

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

Summary report

The Scottish Government

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Executive Summary

Background

This aim of this research project was to build the evidence base on the plastic value chain in Scotland in relation to levels of marine plastic in Scottish waters. The plastic value chain is taken to mean all aspects along the supply chain of plastics in Scotland from raw material to end point, including; production, transportation, retail, consumption, disposal and pollution. Evidence on this chain is sought for three dimensions and the interactions between these: (1) conventional economics in terms of utility maximising rational actors and businesses; (2) behavioural economics incorporating for example, norms, heuristics and frames, and; (3) social and cultural factors not captured elsewhere but which influence this eco-system and the levels of marine plastics.

Globally, marine litter and especially marine plastics have been identified as an emerging threat to marine biodiversity and environmental health with consequences expected on the economy and society as well as directly on the environment. While large plastic items can entangle marine life, as well as be ingested by larger marine animals, microplastics (<5mm) can be ingested by a huge range of marine life, and be passed up the food chain.

The Scottish Government has made tackling marine litter and plastics one of its key goals. Under the Scottish Marine Litter Strategy, a number of initiatives are underway in order to bring a strategic approach to tackling this growing anthropogenic threat to our seas, the life within them and to wider society. Further information can be found at: [Marine Scotland - Marine Litter](#).

Progress is being made in this field with new legislation on microbeads and plastic cotton buds and funding of clean-up efforts. Not all products which contribute towards marine litter however can be easily banned nor is a ban always the best solution in terms of cost-effectiveness, impact and unintended consequences. The value of plastics in Scotland is significant, from food packaging to providing lighter, more fuel-efficient transport solutions, but the leakage of these plastics into the marine environment is not a necessary consequence of their use.

Little is known of the drivers and barriers faced by businesses, individuals and others across the plastic eco-system in Scotland which lead to marine plastic pollution. This study was commissioned to better understand this landscape and the potential to support the private sector and address marine litter issues.

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 product categories were chosen for the different functions they provide, contrasting value chains and different pathways into the marine environment. Key decision points in the value chain were identified for each product where there is opportunity to help tackle marine litter. The drivers and barriers for these decisions were explored through stakeholder engagement. Potential solutions were identified and evaluated for their effectiveness to influence key decision points, addressing the drivers and barriers that were identified. Comparable products were explored to understand if the products could act as indicator products for a wider group of marine litter items and to draw wider conclusions about value chain solutions to the problem.

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 *Summary report* and key findings for all four products are presented in this Executive Summary.

Key findings

- Systems thinking and circular business model development have the potential to address end of life impacts including marine litter issues. However, few examples were found for the four product groups researched. Supportive measures may be justified to encourage change in the market and overcome the marine litter risks associated with these products.
- For some of the product groups researched, designs already exist on the market that tackle the associated marine litter issues whilst still fulfilling the product functionality requirements of the users. However, these alternative products often struggle to compete on price and other barriers were identified that inhibit their widespread use.
- Targeted education and engagement efforts around product choice, procurement, use and waste management were supported by many stakeholders engaged in the course of the research, and some specific avenues were identified for the Scottish Government to provide support.
- Policy intervention may be warranted in some cases. In particular, EPR for commercial fishing gear, as set out in the EU Single-Use Plastics Directive, could be effective in reducing losses of gear and deliver positive change through a modulated product fee system (varying fees by environmental risk), building upon the and minimum general requirements set in the EU Circular Economy Package.
- The potential for product design changes to crisps, snack and sweet wrappers are explored, with initial findings on potential barriers and opportunities. Further research and private sector engagement is recommended.

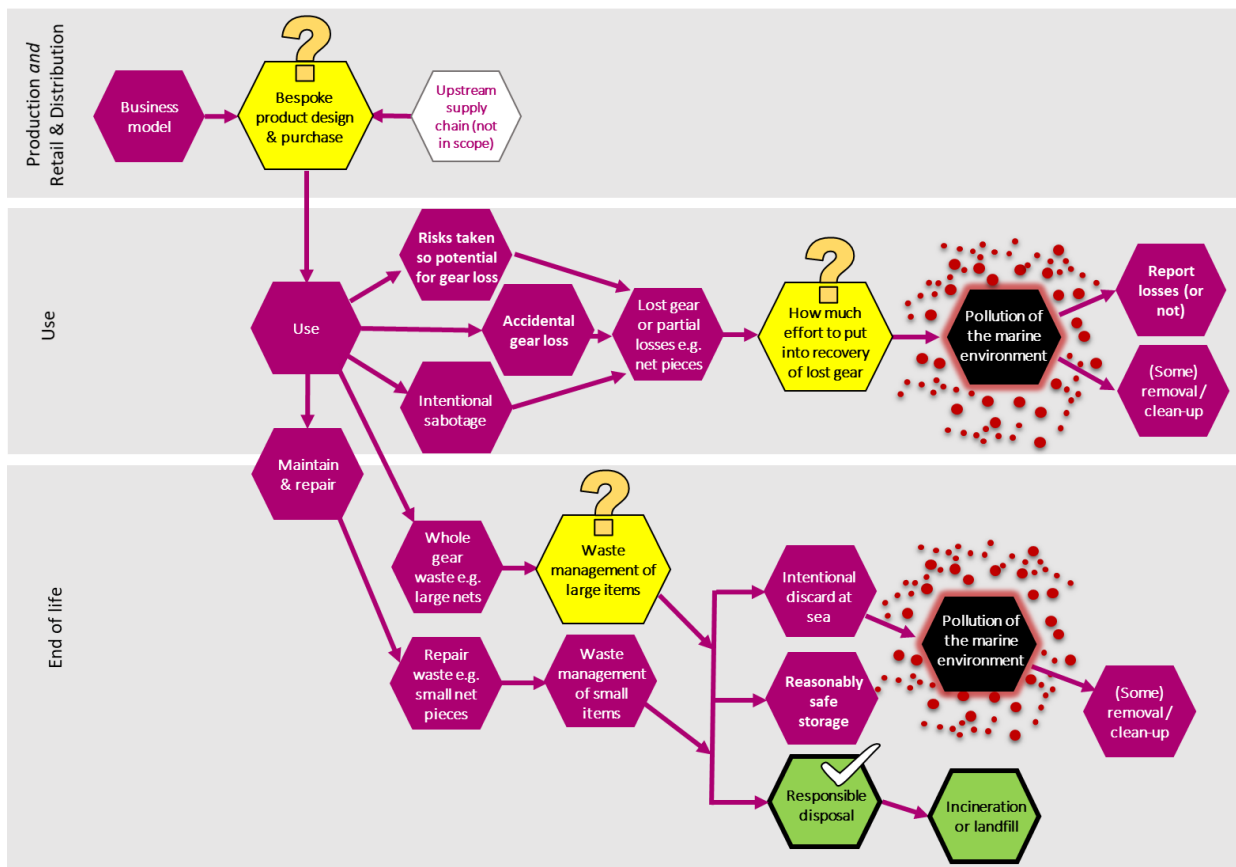
- Serious concerns were uncovered for artificial grass pitches, not only relating to the leakage of microplastic pollution from 'infill' but also potential underfunding and mismanagement of waste pitches at end of life.
- An integrated communications strategy is recommended for menstrual products, covering labelling standards for 'Do not flush' messaging, a schools' education programme and other key touch points. Further research is recommended to understand if consumers can be supported in disposing of the waste products responsibly with sanitary bags, the provision of bins in public and workplace toilets, and sinks to support washing reusable products.

These findings and others are described in more detail in this summary report and associated product-specific reports. Recommendations are presented for the Scottish Government. The recommendations have different potential efficacy, costs and timescales. To some degree the likely impact is related to the resources and support invested in any single measure. Further details are given in the four product-specific reports.

Commercial fishing gear

The first product group, commercial fishing gear, was researched in detail. It is commonly found in marine litter surveys and is particularly harmful in entangling wildlife. It can be lost accidentally or intentionally dumped at sea, although some stakeholders dispute whether the latter is widespread practice or happens at all in Scotland. The marine litter pathways and key decision points in the value chain to help tackle marine litter are illustrated in Figure E1. The findings are mapped against stages in the product life cycle, shown as grey boxes and described down the left hand side of the figure. Key decision points explored in this research are highlighted in yellow. Respective business models were also identified as potential key decision points, e.g. adopting reuse and circular economy business models. However, these are not highlighted and explored in detail in this research due to a lack of examples to draw upon.

Figure E1: Commercial fishing gear - Marine litter pathways and key decision points



A driver commonly raised by commercial fishing gear stakeholders is the effort required and cost of waste management, especially since other than nylon nets they have little or no recoverable value at present. Potential solutions focussed largely on communications and awareness raising across the supply chain and ensuring the waste retains some value or otherwise an incentive to manage it responsibly is provided. The quantity and type of gear purchased and the waste generated is a major knowledge gap, and mandatory reporting on this would be a valuable first step in implementing extended producer responsibility (EPR), as required by EU legislation in the Single-Use Plastics Directive. This information would help direct further measures to address marine litter. Supporting best-practice behaviours and new technology can also help reduce losses. Wider opportunities may be brought about by systems thinking and business model development, including design for end of life and even recovery of lost gear, or product service system innovation to address marine litter issues.

Table E1 presents an analysis of where potential solutions may have the most influence in relation to key decision points shown in Figure E1. Solutions will have varying degrees of impact, which will also be affected by their design and implementation. Recycling would aim to reduce the cost and effort to fishers in handling waste gear. Similarly, the 100% indirect fee would mean that waste costs are covered by harbour fees paid at a flat rate irrespective of the quantity of waste delivered. Gear marking and tagging can help in tracking and recovering lost gear and inform enforcement should this be progressed. Several forms of EPR are assessed.

Table E1: Commercial fishing gear - where solutions can most influence key decision points

Life cycle stage	Key decision point	Education and engagement	Recycling	100% indirect fee	Gear marking and tagging	EPR takeback scheme	EPR advance disposal fee	EPR modulated fee	EPR deposit return scheme
Production and Retail & distribution	Bespoke product design and purchase	✓	✗	✗	✗	✓	✗	✓	✗
Use	Recovery effort for lost gear	✓	?	✓	✓	✓	✓	✓	✓
End of life/Recovery	Waste management of large items	✓	?	✓	✗	✓	✓	✓	✓

✓ = Yes, ✗ = No, ✓ = Yes - if solution designed with this in mind, ? = Unknown

On the basis of the research findings, the following recommendations are made for the Scottish Government and the private sector to tackle marine litter from commercial fishing gear:

1. Support education and engagement measures. Priority areas are engaging fishers on waste management options and the impacts of marine litter. Also advice on life cycle costs of more durable, repairable equipment to influence their procurement and design.
2. Evaluate feasibility and efficacy of EPR, recycling, and other waste management options
 - a. Mandate reporting of products placed on market, and data on the collection and treatment of waste
 - b. Understand current (baseline) waste management costs to fishers
 - c. Evaluate EPR options for fishing gear
 - d. Research recycling enablers and conduct cost-benefit analysis
 - e. Gather industry views on 100% indirect fee, EPR and recycling measures in a combined consultation
3. Support best-practice and new technology

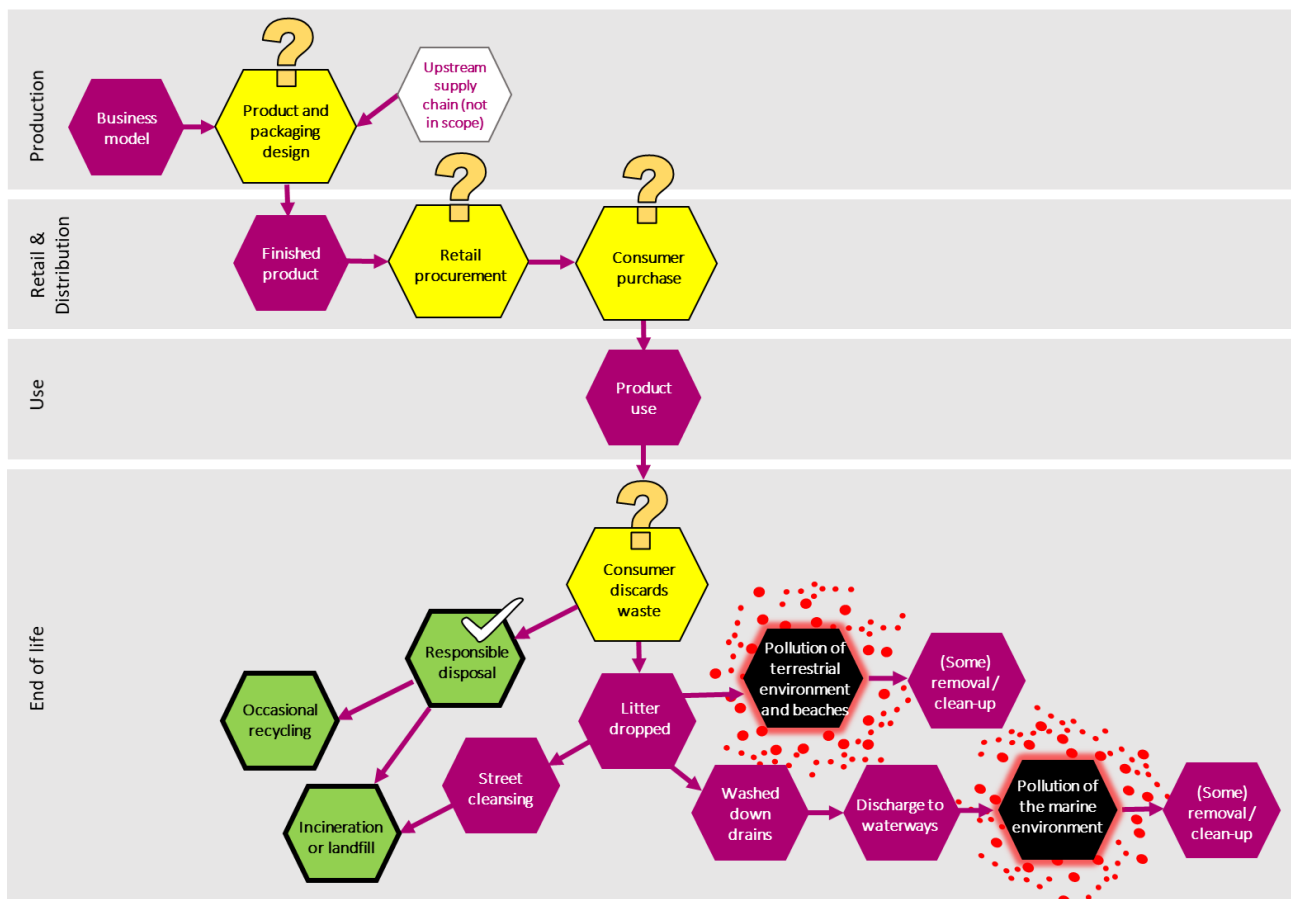
Recommendation 2 suggests evaluating the feasibility and effectiveness of EPR, recycling, and other waste management options as further work is needed to understand if they will be effective, how best to design to prevent marine litter and, in the case of recycling, how it will be funded.

Crisps, snack and sweet wrappers

Crisps, snack and sweet wrappers are packaging items littered on land, a proportion of which are washed down drains and transported to the marine environment, and some are dropped directly on beaches.

Marine litter pathways and key decision points are illustrated in Figure E2. Key decision points explored in this research are highlighted in yellow. Business models are not highlighted and explored in detail due to a lack of examples to draw upon. Such business models are potentially inhibited by incompatibility with current systems optimised to deliver single-use packaging products, but there may be opportunity to support such models in the future.

Figure E2: Crisps, snacks and sweets - Marine litter pathways and key decision points



During the research, only one product was identified as being specifically designed to limit impacts when littered (replacing plastic with a paper wrapper). Undoubtedly further product design and business model solutions are possible and design and materials innovation will be underway in industry. Action could be delivered through voluntary agreements or policy measures such as EPR or a deposit return scheme. Table E2 presents an analysis of where potential solutions may have the most influence in relation to key decision points from Figure E2. Solutions will have varying degrees of impact, which will also be affected by their design and implementation. Litter education is also part of the solution, although traditionally delivered by NGOs rather than value chain actors.

Table E2: Crisps, snack and sweet wrappers - where solutions can most influence key decision points

Life cycle stage	Key decision point	Voluntary agreements	Packaging innovation	Recycling	Extended Producer Responsibility	Deposit Return Scheme
Production	Product and packaging design	✓	✓	✓	✓	✗
Retail	Retailer procurement	✓	✗	✗	?	✗
Use	Consumer purchase decision	✓	✗	✗	✗	✗
End of life/recovery	Consumer discards waste	✗	✗	?	✗	✓

✓ = Yes, ✗ = No, ✓ = Yes - if solution designed with this in mind, ? = Unknown

Further research into the nature of the problem is needed: what brands, products and formats are most littered, and how much is whole wrappers versus torn corners and what their impacts are in the marine environment. This information should inform further consultation with industry to spur on value chain solutions.

On the basis of the research findings, the following recommendations are made for the Scottish Government and the private sector to tackle marine litter from crisps, snack and sweet wrappers:

1. Better understand the nature of this item in litter
 - a. Publish brand and product litter survey
 - b. Research relative litter abundance of whole wrappers and packets versus pieces
2. Industry workshop for solutions
3. Product design change assessment

Artificial grass pitch

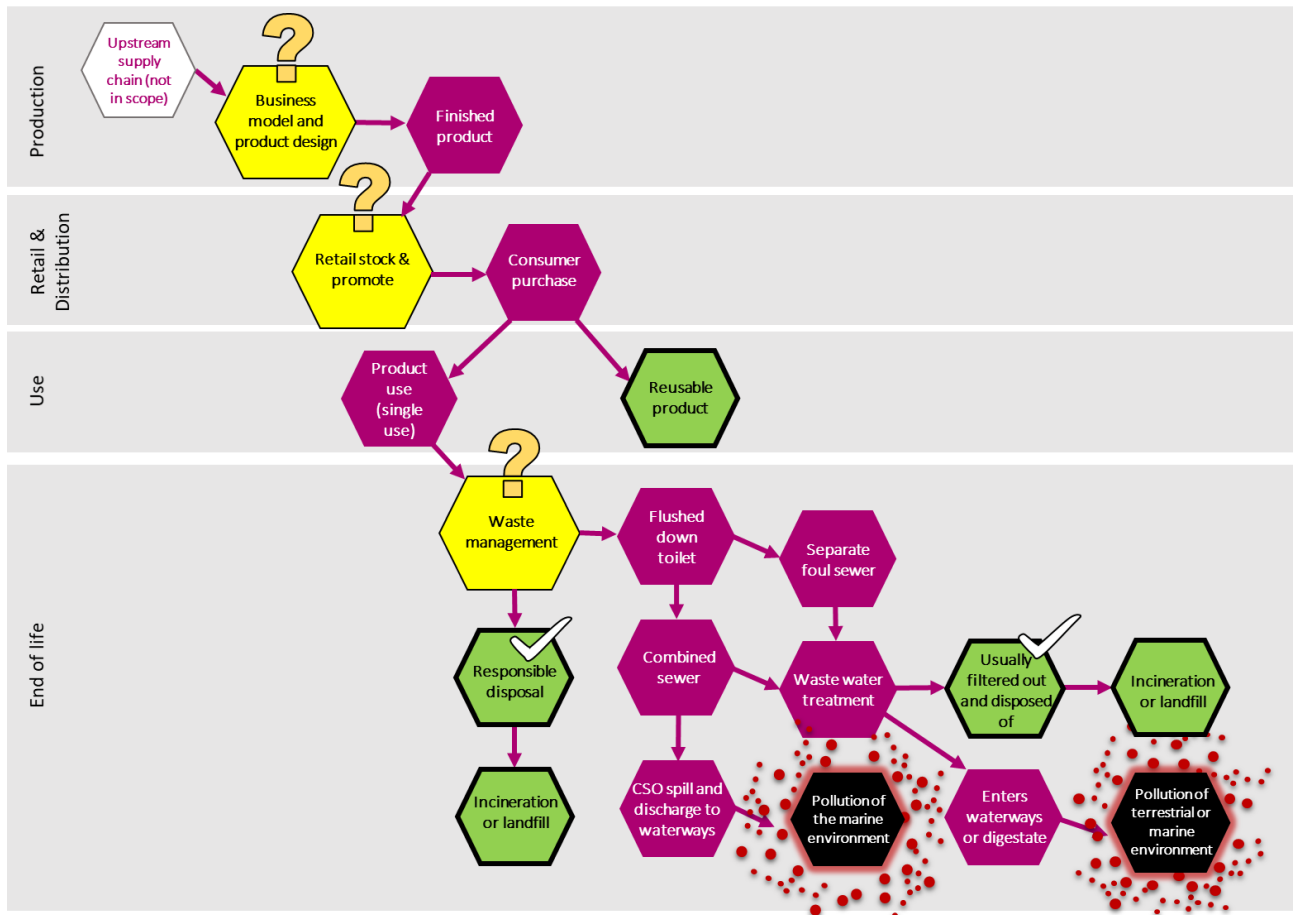
Artificial grass pitch represents a unique problem. Plastic infill granules, known as rubber crumb, are used to improve the playing surface for performance and safety. These granules are typically made of shredded waste tyres. Other materials are available but are not in widespread use due to differences in cost and performance.

The infill can be walked off the pitch on players’ clothing and in their boots and washed down drains in showers or washing machines. Infill can also be blown off pitch and washed off during rainstorm events and maintenance work with similar risk of entering drains that transport it to the marine environment.

Furthermore, there are reports that end of life pitches are not managed properly, and many are stored indefinitely, with insufficient funds to treat the waste, or handled illegally. Industry has developed solutions to address infill loss but they are not widely adopted. Marine litter pathways and key decision points are illustrated in Figure E3. Key decision points explored in this research are highlighted in yellow. Business

models were also identified as potential key decision points if companies can adopt circular economy principles and provide services over different phases of the product life cycle. However, wider examples such as leasing models were not found and so business models are not highlighted and explored in detail due to a lack of examples to draw upon.

Figure E3: Artificial grass pitch - Marine litter pathways and key decision points



The procurement process acts as a major barrier as the issue of infill loss is not recognised in the process and so solutions are not properly valued. Procurement rules often stipulate a 90:10 price to quality scoring system for tenders, and in a very competitive market this prevents a company offering infill management solutions as the additional cost will lose them the contract. Suggested solutions address this issue via procurement guidance, accreditation of suppliers, a green procurement framework, or simply education and training opportunities across the value chain. Funding for retrofitting infrastructure to reduce infill loss would help address pitches already in installed. There is also activity to transpose best practice guidance on infill loss into a European Eurocode standard (EN), and ECHA is currently consulting on a potential ban of synthetic infill altogether. Table E3 presents an analysis of where potential solutions may have the most influence in relation to key decision points shown in Figure E3. Solutions will have varying degrees of impact, which will to some extent depend on their design and implementation.

Table E3: Artificial grass pitch - where solutions can most influence key decision points

Life cycle stage	Key decision point	Green procurement framework	Accreditation	Education	Funding	Guidance	Eurocode Legislation	ECHA Ban
Production	Product design	✓	✓	✓	✓	✓	✓	✓
Retail	Procurement decision	✓	✓	✓	✓	✓	✓	✓
Use	Maintenance decision	✓	✗	✓	✗	✓	✓	✓
End of life/recovery	Waste management decisions	✓	✓	✓	✗	✓	✓	✗

✓ = Yes, ✗ = No, ✓ = Yes - if solution designed with this in mind, ? = Unknown

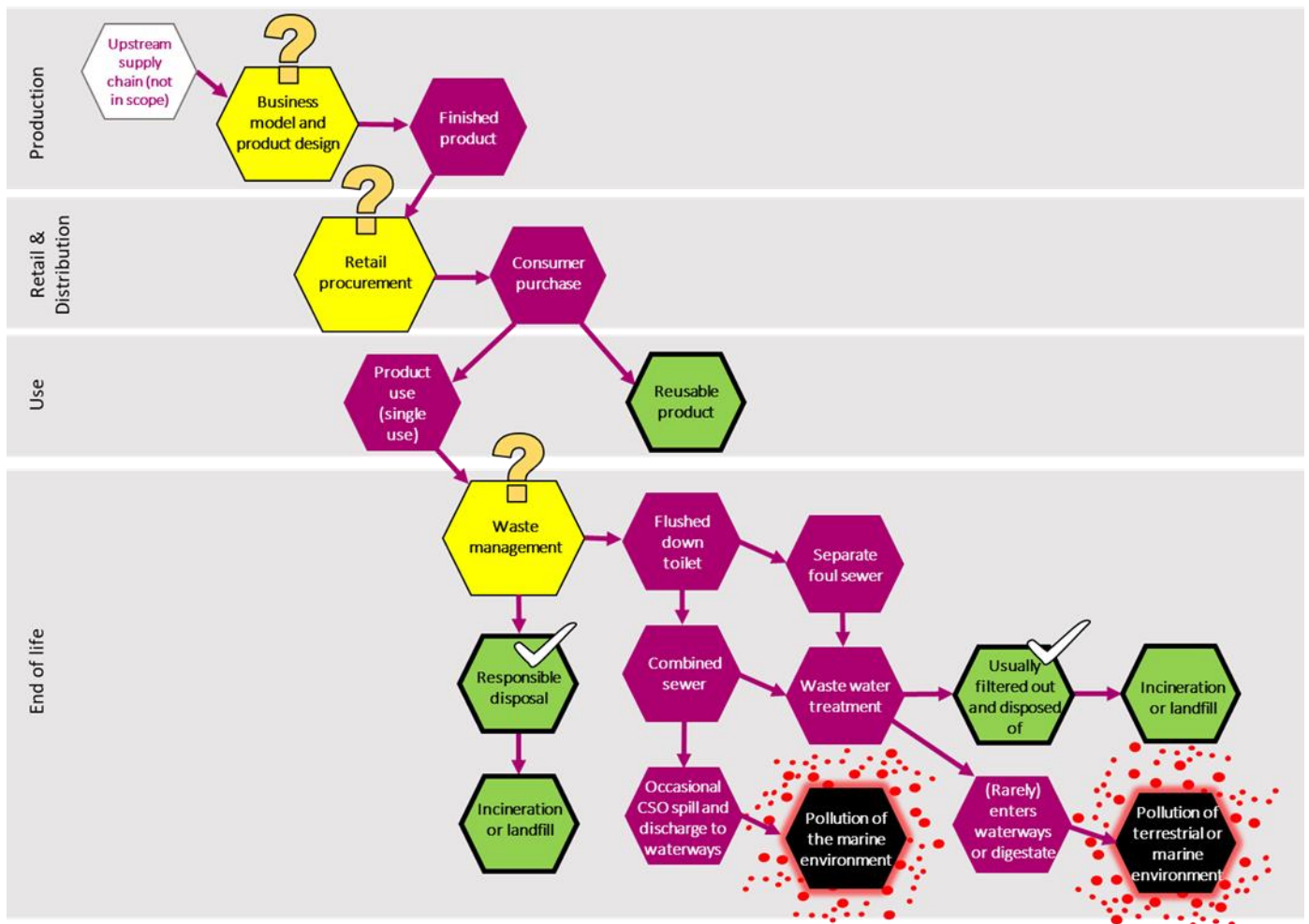
On the basis of the research findings, the following recommendations are made for subsequent action by the Scottish Government and the private sector to tackle marine litter from artificial grass pitch:

1. Support education and engagement measures
2. Develop a green procurement framework
3. Develop guidance for procurement teams
4. Review and improve current waste management processes
 - a. Mandate reporting on the collection and treatment of waste
 - b. Understand current (baseline) waste management costs
 - c. Enforce appropriate duty of care requirements for waste from end of life artificial grass pitch
5. Support best-practice and new technology

Menstrual products

Menstrual products are frequently found on beaches, having been flushed down the toilet and discharged to waterways through the sewerage network. Marine litter pathways and key decision points are illustrated in Figure E4. Key decision points explored in this research are highlighted in yellow.

Figure E4: Menstrual products - Marine litter pathways and key decision points



New innovative products are available that are expected to help tackle marine litter by avoiding plastic altogether, since the materials used biodegrade quicker, or are reusable affecting a reduction in the quantity of products consumed. There is a market for ‘plastic-free’ period products, typically marketed as biodegradable, such as organic tampons with cardboard applicators/without applicators, and tampons with bio-plastic applicators¹. The market for ‘plastic-free’ and reusable menstrual products is small, and education and engagement efforts could help the market grow, particularly addressing barriers such as consumer confidence in unfamiliar product designs. On a per unit cost basis these alternatives are presently more expensive. However, over a lifetime, reusables can be significantly cheaper for the consumer. This generates a lot less revenue per customer than disposables, and so it is likely that small specialist companies will continue to serve this market, at least in the short-term. In this context, EPR should be considered, but with caution, ensuring discussions are cognisant of the need to balance environmental benefits with respecting social implications and protecting the rights of people who menstruate, and delivered in a positive manner particularly for vulnerable product users.

¹ <https://www.heygirls.co.uk/shop/applicator-tampons/>

Other approaches focus on labelling and educating the user not to flush items, or supporting responsible waste management with sanitary bags and bins where needed. Table E4 presents an analysis of where potential solutions may have the most influence in relation to key decision points in Figure E4. Solutions will have varying degrees of impact, which will also be affected by their design and implementation

Table E4: Menstrual products - where solutions can most influence key decision points

Life cycle stage	Key decision point	Education and engagement	Improved labelling	Sanitary bags	Bins and infrastructure	Extended Producer Responsibility
Production	Business model & product design	✓	✗	✗	✗	✓
Retail & distribution	Retail stock & promote	✓	✗	✗	✗	✓
End of life/Recovery	Waste management	✓	✓	✓	✓	✓

✓ = Yes, ✗ = No, ✓ = Yes - if solution designed with this in mind, ? = Unknown

On the basis of the research findings, the following recommendations are made for the Scottish Government and the private sector to tackle marine litter from menstrual products:

1. Design an integrated communications strategy
 - a. Agree common standards for 'Do not flush' labelling
 - b. Publish best practice on education and engagement
 - c. Commission schools' education programme
 - d. Awareness raising campaign
2. Research whether sanitary bags can prevent flushing behaviour
3. Review public and workplace provision of bins, quality of bin provision and adequate access to sinks in toilet cubicles
4. Evaluate feasibility and efficacy of EPR

Broader analysis and conclusions

The analysis of the four products reveals some commonality when assessed against a life cycle framework. Pathways to the marine environment commonly occur in use and at end of life, and key opportunities in the value chain to tackle marine litter typically include product design and waste management decision

points. Retail decisions also present opportunities when products are sold to the public. Where the waste owner is responsible for waste management costs this is a commonly reported driver in littering behaviour.

A number of innovative circular business models have the potential to help tackle marine litter. For some products these may include product leasing or refillable/reusable models and vertical supply chain integration through to waste management services, wherein producers retain ownership or full financial responsibility for their products during the life cycle. However, limited examples were found relating to the four products reviewed. In most cases, the existing systems are optimised to delivery of single-use products and inertia potentially inhibits the change to new models that are incompatible or require additional thought, infrastructure, behavioural change or supporting services.

The analysis shows the four products also portray some unique marine litter pathways and opportunities for tackling marine litter. The potential solutions put forward address specific decision points in the value chain, addressing existing drivers and barriers or adding incentives for behaviour change. Innovation in product design, coupled with systems thinking, could deliver future solutions with benefits across the value chain. However, the right conditions need to be created to stimulate innovation and stimulate demand for alternative products. Market interventions that create these conditions may ultimately be favoured if widespread impacts are to be achieved.

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1 Introduction

Concerns around marine litter and its consequences on the environment and wildlife are growing as we understand more about the problem. In just a few minutes footage of marine litter, the Blue Planet II documentary brought the issue to the forefront of public attention and galvanised subsequent action. Many different materials are found in marine litter but the focus is often on plastic litter due to its very slow decomposition and concerns around ingestion by wildlife, entanglement and other harmful environmental impacts.

Government policies which help tackle marine litter have been published by the Scottish Government, the UK Government and the European Parliament.² Many are targeted at specific product categories. Cosmetic plastic microbeads have been banned already and other several single-use plastics (SUPs) bans have been consulted on or researched.^{3 4 5 6} Manufacturers and retailers are responding to public concern by voluntarily phasing out plastics from their products, changing product design, setting up takeback collections for their products when they are discarded and adopting reuse models to reduce plastic consumption.

Whilst there is significant activity on reducing marine litter, there are some products which cause marine litter that are not presently being addressed. The aim of this research study was to identify these problem products and investigate opportunities throughout the value chain to tackle marine litter issues, with Government support or interventions where necessary.

The research findings are presented in six documents: an overarching summary and discussion, a separate report for each of the marine litter product groups researched in detail, and a literature review. Some of the detail covered in the Executive Summary above is found in the four product-specific reports. The list of six report documents is 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**

² These include a deposit refund scheme for food and drink packaging in Scotland; an EU Directive for certain single-use plastics (SUPs) and fishing gear outlining bans, labelling requirements, changes to product design, and extended producer responsibility schemes; UK and Scotland bans of specific single-use plastics; and reform of the existing producer responsibility scheme for packaging and key waste items in the UK.

³ Cosmetic microbeads banned in the UK, <https://www.gov.uk/government/news/world-leading-microbeads-ban-comes-into-force>

⁴ Plans to ban plastics straws in Scotland by end of 2019, <https://resource.co/article/scotland-proposes-plastic-straw-ban-end-2019-12404>

⁵ Defra consultations on further SUP bans: (1) <https://www.gov.uk/government/news/gove-takes-action-to-ban-plastic-straws-stirrers-and-cotton-buds>; and (2)

⁶ Resource Futures and Defra (2018), A preliminary assessment of the economic impacts of a potential ban on plastic cutlery, plastic plates and plastic balloon sticks, <https://www.resourcefutures.co.uk/assessing-the-impact-of-a-ban-on-plastic-plates-cutlery-balloon-sticks/>

This document is the *Summary report*, describing the research methodology and overarching analysis and results. The report is structured as follows:

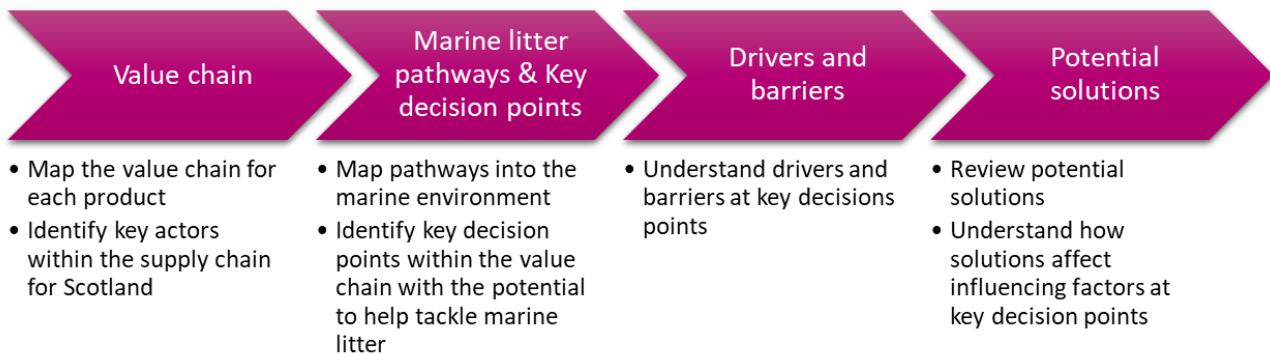
- **Methodology** - section 2
- **Comparison of the products** – section 3
- **Summary and conclusions from the research** – section 4
- **Wider analysis of EPR considerations** - Appendix A

2 Methodology

2.1 Research methodology

Over the product life cycle, materials and products pass through multiple actors in the Scottish economy, from raw materials extraction and product manufacturing to the point when products are discarded and recycled or disposed of. The pathways a specific product takes are dictated by decisions taken by the actors in the value chain. This raises an important question: why do some products become marine litter, i.e. what decisions have been made and by whom, *throughout* the product's value chain, that result in 'leakage' into the marine environment? To answer this question, it is necessary to understand decision making in the value chain. Whilst actors may already be aware of marine litter issues and may want to address them, there may be barriers or more dominant drivers that dictate how key decisions are currently made. With an understanding of key decision points in the value chain it is possible to consider how potential solutions can affect decision making to help tackle marine litter. This is the basis of the research framework used in this study, as summarised in Figure 1. The research framework is reflected in the structure of the four product-specific reports and referred to throughout.

Figure 1: Outline of research framework



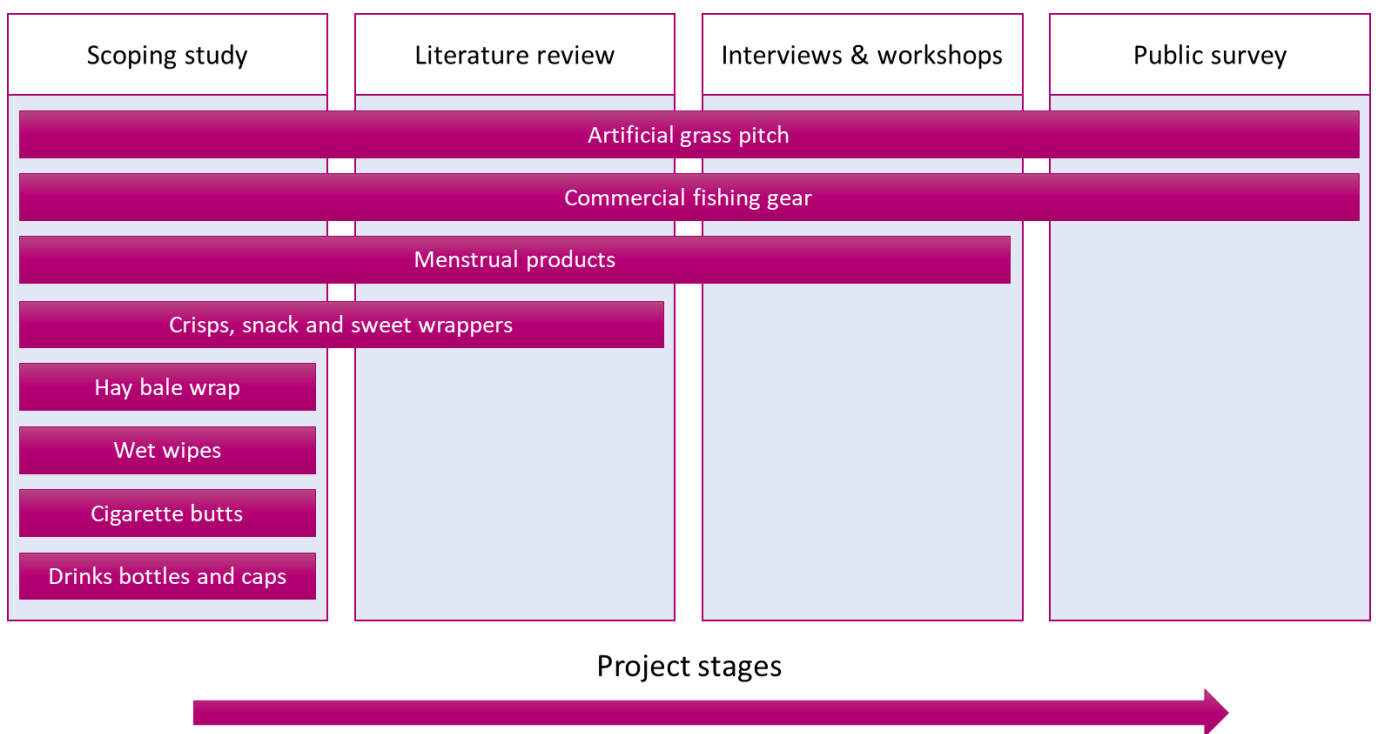
The framework above outlines the approach taken within the research. To gather this information to inform the study, research activities were conducted in four stages:

1. Scoping study
2. Literature review
3. Interviews and workshops
4. Public survey

The approach taken was designed to iteratively act upon the findings at each stage and refine the products carried through for research in subsequent stages, as illustrated in Figure 2. Initially eight products were identified in the scoping study stage representing the different types of problem products in the market,

the environmental risk of marine litter, and their attributes and value chain. Four products were taken forward to the literature review stage to investigate in more detail based on the research findings at that stage considering potential knowledge gaps and wider factors, under the direction of the advice of the project steering group. Following the literature review, three products were investigated in more depth in the stakeholder interviews and workshops stage. The three products were chosen based on their readiness for potential solutions in the value chain. Lastly, a public survey research stage was used to test the awareness of these marine litter issues and attitudes towards key findings that might affect the public or require public support. Menstrual products were not covered by the public survey to avoid duplication with a parallel behaviour and attitudinal study conducted by Zero Waste Scotland⁷. Figure 2 summarises how each product was considered at each project stage of the research.

Figure 2: Project stages and refinement of product categories



The products in this study were chosen as they each are associated with marine litter and each have different supply chains, sources and pathways to the marine environment and so different solutions are likely to be available to tackle them. The products were chosen and refined in collaboration with the project steering group to ensure the research gave the greatest value to the Scottish Government and avoided overlap with other research projects.

⁷ Zero Waste Scotland (ongoing research), Re-usable menstrual products research

Key research findings are presented for four products:

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

Although the crisps, snack and sweet wrappers product category was not taken forward to the interviews and workshops stage it is included in this report to present initial findings not covered in the literature review. The separate report document on crisps, snack and sweet wrappers therefore follows the same broad structure as the other three products, but contains much less detail as the findings are based on preliminary research only.

Products made from bioplastics were considered out of scope in this research. Research and innovation in material science is leading to the development of many new polymers marketed as biodegradable plastics. However, there is ongoing debate over the efficacy of these polymers to biodegrade in the marine environment over short enough timescales to reduce the impacts of marine litter. This is a complicated subject worthy of a dedicated research project, and so was considered outside the scope of this study to assess. Instead, the research scope starts after polymerisation at the point in the value chain where plastic products, or semi-finished products, are manufactured.

2.2 Engagement approach

The research findings were informed by engagement with approximately 165 stakeholder organisations. Of this initial sample, 57 individual stakeholders attended the three workshops, with an additional 51 interviews taking place by telephone. Stakeholder mapping, workshop aims, agendas and participant lists are provided in the four product-specific reports. We have aimed to summarise the information received, drawing out common themes, uncertainty and conflicting views. Stakeholder views represent personal experience and received views from their own networks. It is therefore natural that there will be differences in opinion on some matters and we have aimed to represent these differences.

The main product life cycle stages are used as the structure for value chain analysis, to represent and understand the sources of marine litter, marine litter pathways and key decision points within the value chain. This enables a clear and consistent structure for analysis and comparison between products that have different value chains and marine litter pathways. The stages in the product life cycle described in this research are:

- Raw materials
- Production
- Retail & distribution
- Use
- End of life/recovery

3 Comparison of the products

This study presents detailed research for four products known to be marine litter issues. Full details are given in a separate report for each of the four products and key findings are summarised in the Executive Summary of this report. The products were chosen to represent different uses, value chains, and marine litter pathways and to identify learnings which may be applied more widely. This section presents a comparison of findings, the differences and commonalities.

Marine litter pathways

Visual representations of the marine litter pathways presented in this study clarify the point in the products lifecycle where leakage into the environment can occur. For commercial fishing gear and artificial grass pitch leakage happens in use and at end of life, with different drivers and solutions at each pathway. Crisps, snack and sweet wrappers and menstrual products are predominantly lost at end of life, when disposing of the waste product.

A common pathway for marine litter items is public littering behaviour. Crisps, snack and sweet wrappers and menstrual products are both examples of this, though one is dropped on land and washed down drains whilst the other is flushed down the toilet by the user. Both are high-volume, low price products. However, they share few other similarities in the value chain research, as alternative menstrual products that help tackle the issue are readily available and need support in reaching a wider market, whereas preliminary findings on crisps, snack and sweet show just one or two new product design solutions recently announced.

Commercial fishing gear stands out as the only product where the source of marine litter comes from commercial operations – i.e. the fishing industry accidentally losing gear or intentionally dumping it at sea. Artificial grass pitch by contrast is thought to be a steady and gradual emission of microplastics through use and maintenance, but waste management at end of life also poses considerable risk.

Value chains and key decision points

The value chains of the four products are very different and often, in these examples, local or national companies were leading product design innovation to tackle marine litter whereas multinational brands were slower to respond. This is especially true of menstrual products, but in this case another factor may be a barrier to multinationals adopting some of the product design solutions. Reusable menstrual products were found to generate 88% to 98% less revenue than single-use products, serving the same customer base. This is an important finding and may have wider implications for similar products where the product itself, rather than the packaging or delivery method, is single-use, as such a drop in revenue would be seen as a threat by the dominant market players.

All four products shared key decision points with opportunities to tackle marine litter through business model and product design and waste management. Retail decisions were also important for goods consumed by the public (crisps, snack and sweet wrappers and menstrual products), whereas the supply chain for commercial fishing gear and artificial pitches typically has closer links between the consumer and the supplier manufacturer, without an intermediary retail actor.

Business models

A number of innovative circular business models have the potential to help tackle marine litter. For some products these may include product leasing or refillable/reusable models and vertical supply chain integration through to waste management services, wherein producers retain ownership or full financial

responsibility for their products during the life cycle. Producers are thereby incentivised to reduce consumption and waste by making products durable and compatible with repair, reuse, remanufacturing, and recycling to reduce their costs and improve the customer experience. A commonly used example is the Philips lighting lease scheme, selling 'light as a service' rather than selling lighting units⁸. However, other examples are scarce and very few were found in relation to the four products in this report.

In some cases, new business models are driven by product design. Reusable products are one example. As shown with reusable menstrual products they generate a lot less sales revenue per customer (taking account of product lifetimes), and the market is currently served mostly by companies motivated by social and environmental aims. Other reusable products require additional infrastructure and services (e.g. refill stations and washing services) which must be factored into the business model.

Supply chain integration can also incentivise systems thinking when a company's role encompasses several lifecycle stages. This can support servitisation business models, providing a service to the customer rather than the traditional model of selling a product and having little involvement past that point. For example, some artificial grass pitch suppliers provide a service covering supply of the pitch, installation, maintenance and waste management. In theory this enables a holistic view to be taken whereby net saving can be gained by investing more in pitch designs that reduce maintenance and waste management costs. The extent to which this happens in practice is limited by barriers identified in the artificial pitch industry, particularly around procurement procedures, and where maintenance and waste management services are subcontracted to other parties there is a weaker incentive for such systems thinking.

The drivers and barriers associated with such business models could not be explored in depth due to the lack of relevant examples for the four products in this study, with the few exceptions above. However, it will be important to support promising new business models as they emerge in this context.

Drivers, barriers and potential solutions

Analysis revealed that for all products plastics are favoured for their strength, light weight, versatility, and often relative low cost. Growing public concern is a driver to tackle marine litter, but there are currently few additional market drivers to support that change, and where solutions have been developed there are barriers to them being adopted and properly valued by consumers and subsequently demand is often low.

Innovation in product design, coupled with systems thinking, could deliver solutions for all four products assessed in this study. It is important that product designers consider end of life impacts, including marine litter risks, and manage these issues through design without negatively affecting the essential function of the product. Education and awareness raising efforts are important in behaviour change, particularly around irresponsible waste management decisions, but some actors will refuse to engage, particularly where there are competing interests. The value chain therefore needs to share responsibility in responding to the issues presented by their products.

Product designers have arguably overengineered some products, particularly single-use products such as crisps, snack and sweet wrappers and menstrual products, where the product is only used for a short period of time but the materials used persist in the environment for decades. Some compromise of functionality may be favourable to limit environmental impacts. Indeed, some alternative product designs, such as reusable menstrual cups, address a number of consumer concerns and attract vocal advocates for

⁸ <https://www.ellenmacarthurfoundation.org/case-studies/selling-light-as-a-service>

the benefits they deliver. Other solutions may diminish functionality and not all parties will value the environmental gains over a loss in functionality. For example, outside of the products considered here, paper straws are now commonplace but many users report a loss of utility as current designs quickly become soggy and collapse. Paper straws have also raised concerns around lack of recyclability when compared with plastic counterparts⁹, but it is important to consider how many are realistically recycled anyway when consumed in fast food restaurants or on the go and they are difficult for recycling equipment to identify and sort due to the small size. Measures to affect product design innovation must consider where the desired balance lies in such a trade-off in short-term product substitution, but being mindful of future improvement on product design that can address functionality issues in the first wave of new products.

A wider barrier that the research raises is the difficulty in introducing new product designs into an established market, particularly where the consumer is unfamiliar with the product design and resistant to change, and where a different business model, or additional infrastructure and services are required by the product. As seen with reusable menstrual products, consumers are reticent to try unfamiliar products when they are ill informed on the use of the product or have misconceptions about the risks. In addition, reusable menstrual products are washed rather than disposed of after use and very few public and workplace toilet cubicles are set up to support this. This raises the question of how much market inertia from the existing product and service delivery models are inhibiting new designs. Very few alternatives were found for crisps, snack and sweets packaging that address the associated marine litter issues. The current system of packaging, distribution and retail has been optimised over many years to deliver single-use packaged products and consumers are accustomed to the convenience that model provides. However, consumers have shown willing to trade some convenience and utility for environmental benefits with other products such as coffee cups and drinking straws. For this product category there is also a question of making packaging fit for purpose without over designing and causing the cost to the environment. Packaging does not need a shelf life of several years if the goods are packaged, sold and consumed in much shorter timeframes of weeks or months. As options are explored for other products, there will be cases where simply removing or replacing single-use products with reusable alternatives is neither practical nor a more sustainable option due to incompatibility with existing systems. It is therefore important to consider how a delivery system supports the use of single use items and if system changes are required to eliminate the need for, or replace, single use items. Failure to do so may result in assessments which provide an inherent advantage to incumbent single-use systems. The transition costs of system change will be high for the first movers but lowered for subsequent developments and could support others to move to more sustainable models. Any such change should be also evaluated from a life cycle perspective, taking a broad range of impacts into account.

Cultural factors also play a part, as certain products can become associated with a certain cultural group or identity. For example, reusing shopping bags was at one time considered as an unusual or even 'hippy' activity but is now a normalised and commonplace behaviour. Vegetarian and vegan food products are currently going through a similar transition. Such associations can act as an initial support for products as they are shared and supported by a close-knit community who may be willing to pay higher prices as early

⁹ <https://www.packagingnews.co.uk/news/mcdonalds-admit-recycling-issues-paper-straws-06-08-2019>

adopters and ethical consumers, but such associations can become a barrier to products being adopted by the wider society.

Menstrual products and artificial grass pitch both have alternative product designs available on the market that tackle the marine litter risk, and yet they struggle to compete with the traditional product designs. A lack of awareness of the issues they are tackling and the benefits they provide were cited as reasons for the lack of demand for the alternative products. Both groups also could not compete on price with the traditional product designs because the environmental externalities (i.e. the costs of the harm caused by pollution and waste) were not reflected in the market price of those products. This would suggest a clear case for market intervention to level the playing field, for example through EPR modulated fees or ensuring infill loss and end of life is properly evaluated and valued in pitch procurement processes.

A lack of viable or affordable waste management options was raised as a major concern for commercial fishing gear and artificial pitch. The difficulty and cost of managing commercial fishing gear at end of life was reported by some stakeholders and a key driver in dumping waste at sea, although this was disputed by others. The research also discovered worrying waste management procedures for artificial pitch, with many purported to be recycled when really kept in indefinite storage, contracts let with insufficient funds to handle waste responsibly, and even illegal movements of waste.

Developing recycling options was discussed for all products. The logic is clear, if the waste has a value it won't be littered. Given the inherent value, the market will respond to develop suitable collection and recycling. However, for this to be true the value must be redeemable and valued by the appropriate waste owner or handler as they are making the decision whether to litter. For example, the public don't pay directly (e.g. per kg) for their waste services, and so even if crisps wrappers retained some recycling value the people littering would be unlikely to receive a direct financial benefit that changes their behaviour. Furthermore, these products are complicated and expensive to recycle and so require subsidies or radical change in product design or recycling technology to make recycling more financially viable.

Another common finding was that education and engagement were favoured for most products to address knowledge gaps in users and other actors the value chain, or to reinforce messages they may already be exposed to. Crisps, snack and sweet wrappers as terrestrial and marine litter are visible to all sectors of society and there is widespread awareness of the issue. The other three products, however, are thought to be less well known even by the product users. The public survey found that respondents typically were aware of lost fishing gear and marine plastics linked to the fishing industry but pitch users reported a low level of awareness of the risk of rubber crumb escaping into rivers and oceans.

A common debate in discussion of terrestrial and marine litter is whether measures targeted at specific products are effective and really tackle the heart of the issue, or whether this is a piecemeal approach that is only addressing the fringes of the problem and won't achieve the scale of change needed in acceptable timeframes. The in-depth analysis of four products in this study shows the complexity of marine litter issues and that products can present vastly different problems requiring different solutions. A one-size-fits-all approach is therefore unlikely to be effective or efficient. However, there are groups of products that share similar attributes, as we have explored briefly by considering 'comparable products' in the four product-specific reports, and could be suitable for similar or shared solutions.

4 Summary and conclusions

Marine litter is commonly caused by illegal littering (uncontrolled, irresponsible or unknowing) or dumping behaviour, or more passive forms of negligence. It reflects a market failure to manage resources and waste responsibly and limit end of life impacts leading to negative externalities. Most agree that intervention is needed to correct the problem, as the market will not do so by itself.

In this study four product groups were researched to understand their marine litter pathways, product value chains and key decision points where action could be taken to help tackle marine litter. Drivers and barriers were identified through stakeholder engagement and potential solutions assessed against these findings to understand their potential efficacy and design considerations.

The analysis of the four products reveals some commonality when assessed against a life cycle framework. Pathways to the marine environment commonly occur in use and at end of life, and key opportunities in the value chain to tackle marine litter typically include business model and product design and waste management decision points. Retail decisions also present opportunities when products are sold to the public. Where the waste owner is responsible for waste management costs this is a commonly reported driver in littering behaviour.

The analysis shows the four products also portray some unique marine litter pathways and opportunities for tackling marine litter. The potential solutions put forwards address specific decision points in the value chain, addressing existing drivers and barriers or adding incentives for behaviour change. Innovation in product design, coupled with systems thinking, could deliver future solutions with benefits across the value chain. However, the right conditions need to be created to stimulate innovation and stimulate demand for alternative products. Market interventions that create these conditions may ultimately be favoured if widespread impacts are to be achieved.

Specific recommendations are presented for each product group, taking into account the need to address key information gaps, and the collaboration and support of actors throughout the value chain. These aim to support the value chain in tackling marine litter from their products in the short to medium term.

The recommendations for each product group are summarised below, broken down into subtasks where necessary. The recommendations presented have different potential efficacy, costs and timescales. To some extent the likely impact is related to the resources and support invested in any single measure. Further details are given in the four product-specific reports.

Recommendations for commercial fishing gear

1. Support education and engagement measures
2. Evaluate feasibility and efficacy of EPR, recycling, and other waste management options
 - a. Mandate reporting of products placed on market, and data on the collection and treatment of waste
 - b. Understand current (baseline) waste management costs to fishers
 - c. Evaluate EPR options for fishing gear
 - d. Research recycling enablers and conduct cost-benefit analysis
 - e. Gather industry views on 100% indirect fee, EPR and recycling measures in a combined consultation
3. Support best-practice and new technology

Recommendations for crisps, snack and sweet wrappers

1. Better understand the nature of this item in litter
 - a. Publish brand and product litter survey
 - b. Research relative litter abundance of whole wrappers and packets vs. pieces
2. Industry workshop for solutions
3. Product design change assessment

Recommendations for artificial grass pitch

1. Support education and engagement measures
2. Develop a green procurement framework
3. Develop guidance for procurement teams
4. Review and improve current waste management processes
 - a. Mandate reporting on the collection and treatment of waste
 - b. Understand current (baseline) waste management costs
 - c. Enforce appropriate duty of care requirements for waste from end of life artificial grass pitch
5. Support best-practice and new technology

Recommendations for menstrual products

1. Design integrated communications strategy
 - a. Agree common standards for 'Do not flush' labelling
 - b. Publish best practice on education and engagement
 - c. Commission schools' education programme
 - d. Awareness raising campaign
2. Research whether sanitary bags can prevent flushing behaviour
3. Review public and workplace provision of bins and sinks in toilet cubicles
4. Evaluate feasibility and efficacy of EPR

EPR has been discussed in the context of two products groups: commercial fishing gear and menstrual products. However, as is shown in the analysis for commercial fishing gear, EPR is a broad church of measures, which can be adapted to tackle different situations. In the case of these products, EPR will be most effective if designed to internalise end of life impacts including marine litter into the traded price of a product, thereby providing consumers transparency of these costs and incentivising the value chain to address them. It is important to consider the wider context to avoid unintended consequences and ensure overall benefit from any such policy measure. This is explored in more detail in Appendix A through a discussion of the wider environmental considerations for EPR and an analysis of different forms of EPR.

Education and engagement were raised by stakeholders for almost every product researched, for key actors within the value chain to understand the marine litter issue and its consequences and the options available to them to help tackle it. Recycling options were also explored for many of the products, but a step change is needed to move from currently financially unviable recycling processes to establish independently profitable businesses that might even pay the waste owner for the waste, unless Government wishes to subsidise such operations. Other solutions discussed are product-specific, reflecting particulars of the decision making drivers and barriers within the value chain.

Any solutions need to be considered in the wider environmental, social and economic context, and we highlight four key environmental criteria, as below:

- 100% waste collection, 0% litter leakage
- Adherence to the waste hierarchy
- Stimulate Circular Economy business practice (including product design innovation)
- Polluter pays principle

Whilst some may consider with current levels of societal concern that littering behaviours are entrenched and progress on marine litter is slow, the research showed that for four marine litter items at least, there are many actors in the value chain keen to engage on the issue, and many already developing solutions that simply need support or a level playing field to compete effectively. Intervention in these markets won't be welcomed by all, particularly those currently saving costs through irresponsible waste management, those disadvantaged by highlighting their products role in contributing to marine litter, and those whose products carry the greatest marine litter risk where representing the true cost of litter into the product price would shift their market advantage. However, many manufacturers and suppliers spoken to in this research welcomed market intervention as providing the enabling conditions for them to innovate solutions and to be recognised and rewarded for doing so.

Engagement on the issue is welcomed across the whole value chain, and from organisations of all sizes. Local manufacturers and suppliers of some products were found ready to move fastest, and will likely prove valuable partners in future consultation and collaboration. Multinationals may require more time to bring new designs to market, and are often concerned about specialising products for individual countries, but have an important role to play are well placed to affect widespread change.

Appendix A Wider analysis of EPR considerations

A wider analysis of EPR considerations is warranted to identify guiding principles and avoid unintended consequences. The wider environmental considerations, alongside marine litter impacts, are discussed in the following sections and different forms of EPR analysed against these.

A.1 Wider environmental considerations

Whilst there is urgent need to address marine litter, we should be cautious of adopting solutions that are later shown to be ineffectual, or worse, cause negative impacts in other ways or simply move the problem overseas. It is therefore important to carefully assess solutions to ensure that the options taken forwards offer the best outcomes across all impacts, considering the full life cycle of the product and all stakeholders across the value chain. We therefore set out the wider assessment criteria for potential solutions shown in Figure 3 to incorporate these impacts in our analysis.

Figure 3: Wider assessment criteria for potential solutions



These four environmental aims will be used to assess potential solutions, as follows:

- **100% waste collection, 0% litter leakage** – All waste should be collected and none should escape control by leaking out of the system as terrestrial or marine litter.
- **Adherence to the waste hierarchy** – Waste should be treated in accordance with the waste hierarchy, e.g. prioritising waste prevention, re-use, and recycling.
- **Stimulate Circular Economy business practice** – The circular economy model goes beyond waste treatment to envision designing out waste and keeping resources circulating in the economy whilst retaining the highest utility and minimising environmental impacts.
- **Polluter pays principle** – Many environmental costs are borne by the general public, e.g. volunteers and Councils cleaning up litter, and the social cost or ‘disamenity’ of a degraded coastal and marine environment. The polluter pays principle states that those involved in producing pollution should be responsible for paying to prevent it or pay for the damage done to the natural environment. The ‘polluter’ can include the consumer and others within the value chain.

A.2 Extended Producer Responsibility

Extended producer responsibility (EPR) is increasingly discussed in the context of waste and litter issues, particularly for specific ‘problem products’ and where waste treatment is performing poorly against the waste hierarchy. The OECD provides a definition of EPR:¹⁰

Extended Producer Responsibility (EPR) is a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products. Assigning such responsibility could in principle provide incentives to prevent wastes at the source, promote product design for the environment and support the achievement of public recycling and materials management goals.

The main approaches to EPR are outlined below:

- **Advance disposal fee** – A disposal fee is paid by the consumer at point of sale. The disposal fee is typically passed directly to a third party, e.g. Government or another authorised body, who administrates the system and uses the fees to pay for waste management costs associated with the product. The consumer is given access to ‘free’ waste management, having paid for it in advance. The system ensures that there are sufficient funds available to deal with the waste product at end of life. It can be used to overcome economic barriers to waste collection, recycling and reuse, particularly where these activities are deemed expensive and so present issues if left to market forces. Where waste management costs apply directly to the waste producer (i.e. waste generated by the private sector), paying the disposal fee in advance removes the incentive to stockpile or illegally dump the waste in order to avoid paying for waste management.
- **Takeback scheme** – In a takeback scheme, consumers return their products to the manufacturer, supplier or retailer at end of life. The takeback organisation is then responsible for waste management. This connects the value chain to waste and end-of-life and, in theory, can incentivise the value chain to minimise these costs and impacts through changes to business model and product design. The takeback is usually offered at no direct cost to the consumer at the point of returning the product, although the costs are often incorporated into the product price and therefore passed on indirectly. Reducing the waste management costs can therefore provide a competitive advantage to the manufacturer. Similar to the advance disposal fee, as the consumer has access to ‘free’ waste management it removes the incentive to stockpile or illegally dump the waste in order to avoid paying for waste management.
- **Modulated fee** - Producers pay fees for waste management and end of life impacts and the fees are modulated to incentivise certain outcomes. For example, producers pay a much lower fee when products are recycled rather than sent to landfill or incineration. The fee can, in theory, incentivise action across the value chain, including changes to business model and product design. The fee can also charge for damage costs associated with the waste, such as the cleanup cost of marine litter or the estimated cost of damage to the environment.
- **Deposit return scheme (DRS)** – The consumer pays a deposit when purchasing a product, which is returned to them when they return the associated waste to an authorised collection point. The deposit incentivises the consumer to return the waste in order to claim back the deposit. The system is used to increase recycling rates and to tackle products that are often found littered or

¹⁰ <https://www.oecd.org/env/tools-evaluation/extendedproducerresponsibility.htm>

illegally dumped. The deposit needs to be transparent to the consumer and of a sufficient value to motivate them to return the item and not treat it as a sunk cost. There is some debate whether DRS is a form of EPR but it fits the OECD definition above and is included in this group for the purposes of this report.

A Producer Responsibility Organisation (PRO) can help manage obligations, administration and fees for producers. This reduces the burden on individual producers and can benefit from economies of scale working for many producers in a single scheme.

In Table 1, the four EPR approaches are assessed against the wider assessment criteria from Appendix A.1.

Table 1: Comparison of different EPR approaches in their basic form

	Advance disposal fee	Takeback scheme	Modulated fee	Deposit return scheme
Incentivise 100% waste collection, 0% litter leakage	✗	✗	✓	✓
Incentivise adherence to waste hierarchy	✓	✓	✓	✗
Comment	Lacks an intrinsic positive incentive to return items at end of life. Schemes can require all items returned are treated in accordance with the waste hierarchy, and costs allocated accordingly.		Fee could be designed to incentivise 100% waste collection and 0% litter leakage, if supported by data and reporting.	Deposit must provide sufficient motivation to be effective No intrinsic incentive on treatment of waste
Stimulate Circular Economy business practice	✓	✓	✓	✗
Comment	In so far as environmental costs are internalised in market transactions, producers are incentivised to reduce these costs by improving product design and practice throughout supply chain.		Depending on fee design	No influence over product design or supply chain management, except to avoid DRS entirely
Polluter pays principle – waste collection and treatment	✓	✓	✓	✗
Polluter pays principle – litter retrieval and damage costs	✗	✗	✓	✗
Comment	Pays for waste items returned but not litter		Fee could be designed to include both waste and litter costs	Unlikely to cover waste and litter costs for low-value materials and difficult to recycle products

✓ = Yes, ✗ = No, ✓ = Maybe, or to a lesser extent