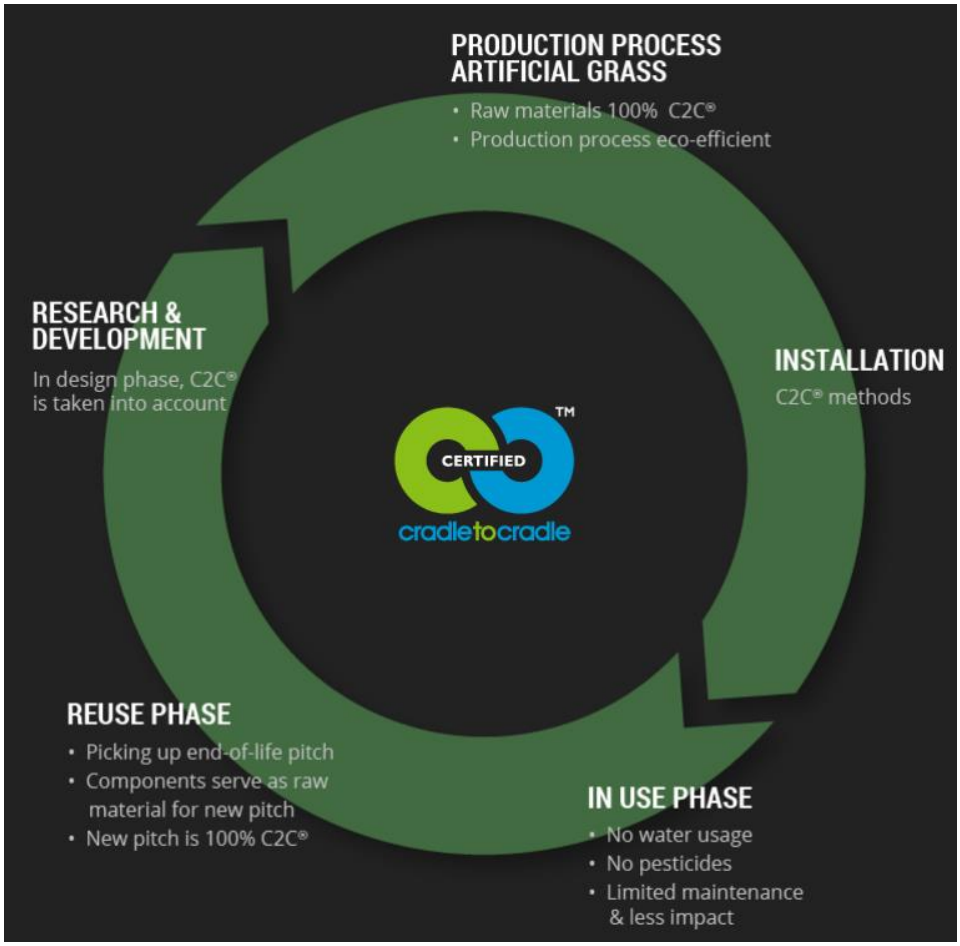
An alternative product which would eliminate infill loss are hybrid turf systems. Hybrid systems have been available since 1989, but this injected fibre system was unpopular[395]. 15 years ago a Dutch manufacturer produced a woven product with an open mesh backing to allow grassroots to penetrate with support to anchor the root zone, which provides the basis for many products currently on the market[396]. Current models involve machines injecting synthetic fibres into the soil, biodegradable backing systems and shock absorption layers integrated into the root zone[397]. Both capital and operational costs are said to be reduced by using hybrid pitches; depending on design, usage and maintenance and fertiliser requirements[398]. Hybrid turf has recently been installed at Celtic Park stadium at a cost of £1.5 million, and has since suffered a disease causing die off of the natural grass[399].

Circular economy in terms of artificial pitch is likely to involve EPR to ensure the product is maintained and the materials recycled appropriately at end of life. If producers retained ownership of the material, including infill, it seems likely that this could incentivise actions to maintain infill and prevent infill loss.

There are already companies operating in the UK under a Cradle to Cradle approach, in which components of end of life pitches are used as material for new pitches (Figure 25). Danish company Re-Match has developed a separation process which enables recycling of 99% of worn out artificial turf into raw, clean components for reuse in the turf industry or other products[400]. Disposing of artificial turf using Re-Match technology is stated to cut disposal costs by 10%, and the recycled materials can be sold at roughly 80% of the price of virgin materials[401]. Re-Match has received approval from FIFA accredited Sports Labs surface testing company[402]. At present, recycling of artificial turf is not widespread, and while manufacturers will state that their products are recyclable, none take steps to ensure this happens[403]. Support from turf manufacturers is required to develop closed loop recycling processes[404], which could be a stream for EPR revenue. Reviews have been undertaken on end of life options for artificial turf, and guidance provided for environmental best practice[405].

[395] Sportslabs (2018), What is the big fuss about hybrid turf systems? https://www.sportslabs.co.uk/field-notes/2018/3/14/what-is-the-big-fuss-about-hybrid-turf-systems
[396] Sportslabs (2018), What is the big fuss about hybrid turf systems? https://www.sportslabs.co.uk/field-notes/2018/3/14/what-is-the-big-fuss-about-hybrid-turf-systems
[397] Sportslabs (2018), What is the big fuss about hybrid turf systems? https://www.sportslabs.co.uk/field-notes/2018/3/14/what-is-the-big-fuss-about-hybrid-turf-systems
[398] Sportslabs (2018), What is the big fuss about hybrid turf systems? https://www.sportslabs.co.uk/field-notes/2018/3/14/what-is-the-big-fuss-about-hybrid-turf-systems
[399] Herald Scotland (2019), Celtic's hybrid pitch has a "slight disease" reveals Brendan Rodgers, https://www.heraldscotland.com/sport/17374259.celtics-hybrid-pitch-has-a-slight-disease-reveals-brendan-rodgers/
[400] Business Europe, 2017 (https://bit.ly/2GDasKq)
[401] Business Europe, 2017 (https://bit.ly/2GDasKq)
[402] Resource, 2018 (https://bit.ly/2XF74nR)
[403] Eunomia & FIFA, 2017 (https://bit.ly/2GmfECk)
[404] Eunomia & FIFA, 2017 (https://bit.ly/2GmfECk)
[405] Eunomia & FIFA, 2017 (https://bit.ly/2GmfECk)

Figure 25: Cradle to Cradle approach used by Desso Sports for artificial pitch, they aim to have all artificial turf systems 100% Cradle to Cradle by 2020[406]



4.6 Levers available to the Scottish Government (intervention and support)

As with the other products, lever categories of bans, penalties, levies, product regulation, support and influence are available where suitable, as described in Section 2.6. The regulatory and non-regulatory measures available to the Government are explored in the sections below in the context of existing legislative powers, proposed legislation, behavioural science and case studies.

4.6.1 Regulatory measures

Leakage of in-fill from artificial pitches is not a well-known issue and there are currently no specific regulations to address it directly. Plastics are not commonly classified as a pollutant in the legislative framework and so leakage of plastics, particularly as a result of ongoing operational practice, can be seen as a legislative gap.

[406] Desso Sports (https://bit.ly/2Vna1Mu)

However, some waste regulations may apply. For example, Waste Duty of Care[407] states you must not allow waste to escape from your control and that of your employees[408], and failure to comply risks prosecution or a fine. In England, Defra clarifies that substances are considered as waste if accidentally, unknowingly or involuntarily discarded, giving the example of when a fuel is leaking from a service station storage tank into the ground beneath and the producer or holder is unaware of the leak[409]. This definition and example suggest in-fill material leaking from a pitch would be classified as waste and subject to the Duty of Care regulations. Categorising used or lost granulate as hazardous waste would be a new approach as would ensuring arrangements are in place to safely remove and dispose of used granulate (preferably before a new playing field is built).

While artificial pitches have durability and weatherproof advantages, Local Authorities could be encouraged to use the planning system to promote the use of indoor pitches, natural pitches, and pitches that do not require in-fill where appropriate. Likewise, local planning systems could be used to ensure that runoff water from newly developed artificial playing fields does not enter storm drains untreated. In this regard, the Irish Government is trialling use of planning consent to require zero plastic loss from artificial pitches, although there are no details published at the present.

4.6.2 Non-regulatory measures

KIMO International and Fidra have provided a number of reports with guidance for designers, procurement specialists[410], owners and maintenance teams[411] on this issue as part of their 'Pitch In' campaign[412]. They have also produced a **Pitch In community toolkit[413]** to spread the word about microplastics from pitches and what users, and community groups, can do to make their own pitches 'greener' and a paper aimed at Sports Clubs and Municipalities[414].

Key interventions that have been recommended by KIMO include:

- **Selective funding:** To promote both natural pitches and indoor pitches through.
- **Procurement:** Include microplastic management as an element of procurement, including value strategies to reduce the risks of contamination in the tender process along with assurance around care during installation and through clean up after pitch installation/ removal / renewal. Also negotiating a 'take-back' scheme with the manufacturers of the granulate/pitches. Incorporate microplastic pollution mitigation features as standard in all new fields.

[407] The Environmental Protection (Duty of Care) (Scotland) Regulations 2014 and associated Code of Practice
[408] https://www2.gov.scot/resource/0040/00404095.pdf
[409] https://www.gov.uk/government/publications/legal-definition-of-waste-guidance/decide-if-a-material-is-waste-or-not#decide-if-your-material-is-waste
[410] KIMO (2017). Pitch In to reduce microplastic loss from artificial pitches: Guidelines for Designers and Procurement Specialists. Accessed from http://www.kimointernational.org/pitch-in/
[411] KIMO (2017). Pitch In to reduce microplastic loss from artificial pitches: Guidelines for Owners and Maintenance Teams. Accessed from http://www.kimointernational.org/pitch-in/
[412] http://www.kimointernational.org/feature/microplastic-pollution-from-artificial-grass-a-field-guide/
[413] FIDRA (accessed 2019). Plastic Pitches. https://www.fidra.org.uk/artificial-pitches/
[414] KIMO (2018). KIMO RESOLUTION 18/01. Microplastic Pollution from Artificial Grass Sports Fields. http://www.kimointernational.org/wp/wp-content/uploads/2018/11/KIMO_Resolution_18_01.pdf

- **Careful design:** Design the pitch and associated infrastructure to minimise the loss of the infill – consider pitch layout, physical barriers, exit gates, pitch drainage and filters. Use infill materials which reduce microplastic pollution (e.g. cork or coconut husk).
- **Communications:** Raise awareness of the problem of microplastic pollution and promote behaviours that reduce infill loss amongst users of artificial grass sports fields. Help players keep the infill in. This might include brush-off zones to remove the infill before leaving the pitch, filters in showers and collection bins in changing rooms, information on best practice such as posters on the edge of the pitch or in the changing rooms.
- **Maintenance**: Adapt current care programme to minimise any loss of infill. E.g.take care when topping up infill so it does not escape into the environment; store infill safely; get the right tools to recover infill and prevent infill loss (e.g. using rakes over leaf blowers); redistribute infill on the pitch regularly; use power sweeping machines to help collect granules; clean equipment carefully; cover drains during maintenance work; try to sort debris that may be contaminated with microplastic so it can be returned to the pitch; avoid removing snow from the pitch and if you do avoid placing it on grass or soil so you can return infill to the pitch when melted.
- **Wastewater:** Encourage investment in better filtration systems at waste water treatment plants (for example, last step treatments of effluent such as membrane bioreactors and sand filters with hydrous ferric oxide can greatly increase the retention of particles including microplastics) and ensure that infill is not lost to surface water drains which drain into watercourses and ultimately empty into the ocean.
- **Legislation:** Enforce existing legislation by establishing linkages between clubs, municipal sports departments and municipal environmental departments to ensure that environmental best practice for artificial turf playing fields is followed.
- **Owner commitment:** Make an individualised 'Microplastic Reduction Action Plan' for each artificial grass playing field..

4.7 Summary

There are two types of artificial grass pitch (AGP): those using a performance infill crumb and those that don't. Typically, AGP used for sports facilities uses infill crumb whereas artificial grass for domestic/garden use does not. In addition, hybrid pitch designs are available that support soil and grassroots with synthetic materials and do not require infill. The infill is used in sports facilities to replicate the bounce and performance of grass pitches, allow for drainage, protect and support the synthetic fibres and help prevent injuries by increasing stability[415]. However, there are some artificial pitches which come without infill, which are promoted for use on small pitches (up to five-a-side)[416]. These operate using a shock absorbing underlay and shorter turf with a special yarn and tuft design – curled fibres to support the synthetic 'grass' stems in staying upright[417].

The infill is commonly made from recycled car tyres (a plastic polymer of polymer styrene butadiene rubber (SBR)), although other materials are available including virgin plastics (thought to leach less toxins) and

[415] Neograss, 2019 (https://bit.ly/2Jh1GED)
[416] Arturf (https://bit.ly/2JbjEbm)
[417] Arturf (https://bit.ly/2JbjEbm)

non-plastics. The infill material is periodically reapplied indicating there are direct losses of the infill material, a proportion of which is thought to enter watercourses and transferred to the sea.

Beach and other marine litter surveys typically do not separately identify microplastics of which the infill would be categorised. The infill may be too small to be easily observed or it may be counted as part of the 'small plastic fragments' categories which are typically the most common beach litter items. Loss rates estimates are relatively high, between 1% and 4%, resulting in between 1,200 tonnes and 4,900 tonnes of microplastic emissions per year in the UK. Just considering the 296 full size synthetic pitches used by football clubs in Scotland[418] represents between 359 tonnes and 1,435 tonnes lost per year. Estimates suggest that 45% of infill is lost during waste disposal, 45% to soil/grass, 5% to internal drains (showers, washing machines) and 5% to surface water drains[419]. Infill is walked out on players' shoes and clothes and then washed down drains from washing or showering. In rainstorms infill is washed into drains and sewers. Sewers and wastewater treatment works are not designed to deal with microplastics and the ability to remove these items before discharging to waterways is highly variable. The best removal rates are in works with tertiary treatment, however only 20% of treatment works in Scotland have tertiary treatment. Drains may bypass WWTW entirely through combined sewer overflow spills.

Research into microplastics is in its infancy but early evidence elicits considerable concern as microplastics appear to enter the lowest levels of the food chain and pass up levels through predation. Ingestion has been linked to detrimental impacts including reduction in feeding capacity, energy reserves, and reproductive output [420]. In response, Fidra and KIMO have researched infill as marine pollution and developed guidelines to minimise losses[421] [422] **[423]**. The European Synthetic Turf Organisation is also engaged on the issue and has suggested a number of design alternatives to reduce infill loss[424].

In the absence of 'design, build, and maintain' contracts, the supply chain for AGP is distanced from the direct costs of replacing lost infill (part of the maintenance costs of up to £10,000 per year for a full-size facility) and the environmental costs are not internalised in the market at all. Non-plastic infill is available, and choosing cork potentially carries additional benefits environmentally and socially for Mediterranean countries that farm it. At present, there are no known sustainable infill non-plastic alternatives which are produced in Scotland.

Not preventing loss of infill may be an offence under Waste Duty of Care, but this would need to be tested in a court of law. The Irish Government is trialling use of planning consent to require zero plastic loss from artificial pitches, although there are no details published at the present. Comprehensive guidance has been

[418] ESTC (https://bit.ly/2WhHRzS)
[419] Eunomia, 2018 (https://bit.ly/2OZDLt9)
[420] Nelms et al., 2018 (https://bit.ly/2Pe7Cyg)
[421] KIMO (2017). Pitch In to reduce microplastic loss from artificial pitches: Guidelines for Designers and Procurement Specialists. Accessed from http://www.kimointernational.org/pitch-in/
[422] KIMO (2017). Pitch In to reduce microplastic loss from artificial pitches: Guidelines for Owners and Maintenance Teams. Accessed from http://www.kimointernational.org/pitch-in/
[423] FIDRA (accessed 2019). Plastic Pitches. https://www.fidra.org.uk/artificial-pitches/
[424] ESTO, 2018 (https://bit.ly/2Gox9BO)

published for designers, procurement specialists, owners and maintenance teams to minimise infill losses [425] [426].

Likely the key barriers for uptake of any of these options is lack of awareness of the issue, possible lack of functional alternatives, lack of public pressure driving change and lack of financial or regulatory incentives.

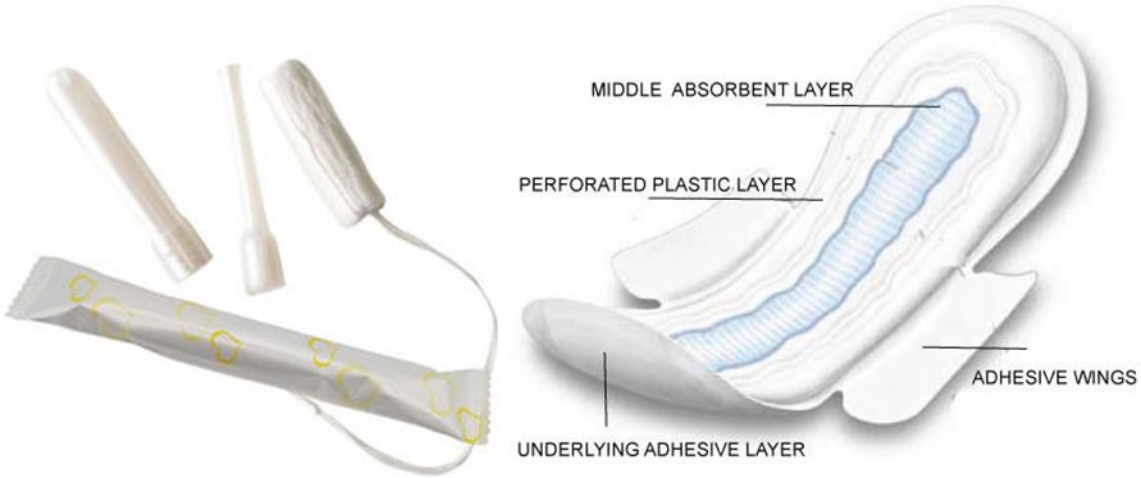
5 Menstrual products

5.1 Product and trade information

5.1.1 Polymer types and % plastic in product

Disposable menstrual products such as pads and tampons are made from synthetic materials, predominantly a range of different plastics. Manufacturers of menstrual products are not required to disclose full list of ingredients in pads and tampons, however in 2015 major brands published ingredients used in their products on their websites following consumer demand.[427] Examples of common menstrual products are shown in Figure 26.

Figure 26: Example of disposable tampon, plastic applicator and wrapper (left)[428] and disposable menstrual pad (right)[429]



Nonwoven menstrual products include hydrophilic cellulosic fibres (wood- derived fluff pulp or viscose rayon), superabsorbent polymer granules or superabsorbent fibres and hydrophobic polyester or polypropylene fibres[430].

[425] KIMO (2017). Pitch In to reduce microplastic loss from artificial pitches: Guidelines for Designers and Procurement Specialists. Accessed from http://www.kimointernational.org/pitch-in/

[426] KIMO (2017). Pitch In to reduce microplastic loss from artificial pitches: Guidelines for Owners and Maintenance Teams. Accessed from http://www.kimointernational.org/pitch-in/

[427] https://www.nytimes.com/2015/10/27/business/under-pressure-feminine-product-makers-disclose-ingredients.html?_r=0

[428] http://www.echosuppliesmachine.com/supplier-334657-tampon

[429] https://www.glamcheck.com/fashion/2010/05/19/what-are-sanitary-pads-types/

[430] Das, D (2014) *Composite nonwovens in absorbent hygiene products*, p. 75

Included in sections 5.1.1.1 and 5.1.1.2. below are figures outlining key ingredients included in the manufacturing of pads and tampons, from major brands operating in the UK.

5.1.1.1 Pads

Components used in pads are illustrated in Figure 27 and Figure 28.

Figure 27: Components in Proctor & Gamble's Always pad[431]

Pad components	Infinity	Radiant	Ultra	Maxi	Pure and Clean
Top Sheet A soft fabric that is designed to pull fluid away from skin	**Polyolefins**, like those commonly used in clothing; with **petrolatum and zinc oxide**, (ingredients found in skin lotions) on **Infinity and Radiant**				**Polyethylene** - Synthetic fibers similar to those used in garments/Clothing
Absorbent Core A layer that acquires and stores fluid, locking it away	**Absorbent foam (Flex Foam)**		**Absorbent wood cellulose** (the absorbent material used in pads since 1920s) with **absorbent gel, rayon, or polyester**		**Absorbent wood cellulose** and super **absorbent gel** pearls to keep fluids inside
Back Sheet A soft moisture proof layer to keep the fluid inside	**Polyolefins**, like those commonly used in clothing (printed on Radiant)				**Polypropylene and polyethylene - Synthetic layer moisture proof to keep fluid inside**
Adhesives	An FDA approved food additive adhesive similar to craft glue sticks				Glue to ensure the layers in the pad keep together and pad adheres to panty
Fragrance Provide a fresh scent	**Fragrance ingredients.** Only on versions labeled as scented				Not present
Wrapper Protects the adhesives before the pad is used	**Printed polyolefin** like that used in clothing, and paper (Maxi only)				**Printed polyethylene** - film to keep pad protected and convenient to carry
Wing paper Protects the wings adhesive before the pad is used	**Printed paper**				**Paper** to protect wing adhesive before pad is used

[431] https://always.com/en-us/about-us/what-ingredients-are-in-always-pads

The typical design of disposable pads includes 'a cellulose-based absorbent core placed between a fluid permeable surface (topsheet) and a moisture impermeable backing (backsheet)'. Woeller & Hochwalt (2015) outline the polymers included in a typical 'sanitary pad': [432]

> the topsheet is a polyethylene/polypropylene non-woven fabric bearing an emollient finish; the core comprises a two-layer, low density, open celled, polyacrylate polymer foam; and the backsheet consists of an impermeable pigmented polyethylene film with a panty fastening adhesive. Scented versions of the pad contain a small amount of perfume applied between the backsheet and the undersurface of the core.

Figure 28: Composition of a 'sanitary pad' [433]

Composition of a sanitary pad with emollient-treated topsheet and absorbent foam core.

Component	Function	Raw material composition
Topsheet	Fluid permeable surface cover that is soft to the skin and allows fluid to penetrate	Perforated non-woven fabric of polypropylene/polyethylene fibers
Emollient	Potential comfort and skin moisturizing benefits	Petrolatum based formulation
Absorbent core	Absorb and capture fluids	Polymeric open-celled foam
Perfume	Scent	Fragrance raw materials
Backsheet (printed)	Moisture impermeable barrier	Low density polyethylene film with pigments
Adhesive	Fasten pad to the undergarment	Polyaromatic/polyolefinic block copolymers, hydrocarbon resins, mineral oil

[432] Woeller, K. and Hochwalt, E. (2015) 'Safety assessment of sanitary pads with a polymeric foam absorbent core', https://www.sciencedirect.com/science/article/pii/S0273230015300386?via%3Dihub [Accessed 22 April 2019]
[433] Woeller, K. and Hochwalt, E. (2015), Composition of a 'sanitary pad'

5.1.1.2 Tampons

Components used in tampons are illustrated in Figure 29.

Figure 29: Components in Tampax tampons[434]

Tampon Components	Function	Material
Applicator	Helps to comfortably insert the tampon	Cardboard made of tightly wound paper or plastic with pigments for color
Absorbent Core	Provides protection by absorbing and storing menstrual fluid	Cotton and/or Rayon
Thin Fabric around Absorbent Core	Helps with smooth removal; helps form the absorbent skirt on certain designs	Rayon and polyester or polyethylene and polypropylene
String	Used to remove the tampon; also has a braid on certain designs	Cotton and/or polyester; Polypropylene braid
Thread	Used to attach the string to absorbent core	Cotton-wrapped polyester or polyester
Fragrance: Only on versions labeled as scented. All other versions do not include fragrance.	Provides a fresh scent	Fragrance ingredients like those found in other women's products

5.1.2 Role/function of plastic in product and reasons for choice

Absorbency and dryness are key functions of menstrual products. Synthetic fibres are designed to retain liquid and to maximize the feel of dryness[435], whilst isolating the feeling of wetness from the skin. There are a range of plastic polymers in disposable tampons and pads that improve the performance and usability of these products. Plastic tampon applicators are marketed as easier to use and more comfortable for tampon insertion than tampons with cardboard applicators or tampons with applicators. These are specifically marketed at younger users. Cardboard applicator tampons are available in all major retailers, and are typically cheaper than plastic applicator tampons. Polyethylene and polyester are mixed with cotton and/or rayon in the manufacture of tampons to strength the product and improve absorbency. In the manufacture of pads, polyethylene or polypropylene is used to improve absorbency as the synthetic fibres can hold more

[434] https://tampax.co.uk/en-gb/tampax-articles/women-s-health/what-are-tampax-tampons-made-of
[435] Das, D (2014) *Composite nonwovens in absorbent hygiene products*, p. 75

liquid than natural fibres. It is estimated that pads contain around 90% synthetic polymers, whilst a tampon is around 6% plastic (tampon only – not including applicator)[436].

UK manufacturers association AHPMA provides a 'Code of Practice for Tampon Manufacturers and Distributors' which includes information on labelling and absorbency[437]. There are no other clear standards in the UK. No other Scottish or UK product standards for menstrual products were identified within this literature review.

In the US, disposable menstrual products are regulated by the Food and Drug Administration (FDA) and must undergo a review where manufacturers submit information on results of testing on safety of materials, absorbency, strength and integrity, and whether tampons enhance growth of bacteria[438]. The FDA provides a number of documents on the subject, including a guidance document to assist industry in preparing premarket notification submissions. However, these do not establish enforceable responsibilities and are viewed as recommendations and best practice[439]. This guidance document recommends conducting biocompatibility testing which evaluates medical devices considering the nature and duration of their contact with the body[440].

Brands such as Bodyform state on their websites that they collaborate with EDANA (the international association for the nonwovens and related industries) to ensure that they comply with the highest environmental and product safety standards[441]. However, there is no clear guidance of the EDANA website as to the product safety standards they follow on their safety related pages[442].

5.1.3 Product volumes placed on market: import, export and domestic production

Detailed information on menstrual products market in the UK can be found in Appendix A.1

According to PRODCOM lists of production, import and export of menstrual products, there is no UK production of these products. There is manufacture of nonwovens in Scotland, however this application is not used in the manufacture of disposable menstrual products. These products have a global supply chain, with the market share dominated by a small number of multinational brands, and as such it is difficult to source data on manufacturing locations.

Research by Zero Waste Scotland (ZWS) estimates a total market of around 430 million disposable menstrual products per annum in Scotland, on the basis that there are around 1.32 million girls and women in Scotland aged between when periods typically start (age 13) and the average of menopause (50 years old), and that on average each user consumes 340 sanitary products a year. The market currently using reusables is estimated (optimistically) at around 5%. [443]

[436] https://friendsoftheearth.uk/plastics/plastic-periods-menstrual-products-and-plastic-pollution
[437] AHPMA, 2017 (https://bit.ly/2YJVDM7)
[438] FDA, 2018 (https://bit.ly/2Wjj4OT)
[439] FDA, 2005 (https://bit.ly/2K2avRU)
[440] ISO, 2018 (https://bit.ly/2YKD2zL)
[441] Bodyform (https://bit.ly/2VGQyCG)
[442] EDANA (https://bit.ly/2WX5ayV)
[443] Zero Waste Scotland (ongoing research), Re-usable menstrual products research

5.1.4 Key players in the market and indications of market share

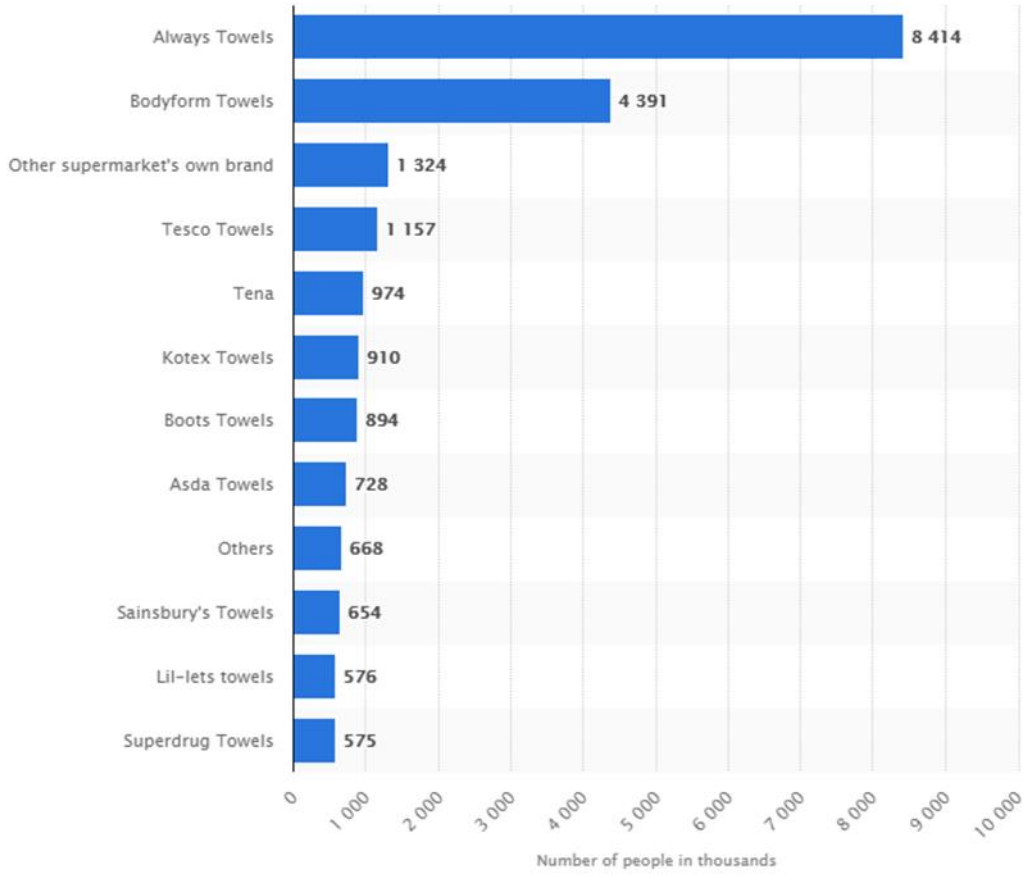
Key players in the Scotland market for menstrual products are given in Table 12 and key brands and products in the UK are shown in Figure 30 and Figure 31Figure None of the key players identified are based in Scotland and evidence suggests companies with HQs in England manufacture outside of the UK.

Table 12: Key players in the Scotland market for menstrual products

Key Players	Market share
Proctor & Gamble UK	Largest manufacturer of menstrual products, with 44% of U.S. market share[444]. Tampax brand within their portfolio.
Drylock Technologies Ltd	Not known
Johnson & Johnson Consumer Services EAME Ltd	Not known
Kimberly-Clark Ltd	Not known
Lil-lets UK Ltd	Not known
Ontex Retail UK Ltd	In 2017, revenue of €2.36 billion, up 18.2%[445]
Essity	The world's sixth largest player, the third largest in Europe and the market leader in Latin America. Examples of regional brands supported by Essity's global brand platform in Feminine Care include Libresse in the Nordic region, Russia, Eastern Europe, the Netherlands and Malaysia, Bodyform in the UK, Nana in France, the Middle East and North Africa, and Saba and Nosotras in Latin America.
Toiletry Sales Ltd	Not known

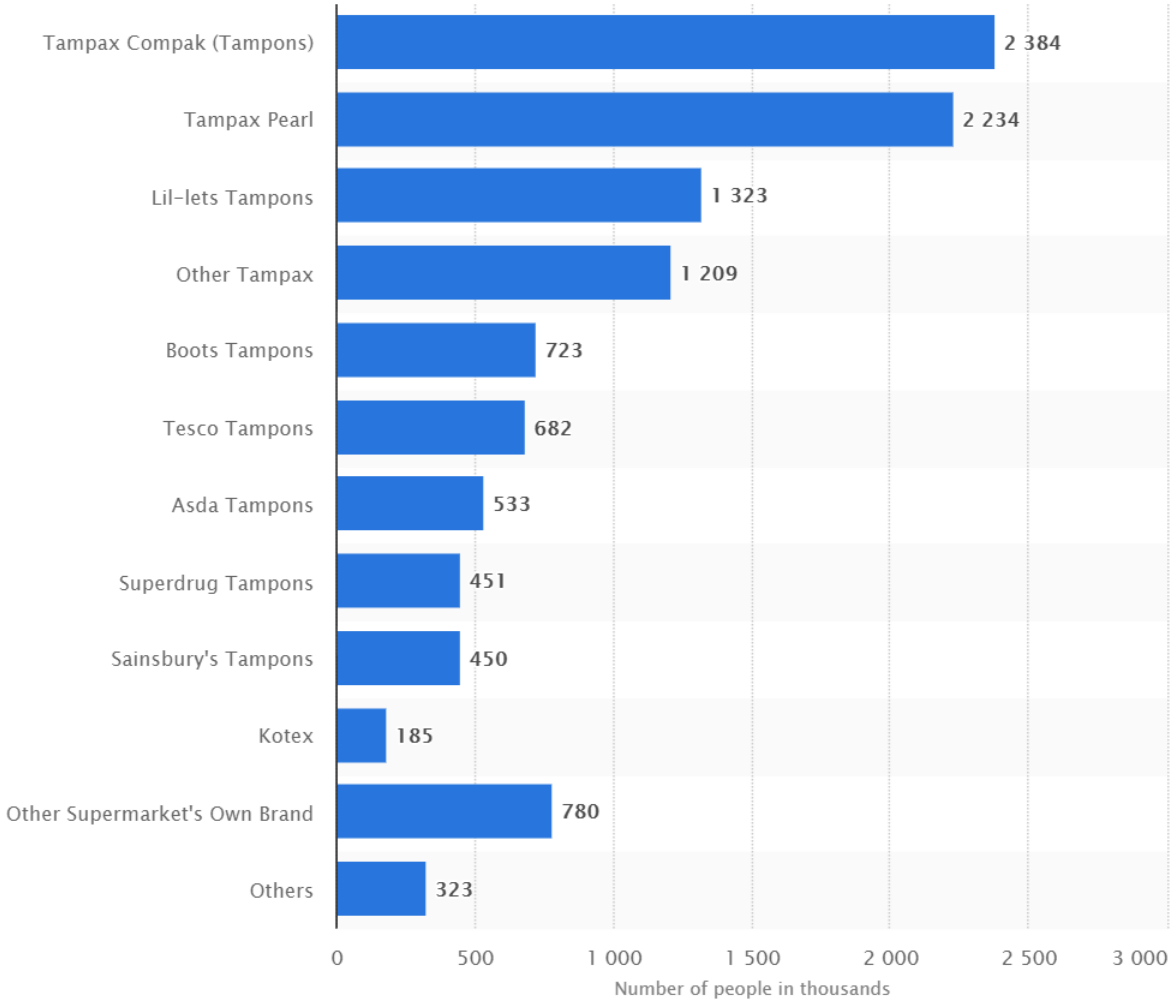
[444] https://edition.cnn.com/2015/11/13/health/whats-in-your-pad-or-tampon/
[445] http://www.ontexglobal.com/ontex-fy-2017-results

Figure 30: Brands of feminine hygiene towels ranked by number of users in the United Kingdom (UK) in 2017 (in 1,000s), Statista[446]



[446] Statista (2017) https://www.statista.com/statistics/305048/leading-brands-of-feminine-hygiene-towels-in-the-uk/

Figure 31 Brands of tampons ranked by number of users in the United Kingdom (UK) in 2018 (in 1,000s), Statista[447]



5.2 Qualifying the problem in the marine environment

5.2.1 Abundance in marine environment

ZWS research estimated that around 220,000 tampons and 122,000 menstrual pads are flushed down the toilet in Scotland every day, nearly 125 million per annum, suggesting around 30% of all disposable products are flushed by the user. [448] Another estimate based on UK data suggests a higher rate of flushing. The Absorbent Hygiene Product Manufactures Association (AHPMA) estimated that 4.3 billion menstrual products are used per year in the UK[449], and another report suggested that 1.5 - 2 billion menstrual products are flushed every year[450], inferring that 35-47% of all menstrual products are flushed every year

[447] Statista, (2018) https://www.statista.com/statistics/305057/leading-brands-of-tampons-in-the-uk/
[448] Zero Waste Scotland (ongoing research), Re-usable menstrual products research
[449] AHPMA, 2007, http://www.ahpma.co.uk/docs/Menstruation%20Facts%20and%20Figs.pdf
[450] MCS, 2015, https://www.mcsuk.org/downloads/pollution/PPPS%20Marine%20Plastics.pdf

although some of the data sources are outdated. Almost 1 in 4 women surveyed online flush tampons down the toilet, as did 4 of 6 interviewed face to face[451]. Frequency of flushing menstrual products is shown in Figure 33. MCS data shows that 4.8 pieces of litter identified as menstrual waste are found per 100m of beach[452].

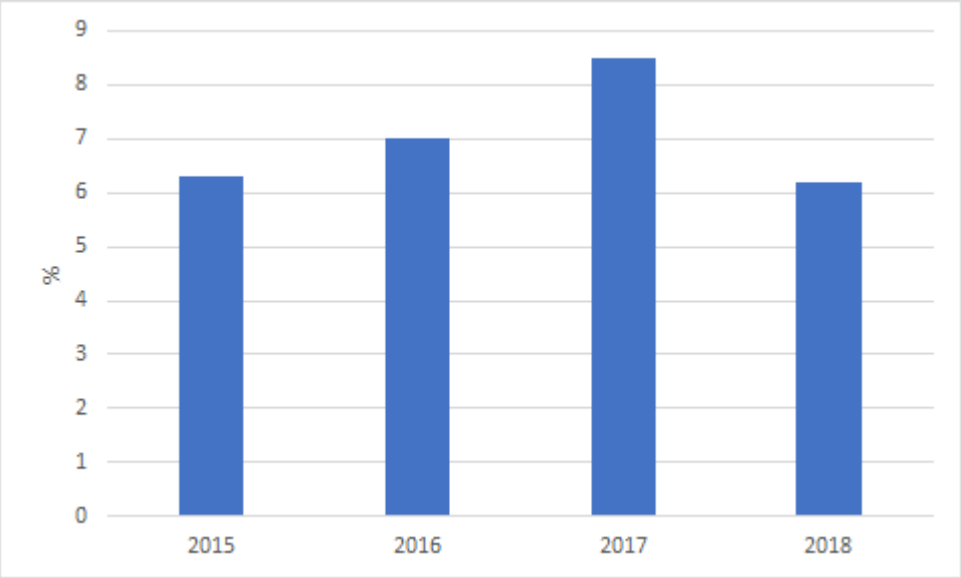
In a comparison of marine litter studies from across Europe; sanitary items including menstrual products ranked in the top 20 most frequently occurring items[453]. At Northern North Sea survey sites, sanitary items (mainly cotton buds, but also menstrual products), were the second most common litter type, representing 9.2% of litter found[454]. On British beaches between 2005-2014, sewage related debris including menstrual products made up 5% of items found (Table 13), this figure has fluctuated over the last four years (Figure 32). The Women's Environmental Network stated that in 2010 there were 23 menstrual pads and nine plastic tampon applicators per kilometre of beach[455].

Table 13: Proportion of beach litter composed of sewage related debris from Nelms et al. (2017), based on surveys on British beaches from 2005-2014 by Marine Conservation Society volunteers[456].

Item Category	Proportion
Sewage related debris	5%

[451] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup), survey of 613 women in NW England
[452] Reloop, 2018 (https://bit.ly/2zQzbqL)
[453] JRC, 2016 (https://bit.ly/2UWfyt5)
[454] OSPAR, 2017 (https://bit.ly/2UC7n62)
[455] WEN, 2017 (https://bit.ly/2pA6UPG)
[456] Nelms et al., 2017 (https://bit.ly/2R6vO5t)

Figure 32: Proportion of litter collected on British beaches composed of sewage related debris during the last four Great British Beach Clean Surveys[457]



Nelms et al. (2017) highlighted that plastic was the most dominant material group found on British beaches from 2005-2014, comprising 66% of material found. Sanitary items made up 5% of plastic products.

Historically, the proportion of sewage related debris of Scottish beaches has been considerably higher than the UK average, necessitating investment in the sewage system to upgrade the sewerage network in order to reduce the frequency of combined sewer overflow (CSO) use[458]. In the 2010 MCS survey, sewage related debris (SRD) accounted for 20.5% of coastal litter (487.5 items/km) in Scotland, a result skewed by one beach which was disproportionately affected by SRD – once this was removed the total was reduced to 12% of coastal litter[459]. Scotland remains the hardest hit by sewage related debris in the UK[460].

5.2.2 Indications of impact

Menstrual products have an ingestion risk, similarly to crisp, snack and sweet wrappers, with a tampon applicator found in the stomach of Laysan albatross chicks which had been found dead in their nests in Hawaii[461]. There is also the potential for chemical leaching into the marine environment as most tampons contain dioxin, chlorine and rayon[462], however the extent of this in the marine environment is unknown. The key impact of menstrual products washed up on beaches is the visual disamenity and impact on tourism value of beaches[463], as these products are associated with the 'yuck' factor and can turn people away from using beaches and the surrounding infrastructure.

[457] MCS, 2018 (https://bit.ly/2rdV4vj); MCS, 2017 (https://bit.ly/2DhCJWS); MCS, 2016 (https://bit.ly/2GmTqAh); MCS, 2015 (https://bit.ly/1MlD75x)
[458] Marine Scotland, 2011, https://www.gov.scot/publications/marine-litter-issues-impacts-actions/pages/3/
[459] Marine Scotland, 2011, https://www.gov.scot/publications/marine-litter-issues-impacts-actions/pages/3/
[460] Scotsman (2019), Fight against sewer-blocking fatbergs takes a step forward, https://www.scotsman.com/news/environment/fight-against-sewer-blocking-fatbergs-takes-a-step-forward-1-4854902
[461] Edwards, 2004 (https://bit.ly/2ZdX5rt)
[462] Organicup, 2018 (https://bit.ly/2PaoOVc)
[463] EC, 2018 (https://bit.ly/2GsEwbq)

The impact assessment for the EU Single-Use Plastics Directive identified that the highest impacts of menstrual products were transport of invasive species, microbial contamination, and economic impacts on tourism (Table 6, above).

5.3 Key points of leakage and pathways into the marine environment in Scotland

Flushing menstrual products can lead to blockages and associated flooding in sewer systems, or these items may reach wastewater treatment works, where they are caught in screens and sent with other captured material to incineration or landfill. However, once menstrual products are in the sewerage network, they may be lost to the aquatic environment via combined sewer overflow (CSO) spills (Figure 33). While CSOs are a crucial part of the sewerage infrastructure designed to prevent flooding at times of high flow caused by rainfall events[464], as pressure on networks increases, some CSOs may spill more frequently. CSOs are often covered by a grill, but the mesh is generally not fine to prevent blockages stopping the CSO from operating as required and as such would be unlikely to prevent menstrual products being spilled to the environment.

There are over 1,800 WWTW and roughly 250,000 private systems in Scotland, a significant proportion of small systems discharge to land via a drainage field, but all other discharge final effluent to rivers, estuaries or the sea[465]. Until the late 1990s, three quarters of the sludge produced in waste water treatment was dumped at sea, now over 70% is spread to land[466]. In 2010, approximately 7% of people in Scotland were reliant on a Private Water Supply (PWS-water supply not provided by Scottish Water), particularly in more remote parts of the country[467]. Scottish Water is obligated under the Sewerage (Scotland) Act 1968 to take it's sewers to a point which will allow customers to connect to the network, only where it is practicable to do so at a 'reasonable cost'[468]. In England, there is a requirement to upgrade septic tanks by 1st January 2020, however this does not apply in Scotland, where septic tanks and package sewage treatments works are widely used in rural areas[469]. Where properly maintained, individual discharges from such systems are rarely hazardous, however they present a risk cumulatively and are such regulated[470]. Domestic sewage is required in all cases to be appropriately treated depending on the receiving environment, however the degree to which discharge from these systems is monitored in unknown, and likely presents a risk.

[464] Welsh Water (https://bit.ly/2ZHJ59v)
[465] SEPA (2018), Water supply and waste water sector plan, https://consultation.sepa.org.uk/sector-plan/water-waste-water-treatment/user_uploads/water_supply_and_waste-water_sector_plan_draft_annex.pdf
[466] SEPA (2018), Water supply and waste water sector plan, https://consultation.sepa.org.uk/sector-plan/water-waste-water-treatment/user_uploads/water_supply_and_waste-water_sector_plan_draft_annex.pdf
[467] Northern Ireland Assembly (2010), Extent of the mains water network in England, Wales, Scotland and the Republic of Ireland, http://www.niassembly.gov.uk/globalassets/Documents/RaISe/Publications/2010/Regional-Development/11310.pdf
[468] Northern Ireland Assembly (2010), Extent of the mains water network in England, Wales, Scotland and the Republic of Ireland, http://www.niassembly.gov.uk/globalassets/Documents/RaISe/Publications/2010/Regional-Development/11310.pdf
[469] SEPA, Small scale sewage discharges (e.g. septic tanks or package treatment plants), https://www.sepa.org.uk/regulations/water/small-scale-sewage-discharges/
[470] SEPA, Small scale sewage discharges (e.g. septic tanks or package treatment plants), https://www.sepa.org.uk/regulations/water/small-scale-sewage-discharges/

Figure 33: Respondents' frequency of flushing non-flushable items[471]

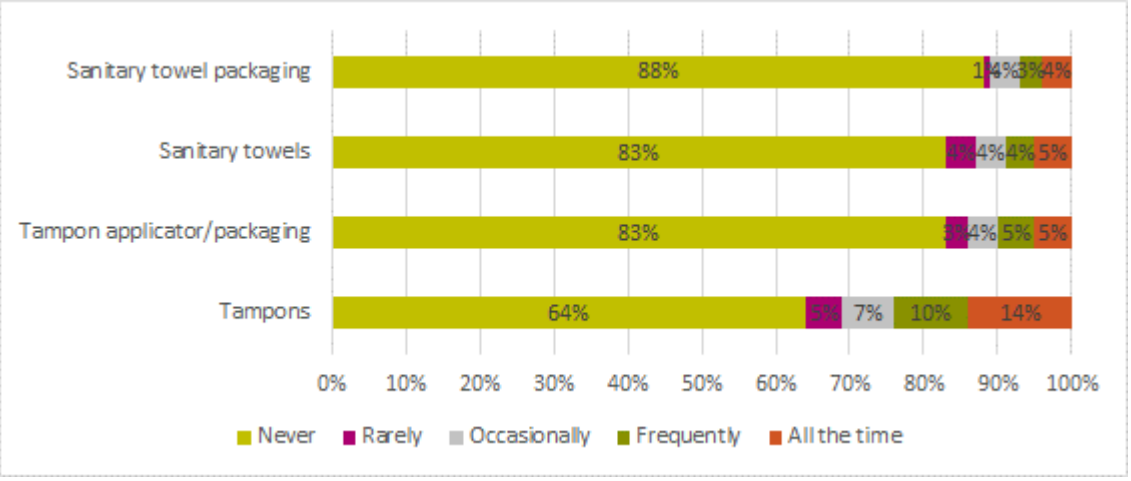
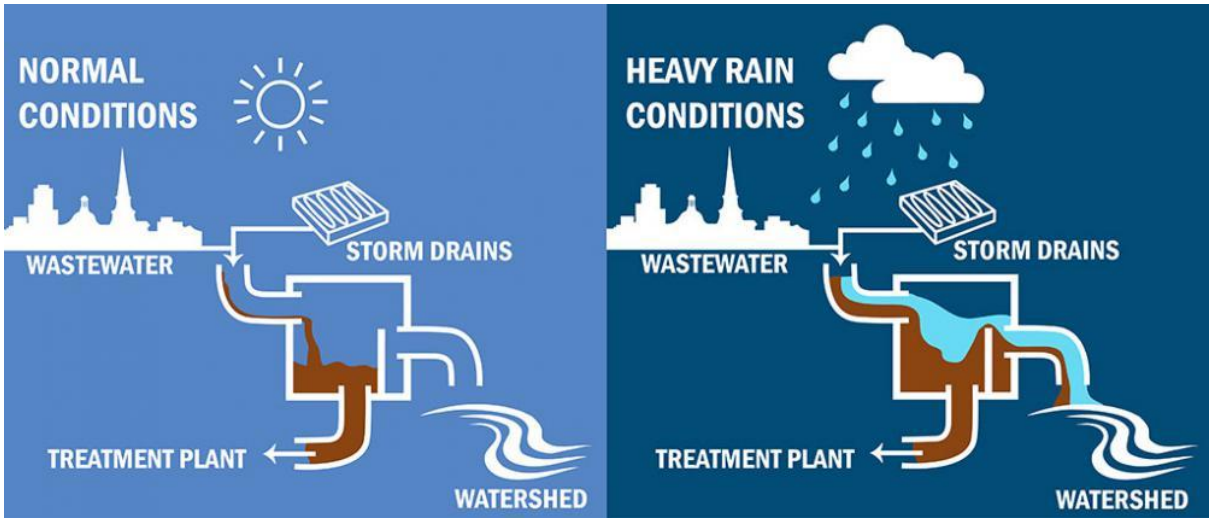


Figure 34: CSO operation in normal and wet weather conditions[472]



5.4 Why leakage happens – economic, behavioural and social factors (drivers and barriers)

5.4.1 Economic and competitive forces

There are around 1.32 million girls and women in Scotland aged between when periods typically start (age 13) and the average of menopause (50 years old) [473],, with the vast majority choosing to use disposable menstrual products. Around 4.3 billion disposable menstrual items are used in the UK each year[474]. The nonwovens market, which includes disposable menstrual products as well as other hygiene products, is

[471] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup)
[472] City of Lynchburg (https://bit.ly/2J3W1Ro)
[473] Zero Waste Scotland (ongoing research), Re-usable menstrual products research
[474] http://ahpma.co.uk/docs/Menstruation%20Facts%20and%20Figs.pdf

experiencing continued growth worldwide[475]. 'Hygiene applications', which includes menstrual products as well as other disposable absorbent products, are the largest consumer segment in disposable nonwoven products. The worldwide growth rate for disposable nonwovens is 6.7%[476]. It is estimated that the global disposable menstrual product market will be worth $33.78bn by 2025[477].

Although the disposable menstrual product market is competitive, it has a number of key players who have dominated the marketplace for significant number of years. Reusable menstrual products have a small market share. In the UK, this market appears to be dominated by newer companies and start-ups.

It is estimated that 60% of women surveyed in the UK prefer to use tampons with applicators[478]. There are a wide range of different products available including tampons with plastic applicators, tampons with cardboard applicators and tampons without applicators. There is a UK-based company that has launched a reusable applicator[479]. Proctor & Gamble, which owns leading tampon brand Tampax, were the first company to market tampons with applicators to users in the UK[480].

Figure 35: DAME reusable tampon applicator with disposable tampon[481]

In order to remain competitive in this global market, disposable tampon and pad producers have moved manufacturing to Asia, resulting in factory closures in the UK[482]. The nonwovens market has a dispersed supply chain and it is difficult to find information on manufacturing locations.

It is widely understood that menstrual products do not enter the marine environment during manufacturing or as a result of leakage from the supply chain. The products are identified as a problem material within the marine environment after-use, and as such, the leakage is a result of mismanagement by the consumer, leakage from wastewater treatment facilities and/or unsatisfactory waste management systems.

[475] https://www.edana.org/docs/default-source/default-document-library/edana-sustainability-report_2014-2015.pdf?sfvrsn=6
[476] https://www.smitherspira.com/resources/2015/december/five-key-trends-in-the-future-of-global-nonwovens
[477] https://www.businesswire.com/news/home/20190326005666/en/Global-Feminine-Hygiene-Products-Market-Size-Share
[478] https://qz.com/quartzy/1224531/why-american-women-use-applicator-tampons-and-european-women-dont/
[479] https://metro.co.uk/2018/03/03/reaction-dames-reusable-tampon-applicator-proves-need-accessible-period-options-7357497/
[480] https://qz.com/quartzy/1224531/why-american-women-use-applicator-tampons-and-european-women-dont/
[481] Jezebel, 2018 (https://bit.ly/2J7OnWL)
[482] https://www.insidermedia.com/insider/midlands/5090-out-of-the-comfort-zone

One economic factor in leakage of menstrual products is in the provision of sanitary bins in workplaces and public spaces. Sanitary bin provision is compulsory under Duty of Care. It is registered as controlled waste and most employers and public building should provide separate sanitary bins and dedicated collections. However, a study by Plan International UK surveyed young people's relationship with menstruation at school. It found that some participants worried about lack of sanitary bins within toilet stalls and that some primary schools were not equipped with adequate facilities for menstrual management[483]. Lack of facilities could be associated with cost of correct disposal, and this could lead to users flushing products. There is also a lack of bin provision within households leading to users to flush menstrual products within the domestic sphere.

5.4.2 Social norms and behaviours at leakage points

There remain many stigmas and taboos around menstrual products both in the UK and worldwide. Kolodko et al discuss the issue of how people are guided by emotions, often relying on inaccurate perceptions and placing preferences on decision context and arbitrary cues such as remaining with the solution they were initially introduced to[484]. These social characteristics are likely key indicators of behaviour around menstrual products.

Keep Britain Tidy's research classifies 'sanitary' products (a wider term which includes menstrual products) as litter that is more unacceptable, dirtier and harder to pick up than most other litter types in their 'Little Book of Litter'[485]. Whilst it is true that discarded menstrual products on a beach may have potential harmful effects on human health due to bacteria and germs[486], the notion that reusable menstrual products are 'a bit gross' – a common comment from young women interviewed by Plan International[487] – shows that these taboos remain in place and continue to drive purchasing options around menstrual products.

Taboos are likely also key drivers in disposal methods. Research by Gouda (2014)[488] for UWE found the practice of flushing menstrual items was driven by convenience and perceived hygiene when investigating people's opinion about the disposal of items. 14% of women that use tampons always flush them, and 10% do so frequently, with 35-44y.o. most likely to exhibit this behaviour[489]. Key drivers encouraging people to not flush menstrual products included increasing the perceived hygiene of other options as well as greater awareness of environmental impacts, financial costs and the number of local blockages[490]. However, both 'flushers' and 'binners' had high levels of concern for the consequences of flushing[491].

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[483] Plan International UK (2018), 'Break the Barriers: Girls' experiences of menstruation in the UK', p.37-38
[484] https://qz.com/quartzy/1224531/why-american-women-use-applicator-tampons-and-european-women-dont/
[485] Keep Britain Tidy (2012). The little book of litter.
https://www.keepbritaintidy.org/sites/default/files/resources/KBT_Little_Book_of_Litter_2012.pdf
[486] Kolodko, Julia and Read, Daniel (2018) Using behavioural science to reduce littering.
http://wrap.warwick.ac.uk/100201.
[487] Plan International UK (2018). Break the Barriers: girls experiences of menstruation in the UK. https://plan-uk.org/file/plan-uk-break-the-barriers-report-032018pdf/download?token=Fs-HYP3v
[488] Gouda, H. (2014) Urban water security: LCA and sanitary waste management.
http://eprints.uwe.ac.uk/25123/1/WS%20Gouda%20urban%20water%20security.pdf
[489] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup)
[490] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup)
[491] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup)

The Essity Annual and Sustainability Report 2018[492] notes there is a need to the break the silence around associated taboos and stigma surrounding menstruation and links this to Goal five of the UN Sustainable Development Goals relating to gender equality.

With currently only one in five girls in the UK feeling comfortable talking about periods with schoolteachers or staff (Plan International), normalising conversations on this topic will be important to increase discussion and help improve education and disposal behaviours. 20% of women had never been told how to dispose of menstrual products, 15% were told at school and 28% through family members – this lack of awareness shows a clear need for more formalised education on the topic, and the fact that many women are educated by family members could be contributing to a spread of misinformation[493]. Lack of conversations also reduces knowledge about reusable alternatives. Whilst reusable and recyclable alternatives for menstrual products are available, they are not commonly used or widely available in mainstream shops. The 'Low Hanging Fruit'[494] analysis suggests that education is required to impact behaviour change due to this reduced availability of alternatives.

Regarding reusables, there is a focus from organisations such as No More Taboo on period poverty and therefore on issues of cost and health benefits rather than the environmental impact of flushing.

Plan International's work identified that many young people are now referring to the internet for education and peer support.

There is a lack of understanding around what happens to flushed items which could influence behaviour – 1 in 10 people believe no items break down in the sewer, but 43% still flush multiple unflushables[495]. People more commonly think that menstrual products will cause blockages in household drains than in public sewers (Figure 36), and of those that believe menstrual products will cause a blockage, a number continue to flush the items (Figure 37). This is surprising, considering householders are responsible for their household drains (Figure 38), and so are flushing items that they believe are more likely to cause a problem in an area they are responsible for. It has also been shown that people will not change their flushing behaviour until they have experienced a blockage first hand, but even then the behaviour change is limited to the item which caused the blockage[496].

[492] Essity (2018), Annual-and-Sustainability-Report-2018. https://masdpstatic.azureedge.net/essity/ce583f21-ac86-4dc7-b576-87aef89b4fdc/Essity_Annual-and-Sustainability-Report-2018-v3.pdf
[493] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup)
[494] Mitchell (2019), Low hanging fruit? Action on single-use plastic to reduce marine plastic pollution. Marine Scotland
[495] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup)
[496] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup)

Figure 36: Items perceived to cause blockages[497]

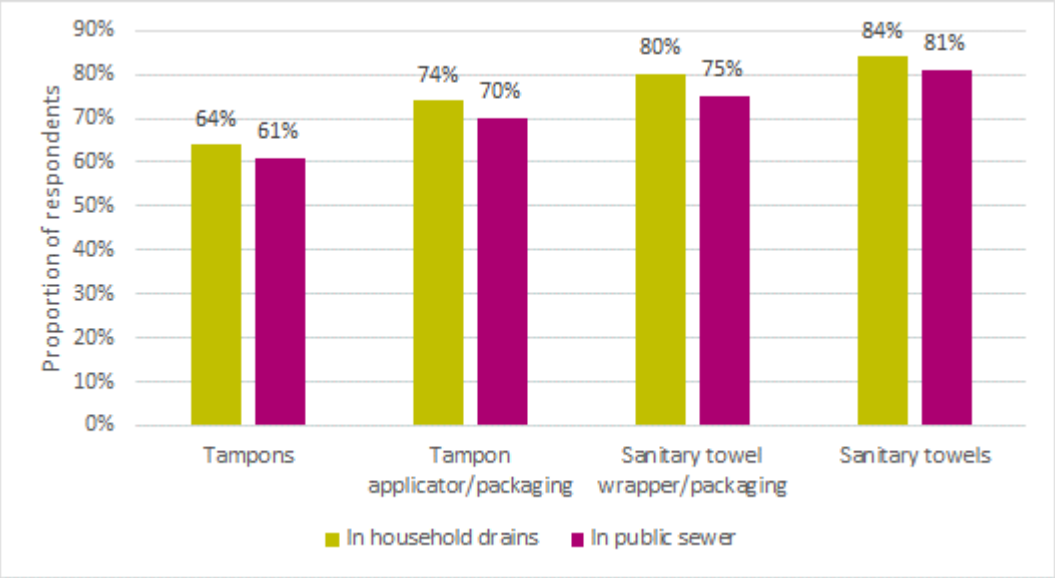
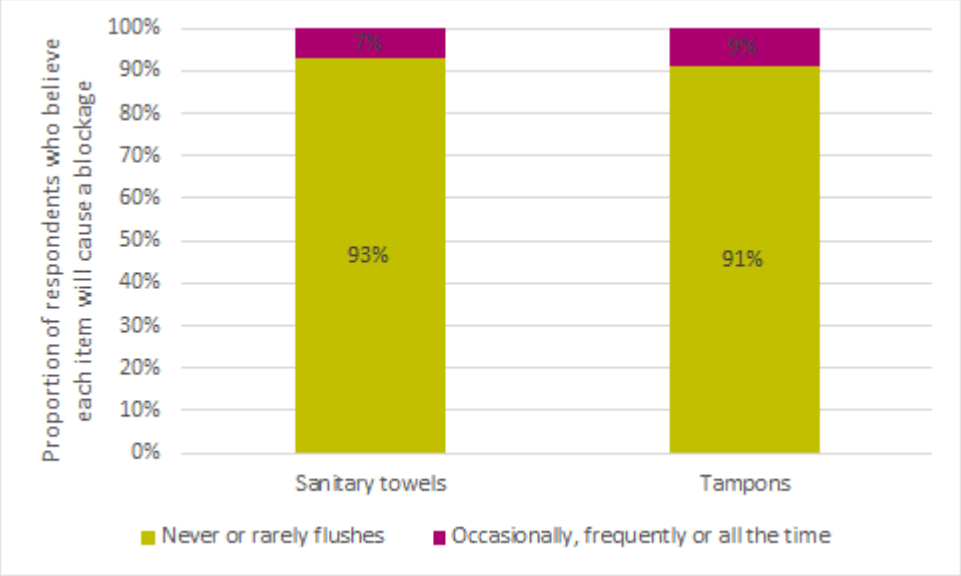
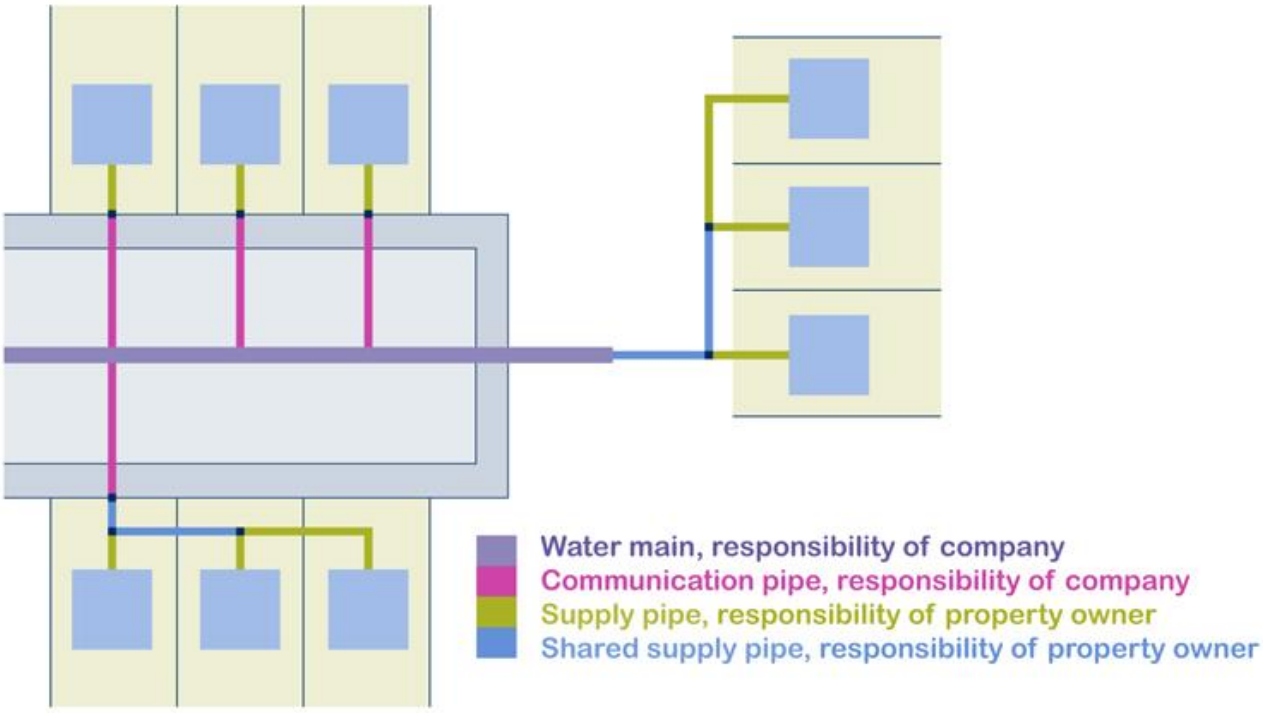


Figure 37: Items that people believe will create a blockage if flushed (by flushing behaviour) [498]



[497] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup)
[498] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup)

Figure 38: Responsibility for pipes and sewers[499]



5.4.3 Where value is lost at each point in the chain

As with crisp packets and sweet wrappers, menstrual products are designed to be single use, so the material value is lost after first use and they cannot be recycled.

If these items are disposed of incorrectly (i.e. flushed) they contribute to lost value in terms of cost to the sewerage industry and disamenity value impacting the tourism industry. In 2017 there were around 35,000 blockages in the public wastewater network, with over 80% caused by inappropriate disposal of items such as menstrual products[500], which cost around £7 million to clear[501]. 150 people are employed by Scottish Water to remove blockages and conduct other routine maintenance[502], a cost which could be reduced if products were disposed of correctly.

In the Scottish Water sewerage network, there are around 3,700 Combined Sewer Overflows (CSOs); 1,400 of which are screened[503]. CSOs are designed to spill sewage to watercourses when a rainfall event pushes the sewerage network over capacity, protecting properties from flooding. When menstrual products are flushed in areas with combined sewers (47% of Scottish network by km length[504]) they are at risk of being discharged to the environment with other sewage when a CSO spills. Menstrual products spilt to waterways will eventually be washed to the marine environment and are regularly found as beach litter (Table 13) – causing a loss of value to the tourism industry and a cost in terms of clearing this litter.

[499] Ofwat, 2019 (https://bit.ly/2IA9xKx)
[500] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup)
[501] Scottish Water (https://bit.ly/2Zs2Th5)
[502] Call with Scottish Water (15th April 2019)
[503] Call with Scottish Water (15th April 2019)
[504] Email from Scottish Water (22nd April 2019)

5.4.4 How market economics can affect behaviour change

The flushing of menstrual products is a behaviour which occurs in private, which introduces potential difficulties when attempting to use market economics to affect behaviour change. Conversations around menstruation have been taboo for many years and it is likely this which will need to change to solve this problem. However, publicising reusable alternatives as a cheaper, more convenient option could allow market economics to affect behaviour change. Another option is using market economics to encourage appropriate labelling of products to encourage responsible disposal, using market incentives to reward those with clear labelling. This could also open chains of communication around disposal, which are currently not discussed even in reports aimed to discuss experiences of menstruation in the UK[505]. Market interventions which discourage plastic tampon applicators and encourages packaging which encourages disposal by binning[506], particularly those that remove the perceived 'yuck' factor of binning such as Bodyform's new 'Roll. Press. Go.' wrappers[507] are other options. Women have been shown to be brand-loyal, and the industry is recommended to target schools to continue their customer base[508] – developing teachings which reduce this 'yuck' factor could cultivate these businesses. Bins reducing the perceived 'yuck' factor could also be incentivised using market economics, particularly those which block odours[509].

5.5 Decision points with opportunities to minimise marine plastics

5.5.1 Material and design alternatives, potential impacts these might have, barriers to uptake

Key material alternatives for disposable menstrual products are removing plastic from menstrual products, and either removing tampon applicators, or making them cardboard instead. Regarding a switch from plastic to 'digital' tampons (those without an applicator), at present 60% of women in the UK prefer applicator tampons, suggesting there would be a barrier to uptake, particularly when the dominating idea is that women will stick with the menstrual products they learn with, and so will use the same products as their mothers[510]. This school of thought is being challenged, with many women adopting plastic free periods – sales of reusable products have grown at double digit rates in the last 10 years[511], however increased initial cost, understanding of the body and menstruation and the perceived 'yuck' factor remain considerable barriers[512]. Cardboard applicators are already available from a number of brands, with

[505] Plan International UK, 2018 (https://bit.ly/2tREgf6)
[506] Fablittlebag (https://bit.ly/2UQOXi6)
[507] Bodyform (2019), Roll. Press. Go., https://www.bodyform.co.uk/products/roll-press-go/
[508] The Guardian (2017), Never mind free tampons – schoolgirls need education about their periods, https://www.theguardian.com/commentisfree/2017/mar/16/free-tampons-schoolgirls-menstruation-period-education
[509] Engadget (2019), 'Zero-waste' Loop delivers Coke and Häagen-Dazs in reusable packaging, https://www.engadget.com/2019/01/28/loop-delivers-coke-haagen-dazs-reuse/?guce_referrer=aHR0cHM6Ly93d3cuYmluZy5jb20vc2VhcmNoP3E9bG9vcCttZW5zdHJ1YWwrYmlucyZmb3JtPUVER0VBUiZxcz1QRiZjdmlkPTY5ZTE5NTg0MmE0YzQ5Y2Y4ZGM0NDA5NDRiYzkzZmI0JmNjPUdCJnNldGxhbmc9ZW4tVVM&guce_referrer_sig=AQAAAH3fF_gQqims7ytd48Y-z542p2H03HVm4l4V_DijesTPUf6vaWUgy1H6RfhFVkPOxqd4Hha-qfCuDgg0qb0GAH8YqMq6Age4YJB524sxeH_6WECDX51l9tr9x2wSHd1-iqRll4yqL387quG3TUgqmwmKY6N6ApHhTjAIz87vWIaH&guccounter=2
[510] Quartzy, 2018 (https://bit.ly/2IDoduX)
[511] BBC, 2018 (https://bbc.in/2NkLbVt)
[512] London Assembly (2018), Written evidence we received during the investigation into single-use plastics: Unflushables, https://www.london.gov.uk/sites/default/files/plastics_unflushables_-_submited_evidence.pdf

guidance available for those making the switch from plastic to cardboard applicators[513]. Tampons made solely of cotton are becoming more available, and there are also brands making plastic free pads and liners, using certified organic cotton, ecologically certified cellulose pulp, plant starch, non-toxic glue[514].

5.5.2 Alternative products and circular economy business models

As with crisp, snack and sweet wrappers, disposable menstrual products do not appear prime candidates for the circular economy. Their use in a sanitary context means they tend to be single-use, very short-lived products, where functionality, aesthetics and feel are important. Plastic-based products are likely to contribute to the low plastic recycling rates in the UK[515]. Previous work undertaken by Resource Futures developed a use phase-based approach to eliminating avoidable plastic proposing a novel approach which categorises plastics by the length of the use-phase[516]. There is a strong correlation between the lifetime of a product, the way it is discarded and the actions which can be taken to reduce the negative impacts of plastics throughout the life-cycle[517]. A use phase based approach to eliminating avoidable plastic supports elimination or substitution of plastics for alternative products and education on 'non-flushables'[518]. Use of alternative materials is possible, for example 100% organic cotton tampons are available on the market[519]. However, as cotton and tampons are absorbent and expand to absorb moisture, these will still expand when flushed and do not decompose in desirable timeframes so promoting these alternatives should be lower priority than preventing flushing.

However, the Loop scheme discussed above, also covers menstrual products with a bin designed by Proctor & Gamble which holds used menstrual products for recycling[520]. The bin has a carbon filter to block out odours and when the used bin is returned, its contents are recycled, and the bin is sanitised and sent out for another use cycle[521].

An alternative option operating higher up the waste hierarchy, and therefore the most preferable option, are reusable menstrual products such as cups, reusable pads and tampon applicators and period pants, which are growing in popularity[522] and are predicted to continue to do so[523]. There are multiple factors leading this trend – from health to financial to convenience and environmental reasons[524]. It is undoubted that a potential barrier to uptake of reusable menstrual products is the perceived 'yuck' factor which currently motivates people to flush disposable menstrual products. There are also a number of fears which

[513] TOTM (https://bit.ly/2tIT1Aq)
[514] Natracare (https://bit.ly/2GDIpKJ)
[515] Figure ES1: https://ciwm-journal.co.uk/wordpress/wp-content/uploads/2018/06/Eliminating-avoidable-plastic-waste-by-2042-a-use-based-approach-to-decision-and-policy-making.pdf
[516] Resource Futures and Nextek, 2018 (https://bit.ly/2XNq0Ft)
[517] Resource Futures and Nextek, 2018 (https://bit.ly/2XNq0Ft)
[518] Resource Futures and Nextek, 2018 (https://bit.ly/2XNq0Ft)
[519] https://wearedame.co/products/organic-cotton-tampons
[520] CNN, 2019 (https://cnn.it/2S9inWe)
[521] CNN, 2019 (https://cnn.it/2S9inWe)
[522] BBC, 2018 (https://bbc.in/2NkLbVt)
[523] Technavio, 2018 (https://bit.ly/2IEZRku)
[524] Treehugger, 2014 (https://bit.ly/2zQi4YC)

act as a barrier to switching to a menstrual cup[525], and they are not easy to use for women with certain disabilities, although new products are being developed to address this specific issue[526]. Women's uncertainty about their own anatomy is also a barrier to reusable cups, prompting the development of the reusable tampon applicator as a way to increase sustainability of a familiar menstrual product[527]

5.6 Levers available to the Scottish Government (intervention and support)

The regulatory and non-regulatory measures available to the Government are explored in the sections below in the context of existing legislative powers, proposed legislation, behavioural science and case studies.

5.6.1 Regulatory measures

Industry has responded to the impacts of menstrual products with innovations in product design, voluntary product labelling and public education campaigns. The Single-use Plastic and Fishing Gear Directive[528] calls for marking requirements to be set for sanitary towels and awareness raising measures[529]. However, it only promotes EPR for wet wipes and not for the menstrual products in the 'sanitary items' category. Nevertheless, The Scottish Government could work with the UK Government which has powers to set requirements for product design (including materials usage), labelling and awareness raising measures if the environmental case were justified and this could be implemented in short timescales, given that options have already been developed on the market. EPR could provide a mechanism to do so and to connect producers to the end of life impacts with economic incentives for further improvements on environmental impacts. Product labelling law has been proposed elsewhere, for example mandatory labelling "Do Not Flush" for wet wipes in New Jersey[530] with penalties of $5,000 for each offence..

41% of women get disposal information from product packaging, so almost 60% do not look at this information[531], showing that improving product labelling could be increase responsible disposal behaviour.

5.6.2 Non-regulatory measures

Plan International[532] has done extensive research into the causes and potential behavioural drivers around menstrual waste. Their recommendations for interventions include:

- Ensuring that all public toilets include at least one toilet with a sink in the cubicle and have adequate provision of bins for disposable menstrual products; this should apply to unisex, accessible and male toilets as well as female, to support all genders who menstruate. This is backed by City to Sea.

[525] Bustle (2018), Why Do People Like Menstrual Cups? Here's What To Know If You're Still Afraid Of Them, https://www.bustle.com/p/why-do-people-like-menstrual-cups-heres-what-to-know-if-youre-still-afraid-of-them-7921187
[526] Bustle (2018), Keela Cup Menstrual Cup Works Like A Tampon To Make It Easier To Use, https://www.bustle.com/p/keela-cup-menstrual-cup-works-like-a-tampon-to-make-it-easier-to-use-7765007
[527] BBC, 2018 (https://bbc.in/2LtXX8r)
[528] http://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf
[529] As mentioned above, UK Government intends to retain all EU-derived waste legislation. However, the Single-use Plastic and Fishing Gear Directive is new regulation and not yet adopted by the UK.
[530] https://nj1015.com/nj-trying-to-pass-do-not-flush-law-for-bathroom-wipes/
[531] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup)
[532] Plan International UK (2018). Break the Barriers: girls experiences of menstruation in the UK. https://plan-uk.org/file/plan-uk-break-the-barriers-report-032018pdf/download?token=Fs-HYP3v

- Use of the internet to deliver educational messages, as their research showed that participants identified the internet as an important educational source when it came to menstruation. Alongside being used to find out about alternative products, it can also be used as a platform for attempting to resist and challenge traditional norms about menstruation, through online interactions with peers on forums, blogs and social media (Plan International).
- Increased support and education in schools for girls and others who menstruate, along with increased knowledge for boys and parents. Increasing knowledge levels surrounding menstruation can impact the choices young people make about use of and disposal of reusable menstrual products as well as how to dispose safely of non-reusable menstrual products.
- They also call for a change in the conversation, calling on leaders and those in authority to help end period poverty, shame and taboos and become menstruation champions, to ensure the topic remains high on the agenda and that taboos are dissolved by making it an everyday subject.

Changes to packaging could also be considered, for example in exploring options brought up by these two research studies:

- The Marine litter research 'Low Hanging Fruits' called for all packaging to be updated to unequivocally reject flushing.
- Keep Britain Tidy research[533] has shown that people behave better when being watched and the use of eyes in printed materials can positively change behaviour patterns by 46% and as much as up to 90%. This could be an interesting inclusion, on menstrual product packaging to emphasise the no flush message.

Existing campaigns that provide non-regulatory interventions include:

- The '**Think before you flush'** campaign: which encourages a change in domestic disposal habits to dispose of sanitary solids via the bin rather than the WC
- The **3Ps campaign**: publicised by MCS Scotland[534] and City to Sea to raise awareness of the dirty dozen and educate people on what should be going down our toilets – only the 3Ps – pee, paper and poo! They also trialled a sticker campaign – on toilet doors in public spaces, universities, cafes and restaurants in the Anglian Water region to help change flushing behaviour so that people know what they should and shouldn't be flushing where it matters.
- **Plastic free periods** – another campaign by City to Sea encouraging women to consider zero-waste, Plastic-Free periods which are better for your health, for your wallet and for the ocean.
- **End to period poverty:** The campaign introduces a 'P-Card' scheme which makes disposable and reusable menstrual products freely available to girls in schools along with advice and information.
- **Re-useable menstrual products campaign** – a consumer engagement campaign is currently being planned for November 2019 by Zero Waste Scotland which aims to encourage behaviour change towards the uptake of re-useable menstrual products as opposed to disposables.

[533] Keep Britain Tidy (2012). The little book of litter. https://www.keepbritaintidy.org/sites/default/files/resources/KBT_Little_Book_of_Litter_2012.pdf
[534] https://www.mcsuk.org/news/WaterUK_fatberg_report

Various flushability standards have been developed by the menstrual product industry[535] and more recently the UK water industry[536]. However, there is a real risk that labelling items as 'flushable' might confuse consumers and send the wrong signal about waste disposal of bathroom products. Conversely, voluntary labelling of products and code of practice, such as the do not flush symbol, are being introduced on some products to aid with and standardise on pack labelling[537].

There are also opportunities for Government and public bodies to provide products with lower environmental impacts and engage consumers in their choice of product. The Scottish Government has a scheme for free menstrual products in schools and other venues, which includes reusable product options[538] [539]. Similarly, NHS England was recently called upon to provide sanitary products for hospital patients[540]. PSHE lessons in schools provide further opportunities to engage menstruators on product choice, potentially shaping habits early on.

Plan International recommend more research is done to provide further evidence for intervention, namely:

- A need to set up a cross-government working group on menstrual health management to focus on pilot projects and research investment on menstrual health management and quality menstrual education for all.
- Research to investigate the outcome of policies around menstruation and any interventions adopted by local bodies / international governments. This research should include the wider experiences of all adolescent menstruators including girls, transgender, non-binary and young people with different sexual orientations, and menstrual health management in the UK.

Recent research has shown that the public feel that wastewater companies have more responsibility than manufacturers to inform them what can and cannot be flushed, but they would also expect this messaging to come from their local authorities alongside recycling messaging[541].

5.7 Summary

Disposable menstrual products such as pads and tampons are made from synthetic materials, predominantly a range of different plastics. Products are typically multi-component items using different materials designed for absorbency and feeling of dryness against the skin. It is estimated that pads contain around 90% synthetic polymers, whilst a tampon is around 6% plastic (tampon only – not including applicator) and the rest is predominantly cotton. Around 4.3 billion disposable menstrual items are estimated to be used in the UK each year, and although the disposable menstrual product market is competitive, it has a number of key players who dominate the marketplace [542]. Of the towel products, Always (by Procter & Gamble) has the majority of the market share in the UK, Bodyform (by Essity) has about half as many users, and other brands and products have much smaller shares. None of the key

[535] https://www.edana.org/industry-initiatives/flushability
[536] https://www.water.org.uk/policy-topics/managing-sewage-and-drainage/fine-to-flush/
[537] https://www.water.org.uk/wp-content/uploads/2018/11/Final-Report-on-monitoring-product-labelling-and-plastic-content-Ref-No-21CDP-Labelling.pdf
[538] https://www.bbc.co.uk/news/uk-scotland-46904775
[539] https://www.gov.scot/publications/access-free-sanitary-products-programme-government-commitment-business-regulatory-impact/pages/1/
[540] https://www.telegraph.co.uk/news/2019/03/03/hospitals-will-supply-free-tampons-sanitary-towels-inpatients/
[541] Jackson and Tehan, 2019 (https://bit.ly/2Nvenup)
[542] http://ahpma.co.uk/docs/Menstruation%20Facts%20and%20Figs.pdf

players identified in our review are based in Scotland and evidence suggests companies with HQs in England manufacture outside of the UK.

Reports suggest that 1.5-2 billion menstrual products are flushed every year[543], representing around 35-47% of all menstrual products. Marine Conservation Society (MCS) data shows that 4.8 pieces of litter identified as menstrual waste are found per 100m of beach based on beaches included in their Beachwatch citizen science project[544]. Menstrual products have been found in the stomach of birds[545], and some menstrual products contain chemical that could risk leaching into the marine environment[546]. The associated 'yuck' factor has a considerable impact on the enjoyment value of beaches and the related tourism economy. Waste menstrual products have negative economic value in disposal costs and cause wider value loss to the economy as marine litter through sewerage blockages and devaluing the coastal environment. They almost solely enter the environment through poor behaviours - a proportion of users flush them down toilets and in the event of combined sewer overflow spills they are discharged to waterways. A lack of adequate sanitary bin provision in workplaces and public spaces is identified as a contributing factor, despite it being compulsory for employers to provide these bins and arrange for waste management under Duty of Care requirements set out in the Environmental Protection Act 1990[547].

Plastic-based products are likely to contribute to the low plastic recycling rates in the UK[548]. A use phase based approach to tackling plastic issues supports elimination or substitution of plastics and education on 'non-flushable' products[549]. Reusable and non-plastic menstrual products are available but presently have a very small/niche market share and evidently market awareness and perception barriers of hygiene and cultural concerns will need to be overcome in this market if it is to develop significantly. In the UK, this market appears to be dominated by newer companies and start-ups. Reusable alternatives are believed to be cheaper over the product lifetime but require a higher initial sales price.

There are no legal product labelling requirements to discourage flushing behaviour, but this is proposed in the recent EU Single-use Plastic and Fishing Gear Directive[550]along with awareness raising measures. The menstrual product and water industries have developed voluntary labelling and flushability standards that could be applied universally. Marine litter considerations could be included in initiatives on 'plastic-free periods' and wider movements on 'period poverty', 'period positivity' and gender equality, which aim to break down taboos and open discussion for the benefit of society as a whole.

[543] MCS, 2015 (https://bit.ly/2I5Ba05)
[544] Reloop, 2018 (https://bit.ly/2zQzbqL)
[545] Edwards, 2004 (https://bit.ly/2ZdX5rt)
[546] Organicup, 2018 (https://bit.ly/2PaoOVc)
[547] https://www.principalhygiene.co.uk/sanitary-waste-faq
[548] Figure ES1: https://ciwm-journal.co.uk/wordpress/wp-content/uploads/2018/06/Eliminating-avoidable-plastic-waste-by-2042-a-use-based-approach-to-decision-and-policy-making.pdf
[549] https://ciwm-journal.co.uk/wordpress/wp-content/uploads/2018/06/Eliminating-avoidable-plastic-waste-by-2042-a-use-based-approach-to-decision-and-policy-making.pdf
[550] http://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf

Appendix A Publicly available UK market data

A.1 Sold production, exports and imports by PRODCOM list (NACE Rev. 2)

			Exports		Imports		Production		
Desired material	PRCCODE code match	Code description	EXPQNT	EXPVAL*	IMPQNT	IMPVAL*	PRODQNT	PRODVAL*	QNTUNIT
Crisps, snack and sweets	10311460	Potatoes prepared or preserved, including crisps (excluding frozen, dried, by vinegar or acetic acid, in the form of flour, meal or flakes)	52,571,400	169,380,460	40,651,400	65,033,500	201,446,248	656,494,462	kg
	10822253	Filled chocolate confectionery (excluding in blocks, slabs or bars, chocolate biscuits, chocolates)	6,432,300	45,554,170	37,330,100	193,780,190	14,533,293	40,129,125	kg
	10822255	Chocolate confectionery (excluding filled, in blocks, slabs or bars, chocolate biscuits, chocolates)	4,830,400	28,688,850	23,564,600	99,904,230	35,141,032	236,332,942	kg
	10822260	Sugar confectionery and substitutes therefor made from sugar substitution products, containing cocoa (including chocolate nougat) (excluding white chocolate)	5,702,200	24,716,170	24,007,900	90,550,990	3,888,144	12,944,437	kg
	10822365	Gums, fruit jellies and fruit pastes in the form of sugar confectionery (excluding chewing gum)	21,451,300	58,990,040	55,805,000	142,048,390	111,152,727	350,111,216	kg
	10822373	Boiled sweets	4,971,200	18,102,560	12,390,500	40,176,130	32,005,636	77,592,481	kg
	10822375	Toffees, caramels and similar sweets	5,436,000	22,921,320	27,254,300	69,947,560	32,452,377	121,946,685	kg
	10822383	Compressed tablets of sugar confectionery (including cachous)	2,504,800	12,114,990	17,631,600	10,396,520	22,134,453	77,512,633	kg
	10822390	Sugar confectionery, n.e.c.	15,071,600	44,662,410	21,108,400	73,298,750	27,571,893	98,585,557	kg

Menstrual products	13922993	Sanitary towels, tampons and similar article of textile materials (excluding wadding)	148,000	1,108,850	2,710,700	10,293,720	0	0	kg
	17221210	Sanitary towels and tampons, napkins and napkin liners for babies and similar sanitary articles, of wadding	838,100	7,121,640	4,014,600	23,263,050	1,482,150	3,248,657	kg
Fishing gear	13941233	Madeup fishing nets from twine, cordage or rope of manmade fibres (excluding fish landing nets)	22,200	213,360	133,000	390,360	:	:	kg
	13941235	Madeup fishing nets from yarn of manmade fibres (excluding fish landing nets)	43,000	338,650	661,600	4,711,780	0	0	kg
	32301600	Fishing rods, other line fishing tackle; articles for hunting or fishing n.e.c.	:	38,869,820	:	77,277,110	:	32,978,202	:

A.2 HMRC 2017 Trade data, within and outside EU

		Export (to non-EU)		Import (from non-EU)		Dispatch (to EU)		Arrival (from EU)	
Desired material	HMRC code and description	Value (£)	Net mass (kg)	Value (£)	Net mass (kg)	Value (£)	Net mass (kg)	Value (£)	Net mass (kg)
Crisps, snack and sweets	17049065 - Gum and jelly confectionery, incl. fruit pastes in the form of sugar confectionery	11,602,666	4,790,916	28,600,574	10,313,446	40,225,008	16,660,364	96,228,859	45,491,589
	17049071 - Boiled sweets, whether or not filled	6,007,279	2,507,975	10,615,542	3,717,535	9,851,990	2,463,160	24,669,111	8,672,992
	17049075 - Toffees, caramels and similar sweets	6,201,214	1,590,411	1,868,758	545,083	13,943,585	3,845,616	59,390,700	26,709,153
	17049081 - Compressed tablets of sugar confectionery, whether or not manufactured with binding agents, not containing cocoa (excl. chewing gum, white chocolate, throat pastilles	3,660,871	788,282	1,515,981	604,472	6,955,528	1,716,493	7,622,236	17,027,097

	and cough drops, gum confectionery and jelly co...								
	17049099 - Pastes, marzipan, nougat and other prepared sugar confectionery, not containing cocoa (excl. chewing gum, white chocolate, throat pastilles and cough drops, gum and jelly confectionery incl. fruit pastes in the for...	12,026,420	2,442,476	19,793,372	4,585,930	27,209,430	12,629,141	44,612,441	16,522,545
	18069031 - Chocolate and chocolate products, filled (excl. in blocks, slabs or bars and chocolates)	16,714,481	2,824,939	3,213,922	469,514	23,349,257	3,607,389	166,807,320	36,860,592
	18069039 - Chocolates and chocolate products, unfilled (excl. in blocks, slabs or bars, chocolates)	5,577,809	1,009,202	2,423,603	364,934	19,568,450	3,821,181	85,292,165	23,199,711
	18069050 - Sugar confectionery and substitutes therefor made from sugar substitution products, containing cocoa	9,771,156	2,335,292	5,561,727	982,211	11,911,638	3,366,870	74,030,658	23,025,730
	20052020 - Potatoes in thin slices, cooked in fat or oil, whether or not salted or flavoured, in airtight packings, suitable for direct consumption, not frozen	13,977,039	3,211,418	1,682,338	476,421	77,566,515	23,560,443	28,648,597	15,571,900
Fishing gear	56081120 - Made-up knotted fishing nets of twine, cordage, ropes or cables, of man-made textile materials (excl. landing nets)	112,700	11,617	224,790	102,578	72,141	10,632	119,441	30,361

	56081180 - Made-up knotted fishing nets of yarn, of man-made textile materials (excl. those of twine, cordage, rope or cables and landing nets)	279,337	36,951	4,121,702	659,307	20,715	6,005	13,897	2,344
	56089000 - Knotted netting of twine, cordage, ropes or cables, by the piece or metre; made-up fishing nets and other made-up nets, of vegetable textile materials (excl. hairnets, nets for sporting purposes, incl. landing nets...	685,455	64,949	1,720,914	272,310	226,873	74,452	169,327	52,267
	95071000 - Fishing rods	939,856	18,093	12,591,450	487,704	4,368,763	118,526	3,350,408	81,074
	95073000 - Fishing reels	663,153	7,276	6,838,011	235,091	1,751,778	75,919	8,561,521	104,447
	95079000 - Line fishing tackle n.e.s; fish landing nets, butterfly nets and similar nets; decoys and similar hunting or shooting requisites (excl. decoy calls of all kinds and stuffed birds of heading 9705)	3,512,884	131,035	28,427,483	2,749,993	20,152,064	1,248,608	3,576,942	282,419
Menstrual products	96190030 - Sanitary towels and tampons, napkins and napkin liners for babies and similar sanitary articles, of wadding of textile materials	774,420	165,794	1,276,636	385,488	5,475,628	672,328	19,118,794	3,629,923
	96190040 - Sanitary towels, tampons and similar articles, of textile materials (excl. of wadding)	266,814	33,548	101,248	17,426	706,092	114,509	8,906,967	2,693,278