A preliminary assessment of the economic, environmental and social impacts of a potential ban on plastic straws, plastic stem cotton buds and plastics drinks stirrers.

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resourcefutures

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Contact	Andrew Woodend, Statistics Team - Materials and Waste Evidence
Client	Environmental Quality Directorate, Defra
Telephone	0208 026 2736
Email	andrew.woodend@defra.gsi.gov.uk
Proposal to	adele.storr@defra.gsi.gov.uk

Document prepared by:

Consultant	Bernie Thomas
Job Title	Principal Consultant - Resource Futures
Telephone	0117 9141282
Email	bernie.thomas@resourcefutures.co.uk
Co-authors	George Cole, Senior Consultant - Resource Futures
	Howard Walker, Director - Bridge Economics

Document checked by:

Name	Sam Reeve
Title	CEO - Resource Futures
Signed	

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Executive summary

Background to the research

The UK Government's 25-year Plan[1] and the EU Commission's Plastic Strategy[2] are determining a strategic direction for plastics use and its environmental impact. The 25-year plan has a specific target for eliminating 'avoidable' plastic waste by the end of 2042 and a target for significantly reducing, and where possible preventing, all kinds of marine plastic pollution.

Each of the UK devolved governments are presently considering a range of legislative and voluntary measures aimed at reducing the use of plastics. Department for Environment, Food and Rural Affairs (Defra) wanted to better understand the potential qualitative and quantitative economic, environmental and social impacts of introducing a ban on plastic drinking straws, plastic stem cotton buds and plastic drinks stirrers in England.

Resource Futures was commissioned to undertake a preliminary impact assessment of a ban on plastic straws, plastic drinks stirrers and plastic stemmed cotton buds. The research, which was undertaken between March and April 2018, comprised an evidence review, engagement of key stakeholders and preliminary impact modelling. The outputs were intended to inform future discussion around whether a potential ban would be advantageous, ahead of further research and impact modelling.

Market failure and the case for intervention

Single use plastics, including plastic stem cotton buds, plastic drinking straws and plastic drinks stirrers, are associated with negative effects on the environment if they are littered or discarded incorrectly after their use. There are costs associated with their clean-up and externality costs imposed on the tourism and fishing industries from littering and the transfer of littered plastics into the environment. They can damage terrestrial and marine life and there is widespread and significant public concern regarding plastics and litter. Resources and greenhouse gas emissions are also associated with plastics production and disposal since they depend on finite fossil fuels.

These costs are not incorporated in the price of the products. Consumers are not incentivised to limit the use nor dispose of these plastic items correctly. The market is failing to deliver an efficient outcome. Consequently, an intervention can be justified to address the market failure – to protect the environment, food supply and other economic sectors from further pollution, and to foster an increased degree of consumer confidence that the products they buy will not harm the wildlife and the environment.

A qualitative assessment was required by Defra to better understand the range of impacts/risks associated with a potential intervention. A quantitative approach was requested to provide an indication of the costs and impacts of a ban, and to understand the extent of the empirical evidence and the main data gaps/uncertainties.

Research approach

Resource Futures undertook the research between March and April 2018. The overall research approach taken was:

1. Initial information gathering – an evidence review and stakeholder initial engagement

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/673203/25-year-environment-plan.pdf
[2] http://europa.eu/rapid/press-release_IP-18-5_en.htm

2. Development of an impact model to estimate quantitative impacts
3. Further information gathering and stakeholder interviews
4. Refinement of the impact model and sensitivity analysis to understand uncertainties
5. Reporting of findings and discussion

A sample of stakeholders across the value chain were interviewed in the research. These provided opinion on the impacts and risks associated with a ban and directed the researchers to further sources of information for an evidence review.

A bespoke product demand impact model was developed to provide indicative estimates for quantifiable economic, environmental and social impacts.

In general, the evidence-base and market data for each of the three products was found to be limited. Annual product sales were compiled following stakeholder engagement or were estimated. Informed by stakeholder discussions, assumptions were also made regarding the speed and depth of change in the market from plastic to non-plastic product. The trajectory of change (a reduction in the proportion of plastic product in each of the markets) is illustrated in Figure E-1. This shows the change under a **Ban** scenario and that which may possibly happen voluntarily under a **No Ban** scenario over the next 10 years.

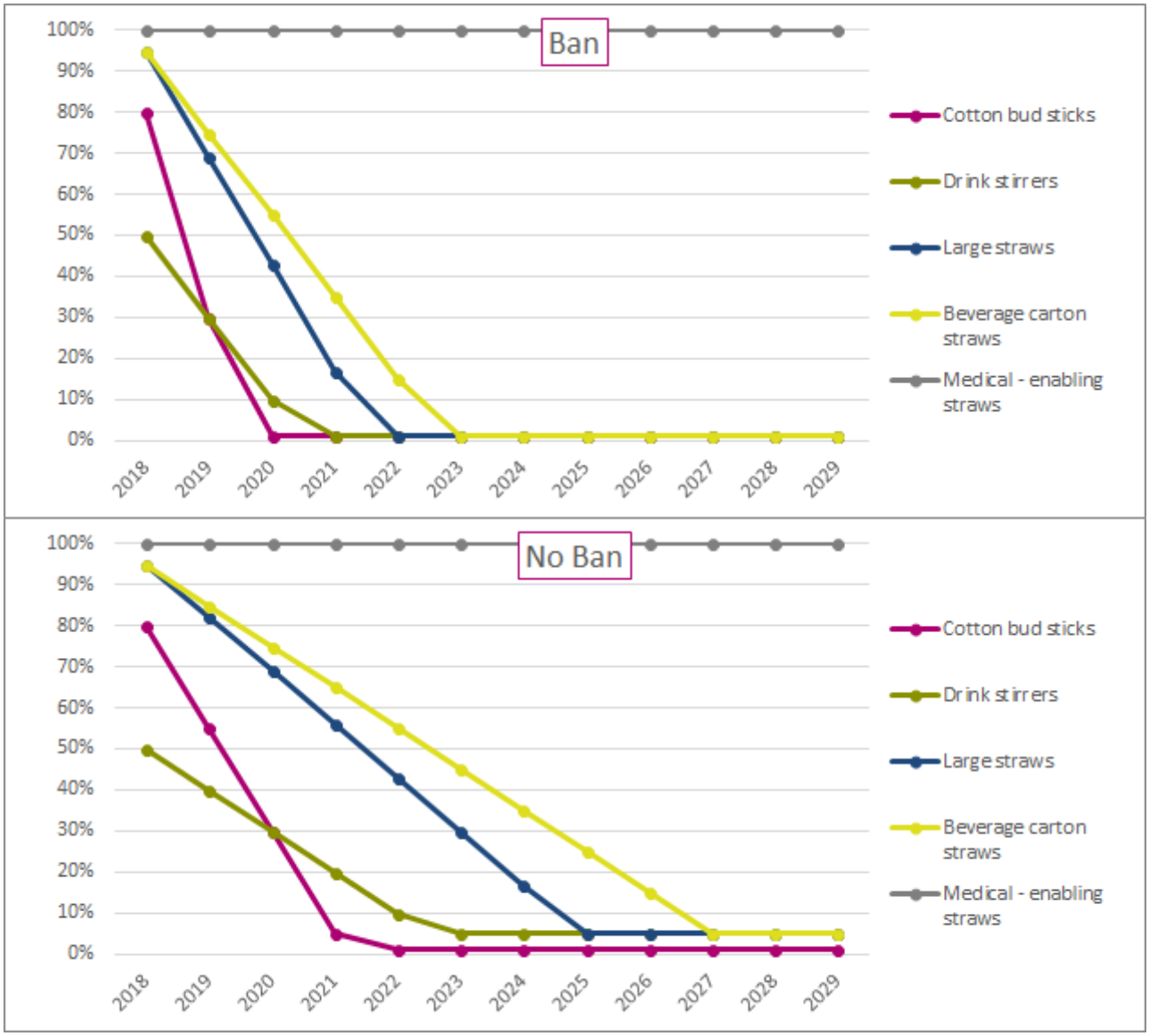

Figure E-1: Assumptions for plastic product share of total market in the two modelled scenarios: Ban and No Ban scenario. Note: the line indicates the reduction in plastics use (as a percentage of market share). The modelling also represented a corresponding increase in plastic-free products over the same period.

Qualitative research findings

The research found that plastic stem cotton buds and plastic straws have a propensity to be discarded incorrectly; either through flushing down the toilet or littering. Sewerage infrastructure is not effective at capturing these items and during rainstorms plastics can be discharged into rivers and the sea via storm sewer outlets. The Marine Conservation Society's Great British Beach Clean 2017[3] indicates cotton bud sticks to be the 8th most frequently counted litter item on UK beaches and straws/cutlery as the 10th.

Discussions with key stakeholders during the research revealed a universal ban for plastic stem cotton buds would be welcomed, with widespread support amongst stakeholders interviewed for action on stirrers and for certain types of straws. Shifting to plastic-free alternatives for these products would represent a first

[3] http://www.keepbritaintidy.org/get-involved/support-our-campaigns/great-british-spring-clean

step towards addressing a significant market failure. A ban would hasten and increase the extent of change in the market. It would also serve to level the playing field and strengthen the plastic-free market by protecting it from competition with low-priced plastic imports.

Further consultation regarding a ban is recommended for drinking straws to better understand options due to the lack of immediately available plastic-free alternatives for certain types of straws. The straws market is much more diverse than the cotton buds and stirrers markets and significant change may take longer. Market leaders in the fast food sector which use billions of large straws each year have made more tentative announcements regarding reducing plastics (e.g. to trial alternatives). In the small beverage cartons sector, plastic-free/strawless alternatives are not market ready and require further development and commercialisation. The research indicates that exemptions from the ban would be necessary for medical uses in hospitals and the home and for some disabled and other medical patient groups who require large flexible plastic straws to consume drinks and medicines. Over prolonged periods, reduced functionality/consumer disutility may be experienced (soggy straws), although for the main use of drinking straws for use in cold drinks over brief timescales, it is expected that functionality of large paper straws will be 'adequate for use'. We would also expect the market to innovate and improve functionality and utility rapidly of non-plastic alternatives.

Quantitative research findings

The quantitative research indicates a ban would serve to accelerate the change in each market and could harmonise the market at modest cost. The effect of a ban would be to reduce litter disamenity and impacts on the economy, because plastic-free items would disintegrate within significantly shorter timescales (months rather than tens to hundreds of years). Finite resources would also be saved.

Table E-1 provides the main outputs from the impact model, made for a central estimate and summed for all three products researched. Column A indicates the impacts in the Ban scenario, and Column B shows estimated impacts under the No Ban scenario. Column C calculates the difference for the Ban over the No Ban scenario by subtracting column B from column A. Column D expresses the relative difference from the Ban scenario.

Table E-1: All products, impact estimates, central estimate, Net Present Value 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A - B)	Difference - % change from No Ban
Regulatory implementation cost	1.4	none	1.4	n/a
Business implementation cost	4.1	3.6	0.5	+14%
Sales	599.0	523.0	76.0	+15%
Revenues to UK manufacturing	18.9	16.5	2.5	+15%
Waste treatment cost	4.1	3.8	0.3	+8%
Local Authority Clean-up cost	3.1	3.2	-0.1	negligible
Cost to fishing industry	negligible	negligible	negligible	negligible
GVA	90.8	80.2	10.6	+13%
Value of traded CO_2e	1.1	1.2	-0.1	-12%
Value of non-traded CO_2e	0.4	0.4	negligible	negligible
Terrestrial litter visual disamenity	14.1	14.3	-0.2	negligible
Beach litter visual disamenity	0.1	0.3	-0.2	-53%

The estimated differences between each of the scenarios are modest overall or small in context. This is not surprising because the modelling (conservatively) assumes that voluntary change will take place in each of the markets irrespective of a ban – albeit less market change experienced over a longer period.

Sales and Gross Value Added (GVA) increase by £76 million and £10.6 million respectively in the modelling. This is primarily due to modelling of large paper-based straws market costing four times more than plastic straws (plastic straw 0.6p to 2.5p per paper unit). This factor dominates the overall impacts when the results are summed for all the types of researched products.

The impact on revenues to UK manufacturing are estimated to be small as most are imported goods. Comparatively small benefits are indicated for the waste, clean-up cost and litter-related costs when monetised although the disamenity costs associated with litter are likely to be greater following recent public interest. Extensive sensitivity analysis was conducted in the research which confirmed the costs of a ban would be likely to be modest. A potential lower and upper range for estimated costs and benefits is provided for each of the model's output in Appendix A.4. Appendix A.6 also provides a list of information gaps and further research to improve the rigour of the assessment.

Next steps

Further consultation on the details of a ban is recommended, especially for drinking straws due to a lack of immediately available suitable plastic-free alternatives in some parts of this market. The findings from this preliminary impact assessment research could be used as a basis for some of the discussions. In particular, longer lead-in times could be consulted upon and set individually for categories of straws where no equivalent plastic-free product has yet been identified. An extended grace period from a ban could provide the time necessary for some parts of the straws market to develop new plastic-free designs and alternatives. Setting such a challenge, with the cooperation of industry, could inspire innovation and enhance competitiveness. A ban for plastic drinking straws, stirrers and cotton buds could be coordinated with bans for other types of single-use plastic products.

In an interim period ahead of a ban, other extended producer responsibility measures could serve to reduce plastics use and their impacts. For example, national litter /do not flush campaigns could be developed and financed by producers. Voluntary action on straws and stirrers in the hospitality sector could help reduce plastics use (e.g. availability on request only, staff training to reduce default use).

1 Introduction

1.1 Research aims

Single use plastics, including plastic stem cotton buds, plastic drinking straws and plastic drinks stirrers, are associated with negative effects on the environment if they are littered or discarded incorrectly after their use. There are costs associated with their clean-up and externality costs imposed on the tourism and fishing industries from littering and the transfer of littered plastics into the environment. They can damage terrestrial and marine life and there is widespread and significant public concern regarding plastics and litter. Resources and greenhouse gas emissions are also associated with plastics production and disposal since they depend on finite fossil fuels.

Each of the UK devolved governments are presently considering a range of legislative and voluntary measures aimed at reducing the use of plastics. Department for Environment, Food and Rural Affairs (Defra) commissioned desk-based research to assess the qualitative and quantitative economic, environmental and social impacts of introducing a ban on plastic drinking straws, plastic stem cotton buds and drinks stirrers in England. It also required an indication of the costs of using alternative materials for the products. Specifically, the following was required:

- consideration of the impacts on business, covering both the domestic manufacturers of plastic straws and cotton buds and the businesses that either use, sell or wholesale import the products; and
- impacts on society, including cost of substitutes like paper straws/non-plastic stem cotton buds, as well as environmental benefits such as amenity impacts and societal effects, with possible exemptions for groups significantly and adversely affected by a ban.

The research took the form of an evidence review and preliminary impact assessment to include engagement of stakeholders and identification of any evidence gaps/uncertainties. The outputs of the research are intended to inform future discussion/direction around whether a potential ban would be advantageous. We understand that if, following the completion of this commission a ban was to be further advanced, the preliminary research would be followed by a full cost-benefit Business and Regulatory Impact Assessment.

1.2 Background to the research

The UK Government's 25-year Plan[4] and the EU Commission's Plastic Strategy[5] are determining a strategic direction for plastics use and its environmental impact. The 25-year plan has a specific target for eliminating 'avoidable' plastic waste by the end of 2042 and a target for significantly reducing, and where possible preventing, all kinds of marine plastic pollution. The Scottish Government is currently consulting on a legislative ban of plastic stem cotton buds[6] and considering action on a range of other plastic products[7]. Market change may be achieved voluntarily with the support of retailers and manufacturers (e.g. phasing out plastics commitments, plastic-free aisles etc.), or may require a policy intervention such as a

[4] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/673203/25-year-environment-plan.pdf
[5] http://europa.eu/rapid/press-release_IP-18-5_en.htm
[6] https://www.theguardian.com/uk-news/2018/jan/11/scotland-to-become-first-uk-ban-plastic-cotton-buds
[7] https://beta.gov.scot/publications/stemming-the-plastic-tide-ministers-statement/

ban or extended producer responsibility to bring about desired outcomes. The latest draft of the amended Waste Framework Directive – part of the 'Circular Economy Package' is noteworthy because it intends that producers finance more of the costs associated with operating and promoting waste collection, recycling and treatment systems[8]. A Deposit Return Scheme[9] for container packaging is presently being consulted upon by government aimed at reducing litter and increasing recycling.

Consumer interest in the environmental impacts associated with single use packaging has been spurred on by media coverage such as the BBC's Blue Planet II series, Daily Mail's Break the Habit, Turn the Tide on Plastic and the Stir-Crazy Campaign[10]. Regulation (a 5p levy) was introduced for single use supermarket carrier bags in Wales, Scotland and England and in 2016-17 it has been estimated that 83% fewer carrier bags were issued in England[11] compared with the figure for 2014. Indeed, new research on marine litter counts in UK seas has noted a reduction in the proportion of plastic bags by around 30%, potentially suggesting policies can affect the amount and distribution of certain marine litter items on short timescales[12] [13].

Following campaigns from pressure groups such as Switch the Stick and The Cotton Bud Project, the 10 largest retailers such as Tesco, Sainsbury's, Asda, Morrisons, Waitrose, Aldi, Boots, Superdrug amongst others have agreed to phase out the use of plastic stem buds[14]. Food service and hospitality sector brands such as Wetherspoons, Wagamama, Waitrose, Costa, Hotel De Vin, McDonalds, TGI Fridays and Pizza Express have also agreed to phase out or limit drinking straw or stirrer use and/or trial alternatives[15] [16] [17]. Pub chains are being encouraged to reduce plastic use by their trade body[18] and businesses in the events industry have recently made announcements to ban plastic straws[19]

In the wider context, China imposed a restriction on the import of contaminated post-consumer plastics in January 2018 which is significantly reducing waste plastics recycling opportunities. The Waste and Resources Action Programme (WRAP) and Ellen MacArthur Foundation (EMF) are working with businesses, local authorities and Non-Governmental Organisations (NGOs) on a new voluntary agreement, the UK Plastics Pact[20]. The aim is to create a circular economy for plastics and leading brands, retailers, manufacturers and trade associations have agreed to work towards targets, by 2025, to make 100% of packaging reusable, recyclable or compostable; to increase rates of plastic packaging recycling and composting; to increase recycled content and to eliminate problematic or unnecessary single use plastic by redesign, innovation or alternative delivery models.

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[8] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CONSIL:ST_6516_2018_INIT&from=EN
[9] https://www.gov.uk/government/news/deposit-return-scheme-in-fight-against-plastic
[10] http://www.recyclingwasteworld.co.uk/in-depth-article/building-on-the-stircrazy-campaign-to-ban-plastic-drinks-stirrers/173025/
[11] https://www.gov.uk/government/publications/carrier-bag-charge-summary-of-data-in-england/single-use-plastic-carrier-bags-charge-data-in-england-for-2016-to-2017
[12] http://www.bbc.co.uk/news/science-environment-43658739
[13] Maes et al. (2018), Below the surface: Twenty-five years of seafloor litter monitoring in coastal seas of North West Europe (1992–2017), https://bit.ly/2JMmfVk
[14] Personal correspondence – Alice Ellison, British Retail Consortium – March 2018
[15] https://www.edie.net/news/5/McDonald-s-unveils-plan-to-phase-out-plastic-straws/?utm_source=dailynewsletter,%20edie%20daily%20newsletter&utm_medium=email,%20email&utm_content=news&utm_campaign=dailynewsletter,%207a8cf94727-dailynewsletter
[16] https://www.edie.net/news /5/Waitrose-builds-on-plastics-pledge-by-banning-plastic-straws-in-cafes/?utm_source=dailynewsletter,%20edie%20daily%20newsletter&utm_medium=email,%20email&utm_content=news&utm_campaign=dailynewsletter,%20d3917c4867-dailynewsletter
[17] http://www.bbc.co.uk/news/newsbeat-43567958
[18] http://barmagazine.co.uk/leading-trade-body-backs-moves-ban-plastic-straws/
[19] https://www.edie.net/news/5/Wimbledon-announces-ban-on-plastic-straws-for-2018-event/?utm_source=dailynewsletter,%20edie%20daily%20newsletter&utm_medium=email,%20email&utm_content=news&utm_campaign=dailynewsletter,%2063ad21ad1b-dailynewsletter
[20] http://www.wrap.org.uk/content/the-uk-plastics-pact

1.3 Market failure and the case for intervention

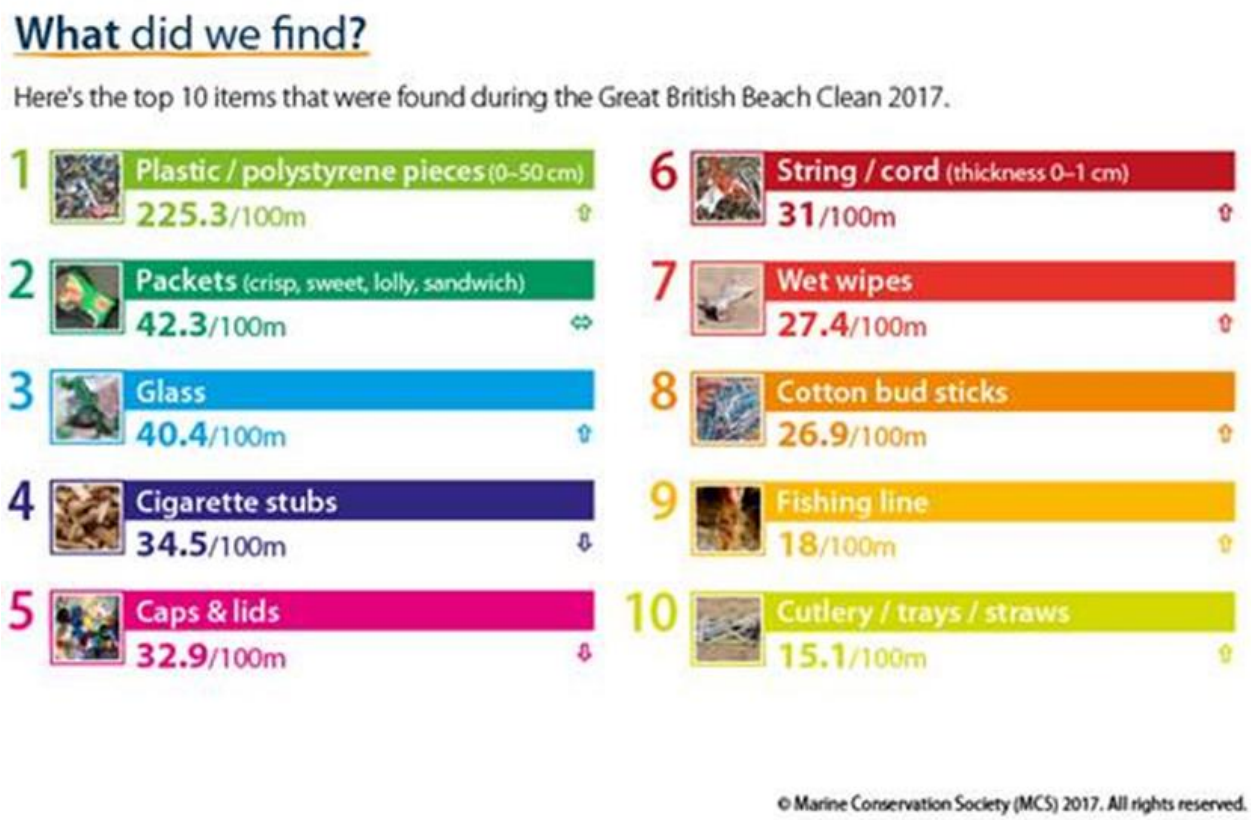
1.3.1 Littering and the environment

When plastic items are littered on land, or are flushed into a toilet, pathways facilitate the transit of the littered items into to the marine environment via the sewage system. During rainstorms sewers are overwhelmed and discharge directly into rivers and the sea. Pre-treatment screens in sewage treatment plants are too coarse to capture items such as cotton buds, which float and travel in line with the direction of flow and therefore either pass through the screens or are discharged in outflows from treatment plants. Plastic items that are discharged do not biodegrade and therefore accumulate in the marine environment. It has been estimated that 1.5-4 % of all global plastics production ends up in the oceans every year. These items may be ingested by marine life (with potential knock-on effects further up the food chain), captured as marine debris in fishing equipment, washed up on beaches or any combination of the above.

Plastics are thought to represent 50-80% of shoreline debris[21]. Table 2 presents an excerpt of the findings of the Marine Conservation Society's Great British Beach Clean undertaken in 2017[22]. It shows cotton bud sticks to be the 8th most frequently counted litter item and straws/cutlery as the 10th.

[21] ISWA (2017) PREVENT MARINE PLASTIC LITTER - NOW!, ISWA Marine Task Force. http://marinelitter.iswa.org/marine-task-force-report-2017
[22] http://www.keepbritaintidy.org/get-involved/support-our-campaigns/great-british-spring-clean

Table 2: Marine litter items collected during the Great British Beach Clean 2017 (by item count)



The quantitative cost of this litter is not known with certainty. The direct costs of marine litter to EU fisheries has been estimated at 1 % of the total revenue realised from catches by the EU fleet[23]. Meanwhile, the annual street cleaning cost to UK local government in 2015/16 was £778m, a proportion of which are attributable to plastics litter. The direct and indirect cost of all impacts from discarded plastic – which includes the plastic stemmed cotton buds, straws and drinks stirrers which would be the subject of the proposed ban – is discussed in more detail in Appendix A.3, where the range of impacts that this kind of litter can have, and the range of associated costs is explored. Regardless of any monetised cost estimate, the qualitative impact on the environment and on the well-being of people is rising as more people become aware of the issue. The Government's Litter Strategy for England quotes a Populus poll from 2015 which found that 81% of people are angry and frustrated by the amount of litter[24]; two years' later, the multi-award-winning documentary series Blue Planet II was broadcast, becoming the most watched TV show of the year[25] and putting the issue of marine litter front and centre in the minds of millions across the general population.

The negative effects and costs of plastics on marine food supply and associated costs of littering, clean up and waste disposal costs are not incorporated in the price of plastic products. Moreover, adverse effects on the economy from whatever source (e.g. loss of productivity caused by interference with fishing boats and gear, negative impacts on consumer confidence in fish and seafood, sewage treatment costs from

[23] European Commission (2018) A European Strategy for Plastics in a Circular Economy. http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52018DC0028&from=EN
[24] https://www.gov.uk/government/publications/litter-strategy-for-england
[25] http://www.radiotimes.com/news/tv/2018-01-11/most-watched-tv-shows-2017/

blockages and flooding, negative impacts on the tourism sector, road traffic accidents, reduced property investment due to visual disamenity, use of finite resources etc.) are similarly not reflected in the prices of plastic products. All of this results in negative externalities as the environmental impact created by the polluters (essentially, those responsible for disposing of the litter into the environment) becomes a cost for public organisations, firms and individuals elsewhere.

Consumers are not incentivised to limit the use and disposal of their plastics and manage them effectively to an acceptable level. The market, left to its own devices, is failing to deliver an efficient outcome. Consequently, an intervention can be justified to address the market failure – to protect the environment, food supply, tourism and other economic sectors from further pollution, and to foster an increased degree of consumer confidence that the products they buy will not harm wildlife and the environment. Intervention in the market would also help those businesses which have already acted to address the damage being done, by establishing a level playing field which will ensure that all businesses, including small businesses, budget retailers, online retailers and those handling imported products carry their share of the cost.

1.3.2 Interventions on plastics use

Suitable non-plastic alternatives made from paper, wood and bio-based plastics are already present in the market for certain products. Furthermore, consumption of these products may be avoidable and not be necessary altogether. For example, pubs and restaurants can restrict use of straws unless requested and coffee shops can provide reusable stirrers and innovative drinks cup designs with drink-through lids which avoid straw use etc. Products that are specifically designed for reuse are increasingly available.

Legislative bans can help convert attitudes and well-meaning intentions into lasting behaviours. An intervention in the market in some shape or form could reduce growth in the overall marine litter load whilst stimulating innovation and efficiencies among businesses.

Legislative bans on the use of plastic microbeads in cosmetics in England and Scotland were passed in January 2018 and a complete ban will come into force in July 2018[26]. HM Treasury has recently issued a call for evidence on using the tax system or charges to address single-use plastic waste[27] and HM Government has recently rejected a levy on hot drinks containers in favour of voluntary retailer action[28]. Most notably, the Scottish Government has announced plans to ban the manufacture and sale of plastic stem cotton buds specifically[29]. The Scottish Government has convened an expert panel to provide advice on action to help reduce use of single use items[30]. A list of products for action was given in the announcement as:

- wet wipes
- plastic cotton bud stems
- drinks containers
- packaging from crisps, sandwiches and sweets
- bottle caps

[26] https://www.legislation.gov.uk/uksi/2017/1312/contents/made and http://www.gov.scot/Resource/0052/00529672.pdf
[27] https://www.gov.uk/government/consultations/tackling-the-plastic-problem
[28] https://ciwm-journal.co.uk/government-rejects-latte-levy-favour-voluntary-action/
[29] http://www.bbc.co.uk/news/uk-scotland-42640680
[30] https://beta.gov.scot/publications/stemming-the-plastic-tide-ministers-statement/

- and other plastic in the form of large items and small fragments (including plastic straws and disposable cups)

The panel is also considering which groups may be affected by the action and specifically includes an adviser on the potential implications for disabled people of the group's proposals[31].

Very recently, the Welsh Government has said it would welcome collaboration with the UK government on the idea of a ban on plastic straws[32] and Commonwealth leaders have agreed a package of research funding to help countries stop plastic waste from entering the oceans across the world[33].

2 Methodology

Resource Futures undertook the research for Defra between March and April 2018. The overall research approach that was taken was:

1. Initial information gathering - evidence review and stakeholder engagement
2. Development of an impact model
3. Further information gathering and stakeholder interviews
4. Refinement of the impact model and sensitivity analysis to understand uncertainties
5. Reporting of findings and discussion

2.1 Initial information gathering – evidence review

A desk-based review of relevant information available in the public domain was undertaken. This focussed on the following:

- Market research for each of the product types - The contents of market research reports such as Euromonitor and QY research and data sources such as UN Comtrade trade data were examined for data on annual sales and sector value. In each case, detailed data was not found to be available at the individual granular product level or specifically for England, so example data and assumptions were used. Other literature such as market turnover information and reports from marine litter NGOs was also examined. Where UK-wide estimates were identified, these were triangulated with data from multiple sources, sense-checked and made representative for England by an allocation by population. To resolve data gaps, 'bottom up' estimates were made following discussions with trade associations and manufacturers and information gleaned during the research about the market and potential consumer behaviours.
- Product supply chains - A sample of leading UK retailers, manufacturers and trade associations were interviewed regarding the current supply and future market. The mapping of the supply chains for the products specifically for England was not possible in the timescales of the research.
- Treatment of each product at 'end of life' - To understand potential pathways and the arising, recycling and disposal behaviours and costs, behavioural research on littering in the terrestrial and marine litter environment was examined, together with outputs from stakeholder discussions.

[31] https://www.holyrood.com/articles/news/disability-adviser-kate-sang-recruited-expert-panel-single-use-plastics
[32] http://www.bbc.co.uk/news/uk-wales-politics-43825384
[33] https://www.gov.uk/government/news/commonwealth-unites-to-end-scourge-of-plastic

- Non-plastic product alternatives - Through stakeholder discussions and online searches, example plastic products alternatives were identified for the purposes of comparing plastic and plastic-free products in the research. Example materials weights and typical unit prices and weights were compiled from online research and contacts with relevant stakeholders.
- Compilation of impact factors - Data on Gross Value Added (GVA) was compiled from ONS. Greenhouse gas impacts were compiled for production and end of life impacts of materials and a wide body of literature was examined on the disamenity impacts associated with terrestrial and marine litter (disamenity cost is an umbrella measure which can be used to represent a range of societal costs (e.g. wellbeing, health, ingestion/entanglement of wildlife etc.).
- Opportunities and interventions - Online research was undertaken on government consultation regarding plastic-free alternatives and the latest retailer/brand commitments. Regulatory impact assessments associated with recent bans on the use of microbeads in cosmetics and the levy on plastic carrier bags were also examined.

2.2 Information gathering – stakeholder engagement

Telephone interviews with a selection of stakeholders were undertaken. Table 1 and Table 2 list the interviews that were conducted plus other contributors, showing the range of stakeholders engaged. Contacts with further trade associations, retailers and manufacturing businesses were also made, but these did not engage within the project timescales. A topic guide was adapted to guide each interview and encourage consistency. This generally covered the organisation's interest in the subject, commitments to avoid plastics use to date, opinion on the impact and timing of the ban, the evidence-base/significant gaps including any unintended consequences of a ban and further contacts for interviews.

Table 1: Interviews undertaken during the research

Organisation name	Type	Interviewee
British Retail Consortium	Trade Association - Retail	Alice Ellison - Environment Policy Adviser
John Lewis Partnership	Retailer	Ben Thomas - Sustainability Manager
Anonymous	Large Drinks Producer	Anonymous
Plastico	Manufacturer/Wholesaler - Food service products	John Reeves - Head of European Sales
Anonymous	Carton producer	Anonymous
Anonymous	Foodservice packaging manufacturer	Anonymous
Foodservice Packaging Association (FPA)	Trade Association - Food packaging	Martin Kersh – Executive Director
UK Hospitality	Trade Association - Pubs, Restaurants	David Sheen - Director of Policy & Research
Alliance for Beverage Cartons and the Environment (ACE)	Trade Association - Carton recycling	Richard Hands - CEO
Fidra	Environmental charity	Sarah Archer - Senior Projects Manager
Marine Conservation Society	NGO/Charity - Marine environment	Laura Foster – Head of clean seas

Organisation name	Type	Interviewee
City to Sea	NGO/Charity - Marine environment	Michelle Cassar – Creative Director
One in Five	NGO - Disabled groups	Jamie Szymkowiak - Campaigner
Scottish Government	Government	Colin MacBean - Head of Zero Waste
Behavioural insights Team	Government/Social Purpose Company	Toby Park - Strategic Behavioural Insights
Defra - Marine economics	Government	Marilena Pollicino - Marine Economist

Table 2: Other contributors to the research (by correspondence)

Organisation name	Type
Defra - Policy	Government
Defra - Economics	Government
Defra - Statistics	Government
Office of National Statistics (ONS)	Government
Ecosurety	Producer responsibility compliance organisation
Water UK	Trade Association - Water Utility
Scottish Water	Water Utility
Seoil	Wholesaler - Food service products
WRAP	NGO

2.3 Overview of the impact model

An impact model was developed to provide a preliminary indication of the quantitative impacts (financial, environmental and social costs and benefits) of two scenarios. A bespoke product demand model was developed in MS Excel and this projected forward plastic and plastic-free product sales over an extended period. Two scenarios were modelled and compared:

The two scenarios that were compared were:

- No Ban: Under this scenario the Government would continue to support current voluntary action from leading retailers and manufacturers aimed at replacing plastic-based products with non-plastic alternatives, though other retailers and manufacturers could still produce and sell plastic-based products if they wished to do so. This 'do nothing' scenario does not consider the impact of potential initiatives which may or may not come to fruition in future e.g. fiscal measures for reducing the use of single use plastics proposed by HM Treasury and further targets under WRAP's Plastic Pact/Courtauld Commitment.
- Ban. Under this scenario a legislative ban on plastic stem cotton buds, plastic drinks stirrers and plastic straws would be introduced. This would have the effect of avoiding the use of such products and substituting plastics for benign alternatives. Under this option, a non-universal ban would be

introduced, including exemptions for certain categories of products where specific groups would be significantly and adversely affected, and alternatives cannot be identified.

In each scenario, the market share of a 'typical' plastic product relative to the share of alternative plastic-free items was estimated. Unit product sales were approximated, and example retail sales value and product weights were used to estimate a baseline (for 2018) and forecast the impact on production and sales for each product type each year over a 10-year period (from 2019). Baseline data and assumptions were prepared to populate each scenario with data estimates. These were informed by the evidence review and the stakeholder interviews, wherever possible.

A traffic light scheme was used in the model to provide an indication of how representative each data point was, with sources and assumptions taken for any data gaps.

Where possible, each impact was monetised, summed and discounted according to HM Treasury's Green Book[34]. For example, costs were kept at constant prices applying the standard Treasury discount rate of 3.5%. Transfers of resources between people (e.g. gifts, taxes, grants, subsidies or social security payments) were excluded from the analysis. Transfers pass purchasing power from one person to another and do not involve the consumption of resources or make society better or worse off as a whole, hence their exclusion. Since VAT collection and payments are entirely of a distributional nature, and values are relatively modest, VAT was a key transfer excluded from the assessment.

A central estimate for the impacts of the Ban relative to the No Ban scenario was calculated using the impact model. Sensitivity analysis was undertaken to investigate the significance of data uncertainties and assumptions. This provided a range (lower and upper impact values) from the central estimate.

A detailed description of the model and the data used within it are described in Appendix A.1 and Appendix A.2.

Resource Futures' and Defra's economists were engaged in the model's development, including a walk-through and internal review of the model's structure and functionality midway through the research and at the initial results stage.

3 Findings

3.1 The market for each product

This section presents information regarding each product and how it is supplied, used and disposed of.

[34] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

3.1.1 Cotton buds

Figure 1: Plastic stem cotton buds

Cotton buds are single-use products used in the home for hygiene purposes such as ear cleaning, first aid and makeup application and arts and crafts. Plastic stem cotton buds have a polypropylene straw stem and use a plastic-based adhesive to attach a small ball (bud) of cotton wool to each end of the stem.

Plastic-free alternatives already exist in the market (the US market is dominated by Q-TIP cotton swabs with paper-based stems). Such alternatives are now sold across Europe, with the dominant brand manufacturer, Johnson and Johnson, now manufacturing paper-based buds in mainland Europe and a leading own brand retailer (Sainsbury's) now offering a plastic-free adhesive[35].

A global market research report lists the top 10 global manufacturers of cotton buds as having their main manufacturing base outside England (predominantly located in South-East and Southern Asia)[36]. The retail market is overwhelmingly dominated by own brand products from the main retailers Tesco, Sainsbury, Asda and WM Morrison, with Johnson and Johnson the leading non-supermarket brand (<5% by value)[37]. Health and beauty retailers such as Boots and Superdrug also have significant market share.

Detailed product sales information was not available for England, so estimates were made based on a range of sources. The British Retail Consortium (BRC) has estimated that the voluntary commitment by the main 10 high street retailers could remove over 2 billion plastic cotton bud stems from the market in the UK each

[35] https://www.about.sainsburys.co.uk/news/latest-news/2017/22-02-2017
[36] Global Cotton Bud Market Research Report 2018
By Players, Type and Applications, Status and Forecast, 2013-2025 https://www.orianresearch.com/report/global-cotton-bud-market-research-report-2018/463369
[37] Euromonitor (2017) COUNTRY REPORT - COTTON WOOL/BUDS/PADS IN UNITED KINGDOM Example data http://www.euromonitor.com/cotton-wool-buds-pads-in-the-united-kingdom/report

year[38]. Waitrose has estimated that removing plastics from their cotton buds could save 21 tonnes of plastics per year[39].

A limited evidence base was available regarding how cotton buds are purchased, used and and disposed of in the home. Evidence from Ireland suggests 26% of 1000 respondents had flushed cotton buds down the toilet[40]. Evidence from Norway indicates that ~10% flush buds down their toilets[41] and a UK-based study said 6% flushed buds down the toilet in the last 3 years. A survey by Anglian water revealed cotton buds are 'commonly flushed items' (see Figure 2). A World Wildlife Fund (WWF) study recently estimated UK litter rates for different types of terrestrial and marine litter (including cotton buds with a litter rate of 13.5%) although the ultimate source was not published at the time of writing[42].

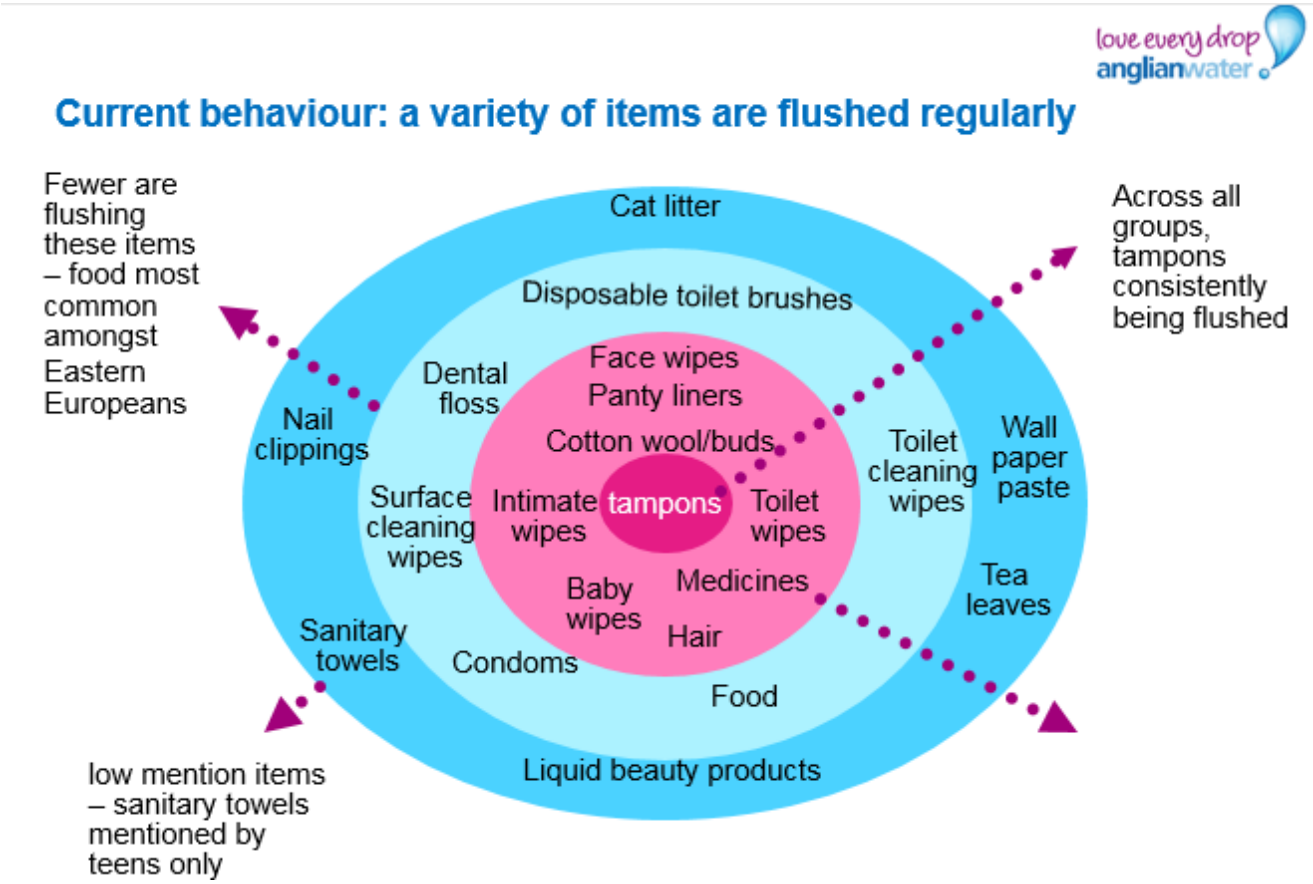


Figure 2: Frequently flushed items/behaviours[43]

From the research, 1.8 billion individual cotton buds were estimated to be used in England each year in the modelling. The modelling assumed 90% of buds are used in bathrooms, 10% of these are flushed, and 90% of these pass through water treatment facilities, so that 8.1% of all buds are estimated to enter the marine

[38] Personal correspondence - Alice Ellison, BRC, 23 March 2018
[39] https://www.businessgreen.com/bg/news/3005084/waitrose-to-roll-out-biodegradable-cotton-buds-to-cut-plastic-pollution
[40] http://thinkbeforeyouflush.org/media/press-releases/
[41] https://www.cottonbudproject.org.uk/news/item/46-keep-norway-beautiful-cotton-bud-cartoon.html
[42] www.wwf.org.uk/sites/default/files/2018-03/WWF_Plastics_Consumption_Report_Final.pdf
[43] Personal correspondence, Clare Pillinger, Anglian Water, 10-04-18

environment. Because buds are small and generally used in domestic bathrooms (and bedrooms), for the purpose of the modelling they are assumed to be disposed of to residual waste with no recycling.

Regarding the sales price of each product, online research revealed a range of prices for both the plastic product and a paper-based alternative. Prices for both were found to be similar. So for the central estimate of impacts, identical costs were taken to represent both types of products with a single unit price of 0.5 pence. A record of data and assumptions for each of the products is provided Appendix A.2.

3.1.2 Drinking straws

Figure 3: Drinking straws

Disposable plastic drinking straws can be rigid or flexible in nature, plain or coloured and may come wrapped in film for hygiene purposes. An array of straws is produced for both domestic and commercial uses[44]. The majority come in two sizes – 'large drinking straws' to suit drinks glasses/cups and 'small beverage carton straws' to suit small soft drinks cartons or juice pouches. Most are bought business-to-business and supplied to restaurants, pubs, hotels, retail and schools. A minority proportion of the large straw market is business-to-consumer and online sales (for home use/parties). In addition to large disposable drinking straws, reusable and durable straws are also sold (cocktail straws, refillable sports drinks bottles, reusable non-plastic straws). 'Plastic medical-enabling straws' are used to administer (durably and safely) pre-dosed granular medicines in hospitals and homes and flexible plastic straws are used to assist/enable drinks and liquid food consumption in older adults and disabled groups with specific needs.

[44] http://www.seoil.co.uk/products.htm

Discussions with trade associations and manufacturers during the resarch indicated that the market for large drinking straws in England is dominated by wholesalers supplying imported drinking straws to the hospitality sector. Another market for straws is small beverage carton producers. It was not clear what proportion of these types of straws are manufactured in England. Our assumption is that whilst cartons are filled in this country, food service suppliers do not have a significant manufacturing base for small beverage cartin plastic straws in England.

Plastic straws are typically made of polypropylene, with other types of plastic used in minority markets e.g. for medical-enabling uses. Plastic-free single-use alternatives already exist in the market for some types of products. For example, paper-based straws are available for certain types of drinking straws, and these can be laminated to improve their strength or be made thicker and heavier weight. A developing market for single-use bioplastic straws made of bio-based materials such as polylactic acid (PLA) is present and these items are being sold to some sectors of the catering sector. Multi-use metal, glass, bamboo and silicone straws are also being offered to the market as reusable alternatives, primarily for use in the home. In the small beverage cartons/juice pouches market, rigid plastic polypropylene straws are dominant. They are used to pierce a plastic film to access the drink.

It was not possible to obtain a detailed estimate for the large drinking straws used in the hospitality sector within the timescales of this research since this sector is extremely diverse. 4.5 billion straws (large drinking straws) have been estimated to be used each year in the UK for the fast food sector[45] . This figure was extrapolated and used as the basis for the central estimate in the model (3.5 billion straws per year in England). It is felt this most likely represents the majority of drinking straws consumed in the hospitality sector. The impacts of this estimate on the model outputs was varied in sensitivity analysis in the modelling (reduced and doubled) to account for uncertainty in this value – see Appendix A.3 and Section 3.7 for further details). A beverage carton producer interviewed in the research estimated that between 1-1.5 billion straws were used in small beverage cartons/pouches in the UK per year. For straws used for medicine and flexible straws used by disabled groups, a ‘bottom up’ estimate of 44 million straws was achieved based on 1% of the English over 65s population and those with manual dexterity disabilities and Parkinson’s disease. Each requiring one straw every day. These types of products were modelled as exempted from the Ban.

Straws are commonly used indoors or outdoors. In terms of waste and recycling behaviours, our assumption for the research is that because straws are lightweight and predominantly used in resturants, pubs, fast food outlets, schools or workplaces, or at parties, they are typically discarded to general waste rather than recycled due to the effort required to segregate and clean them and to sort at recovery facilities. An assumption is used that 0.01% of items placed on market become marine litter. This is based on the ones which are terrestrially littered, not cleaned up and finally find their way into combined sewers and watercourses and the sea.

Regarding the sales price of each product, online research revealed a range of prices for both plastic product and paper-based plastic-free alternatives. Interviewees did not provide specific prices. For the central estimate, a single unit price of 0.65 pence was for large plastic drinking straws (including VAT) and 2.5 pence for large paper drinking straws. An assumed price of 0.065 pence for plastic beverage carton

[45] http://www.bbc.co.uk/news/science-environment-43825197

straws (a tenth of the price of a large straw) and 0.25 pence for paper-based beverage carton straws. A record of data and assumptions for each of the products is provided in Appendix A.2.

3.1.3 Drinks stirrers

Figure 4: Plastic drinks stirrer

Stirrers are rigid single-use products used to help sugar dissolve into hot drinks or to mix drinks. Like straws, the predominant market for stirrers is the hospitality sector and this largely appears to be supplied from outside the UK by importing wholesalers.

Stirrers are typically used indoors. They are simple in design, lightweight and made of polystyrene. The alternative material for single-use drinks stirrers tends to be wood. Metal teaspoons in cafes are also an alternative but are not as widespread due to perceptions over hygiene, time to wash and outdatedness.

A small market exists for decorated party cocktail stirrers. These may be used in pubs, clubs and restaurants, or in the home and are heavier in weight and more reusable. A few plastic-free alternatives for cocktail stirrers exist which tend to be made from glass.

For the modelling, a bottom-up estimate was calculated of 202 million items sold each year, based on 10% of the estimated annual single-use takeaway coffee/tea cup sales requiring a stirrer [46]. This estimate is representative of single use drinks stirrers only and does not include reusable cocktail stirrers used in pubs and homes.

As with straws, in terms of waste and recycling behaviours it is assumed that stirrers are wasted rather than being recycled due to the effort required to segregate and clean them. Only a fraction of stirrers are used

[46] 2.5 billion coffee cups each year in UK http://www.independent.co.uk/news/business/latte-levy-government-rejects-25p-charge-disposable-coffee-cups-starbucks-costa-nero-pret-a-manger-a8247201.html

outdoors, littered and not street cleansed so we have assumed that 0.001% of stirrers used will eventually become marine litter.

Regarding the sales price of each product, prices for both were found to be similar/non-distinguishable. Price parity was assumed with a unit price of 0.5 pence. A record of data and assumptions for each of the products is provided Appendix A.2.

3.2 Stakeholder consultation findings

A summary of the findings/sentiment from interviews and correspondence with stakeholders is provided in this subsection. Comments are summarised and categorised by overall context, key findings, economic, environmental and social impacts.

3.2.1 Overall context

Section 1.1 provided the most recent announcements and commitments made by stakeholders to reduce plastics use in these products and markets. The products examined in this research are all straw-like items. They are especially evocative marine litter items because they have been seen in the media to impact marine species such as turtles and sea horses. They are prevalent in litter and their shape and colour makes them especially recognisable on beaches.

In the last 5 years NGOs began engaging with business and government regarding these types of items (and others) and recent media interest and NGO-led consumer campaigns have promoted action, leading to announcements from leading businesses to reduce or eliminate their use of plastics in these products.

The recent microbead bans in England and Scotland were cited by some stakeholders as a precedent for a proposed ban on further plastic products.

3.2.2 Key findings

Discussions with a sample of stakeholders revealed:

- Near universal support for a ban on plastic stem cotton buds among the UK's largest leading retailers (16 of the 17 main UK retailers were now thought to have pledged to 'Switch the Stick'). It was apparent that NGOs, the water industry and the BRC have all affected voluntary commitments with leading players in this market. In an interview with the BRC, a ban was described as 'helpful to level the playing field' and the BRC said they would tacitly support a ban by not opposing it.
- Widespread support, from stakeholders interviewed, appears to exist for action on plastic straws and stirrers. Announcements have very recently been made by individual organisations in the hospitality sector regarding large drinking straws. So far, these have been a little more cautious than the cotton bud announcements; including promises to reduce plastics use, trial alternatives and eliminate at events, rather than definitively switch within defined timescales. Rather than a ban, the leading hospitality sector trade associations engaged in the research highlighted the potential value of voluntary approaches (e.g. reduction through making products less available at the food service counter and retail sales counter).
- The end markets for buds and straw/stirrer products are fundamentally different. Buds are business-to-consumer (B2C) sold products which are used in the home and littered via sewerage. In contrast, straws and stirrers are a much more varied product category predominantly sold

business-to-business (B2B) but are used indoors and littered terrestrially if they are taken away from premises.

- The buds market is dominated by a small group of leading retailers and manufacturers (from examination of data it appears likely over 95% of retail sales are associated with the largest retailers[47 48]). Whereas straws and stirrers are used in a range of businesses and at home. For instance, for beverage carton straws approximately 1/3 market is 'high street' brands, 1/3 'incidental' at garages/hospitals and 1/3 'independent'.

3.2.3 Economic impacts

Regarding economic impacts the discussions revealed:

- For these products, the plastics market is highly commoditised and produces high volume, low cost products. These are predominantly manufactured outside the UK to reduce labour costs associated with their production.
- Plastic-free products are available for some of the products examined in the research. These could be supplied by existing suppliers, with low transition costs expected and comparatively short timescales to increase production. For buds there appears to be approximate price parity for plastic and non-plastic items. For straws and stirrers, the products and their alternatives vary in price. Key players reported that plastic-free alternatives were 20%-500% costlier for B2B, double or more for B2C paper and bioplastic straws and reasoned they would remain more expensive until production is increased, and economies of scale are reached. From a small sample of prices, our research identified that paper-based straws were around four times more expensive than plastic.
- It was felt by a high street retailer that any difference in costs would be unlikely to significantly impact sales and profit and the consumer would be willing to pay the extra. However, it is not clear what effect an increase in sale price would have on demand. Most respondents felt costs would be likely passed to consumers and these would go unnoticed (a few pence in the price of a drink, or a pack of large party straws etc.) and that even buyers in large hospitality businesses would not regard it as a significant cost, relative to other costs. There was some recognition that demand could be affected by consumer pressure (i.e. stirrers or straws might be stored under the counter and made available on request).
- For some types of products (e.g. small beverage carton straws, large flexible drinking straws) it was felt by some stakeholders that plastic-free alternatives are functionally inferior/unsuitable at present. Some respondents stated paper-based alternatives were weaker and less capable of being used in hot drinks and could not be used by disabled and elderly groups (i.e. older adults and disable individuals with reduced motor function and those with severe Parkinson's disease, Cerebral palsy). If a universal ban were imposed these groups would be significantly affected, being inconvenienced and being concerned about availability.

3.2.4 Environmental impacts

Regarding environmental impacts the discussions revealed:

[47] UK Business Counts - enterprises by industry and turnover size band https://www.nomisweb.co.uk/
[48] https://www.retaileconomics.co.uk/top10-retailers.asp and https://www.retaileconomics.co.uk/top10-retailers-list.asp

- A clear awareness of the issue of marine litter among stakeholders, including established trials and long-term research programmes to identify plastic-free products/design alternatives.
- An awareness that bio-based compostable products could have advantages in both supply and disposal if they are sustainably produced and do not displace food production or forests which themselves fix carbon and reduce global warming. That in catering contexts, food-contaminated bioplastics can be collected and composted in specialist commercial in-vessel composting facilities.
- Concern that large paper-based straw alternatives will be heavier, and that this additional material and the production burden associated with producing, distributing and retailing more material may contribute more to climate change.
- Concerns some retail, supplier and trade association stakeholders that some bio-based products may not be sustainably produced from sustainable biomass sources and some bioplastics can have issues on disposal if they are not separately collected and treated i.e. that they are not compatible with conventional plastics recycling and require centralised and specialised high temperature composting at end of life. It was also noted that some conventional plastics packaging products are a serious source of contamination for commercial composting facilities.
- Concern that a plastic straw ban for small beverage cartons could lead to unintended consequences because there are currently no functionally equivalent alternatives. A ban could lead to more plastic and glass bottles used to supply drinks, resulting in increased climate change impact and other safety concerns. Banning of straws could also lead to more product spillages from cartons. Plastic-free/strawless designs for beverage carton straws are being developed but commercial availability will take time.
- Collection and recycling systems for products such as cartons and plastic food service products are being developed and promoted. There are issues with the costs and quality of the recycling that can be achieved. Multi-material products are inherently difficult to recycle, and takeback systems are costly. Due to contamination and food safety legal requirements, open loop recycling can have lower environmental value with recyclate is being sent to low-grade alternative markets.
- Non-plastic products may fare no better in terms of recycling depending on customer perception/willingness to recycle small items, but they would be likely to be benign in their disposal if they were littered.

3.2.5 Social impacts

Regarding social impacts the discussions revealed:

- Acute awareness of marine litter and damage to wildlife amongst businesses, organisations and individuals interviewed.
- A ban on large flexible plastic straws could have disutility impacts for disabled groups because they would not be able to consume drinks outdoors without having to bring their own costlier (at point of purchase) reusable straws. Bans would make life more difficult to live independently (disutility) and could impose additional cost for reusable alternatives at the point of purchase.
- Simple behavioural changes across the hospitality sector (staff and customers) could result in significant avoided plastic e.g. through behind counter/on request/avoidance of default service provision/use of reusable items.

- A market exists for large reusable cocktail/party straws and stirrers made from plastics. There is a risk that government could be seen to be restricting fun, frivolous behaviours under a ban
- Potential health and safety concerns caused by a ban on straws – more broken glass litter, effects on dental health [albeit the recent sugar tax could mitigate this risk].
- Need for improved messaging to consumers regards prevention, recycling, disposal and littering behaviours through campaigns and on-pack labelling[49] e.g. water industry-inspired 'do not flush' campaigns and labelling to indicate that plastic straws can be pushed 'back in the pack' within small beverage cartons and subsequently recycled with the carton.

3.2.6 Lead time/implementation risks

Regarding the lead-in time required for a ban the research revealed:

- A ban on plastic stem cotton buds could be readily achieved, affecting most of the market within short timescales.
- That suitable plastic-free alternatives for certain drinking straw types are not presently available in the marketplace (see previous). A universal plastic drinking straws ban in the short term would not be supported by industry. Exemptions from bans are likely to be required.
- Longer lead time for some types of straws were appealed for. For example, for large drinking straws used in fast-food restaurants, due to the volume, logistics and scaling up of manufacturing to source alternatives at scale. For small beverage carton straws, concerns were raised over the suitability of plastic-free straw alternatives. It is understood that product research is taking place in the sector which could reduce small carton beverage straws through changes in packaging design, but a lead-in time of years is expected to complete the research, manufacture, trial and commercialise alternatives.

Specifically, the following implementation risks were identified:

- A risk of additional costs and legal challenge for certain essential products used in medical contexts if a plastic ban was imposed.
- A risk of media/legal challenge if certain enabling products are not exempted from the ban. NGOs/campaigners have already expressed concerns[50] and could challenge a ban on large flexible plastic straws (of which there may well be no equivalent alternatives) as unfair under the Disability and Discrimination Act 1995 and Equality Act 2010. There is also a risk of personal litigation claims if rigid non-plastic alternatives were demanded and these straws were choked upon.
- Some risk (partly dependent on outcome of Brexit negotiations) exists that manufacturers could challenge a ban based on the free movement of goods within the EU. For example, Pack2Go, an organisation representing European packaging manufacturers, threatened a challenge against the French Government after it passed a law in 2016 banning disposable plastic plates, cutlery and cups[51].
- A risk of media/legal challenge if fun/frivolous party products are not exempted. There is a risk vibrant reusable plastic 'cocktail' straws and stirrers which could be challenged in the press or under anti-trade/competition law if no functionally equivalent non-plastic alternative exists.
- Risk of illegal activity and border effects if such bans not applied right across the UK.

[49] http://www.oprl.org.uk/get-involved/sign-up-to-the-scheme/
[50] http://www.bbc.co.uk/news/uk-scotland-43076495
[51] https://resource.co/article/france-could-face-legal-action-over-disposable-plates-and-cutlery-ban-11387

3.3 Descriptions of the scenarios modelled

Following stakeholder discussions, further qualitative and quantitative analysis was undertaken to understand the potential magnitude of the impacts. Implementation/market change profiles for the Ban and No Ban scenarios were represented in the impact model for this. These were informed by the discussions with stakeholders. The scenarios are described in detail in this subsection.

3.3.1 Ban scenario: legislative ban

This scenario represents the anticipated change under a ban in the markets for plastic stem cotton buds and most types of plastic straws and stirrers.

- For the central estimate for cotton buds a shift from 80% plastic product to a minimum of 1% is represented, with the share reducing by 50 percentage points in year 1 and in subsequent years to the base share in two years. The main difference between the Ban and No Ban scenario for cotton buds is therefore only in the speed at which plastic cotton buds are substituted for alternative products.
- For the central estimate, plastic stirrers and small beverage carton straws shift from a market share of 50% and 95% respectively to a 1% minimum market share, with reduction in the plastics share reducing linearly by 20 percentage points each year. The difference between Ban and No Ban options is the speed at which plastics are phased out and a greater market share affected by the ban.
- Large drinking straws shift from 95% plastic market share to 1%, reducing by 26 percentage points each year, again reflecting public and commercial interest in the product and the market readiness of the paper-based alternative for most applications. A ban will be more visible to the market and hence it will be more successful in changing the market than a voluntary approach.
- In the Ban scenario, product sales growth flatlines at 0.0% per annum. This represents stabilisation of the overall sales per year over population growth (in effect of 0.6% p.a. reduction in sales growth rate). This is a 0.3% p.a. reduction on the voluntary approach due to the signalling effect to the market of a ban.
- A proportion of the drinking straws market were exempted from the Ban (for medical and disabled persons needs needs) and was modelled as remaining plastic over the period.

3.3.2 No Ban scenario: voluntary change/do nothing

This scenario represents the anticipated change in the buds and straws/stirrers' markets in the absence of a policy intervention. In this scenario leading retailer and hospitality sector business are expected to continue to reduce avoidable plastics and find plastic-free alternatives over time. It is assumed that the government would also continue to provide support measures – engagement with organisations such as the BRC, the British Hospitality Association, Food Packaging Service Association and the Courtauld Commitment/Plastic Pact to facilitate and promote the desired product and behavioural changes amongst their membership/signatories. Smaller retailers, hospitality businesses and online retailers could be engaged by trade associations and wider campaigns. Business change and innovation support could be directed to English product suppliers and manufacturers to help them to innovate.
The following assumptions were made in modelling the **No Ban** scenario:

- For the central estimate for buds a shift from 80% of cotton buds being plastic to 1% being plastic is represented, with the share reducing by 25 percentage points in year 1 and in subsequent years to the base share. Therefore, cotton plastic buds are almost entirely replaced by alternative products within 4 years.
- For the central estimate for stirrers a shift in market share from 50% plastic to 5% was modelled and for small beverage carton straws from 95% to 5%, with the plastics share reducing linearly by 10 percentage points for each year for both cases. Therefore, plastic stirrers are virtually replaced by alternative products over the time scale of the assessment (10 years).
- The large drinking straws market also shifts from 95% to 5% plastics in the central estimate and reduces linearly at a faster rate of 13 percentage points for each year reflecting the growing interest in this product and market readiness of the paper alternative.
- Product sales grow at 0.3% per year (this is less than the present 0.6% population growth rate) because some premises make the items less available by request under the No Ban scenario.
- A proportion of the drinking straws market (<1%) is not capable of being replaced by non-plastic products so was modelled as exempted, remaining as plastic over the period.

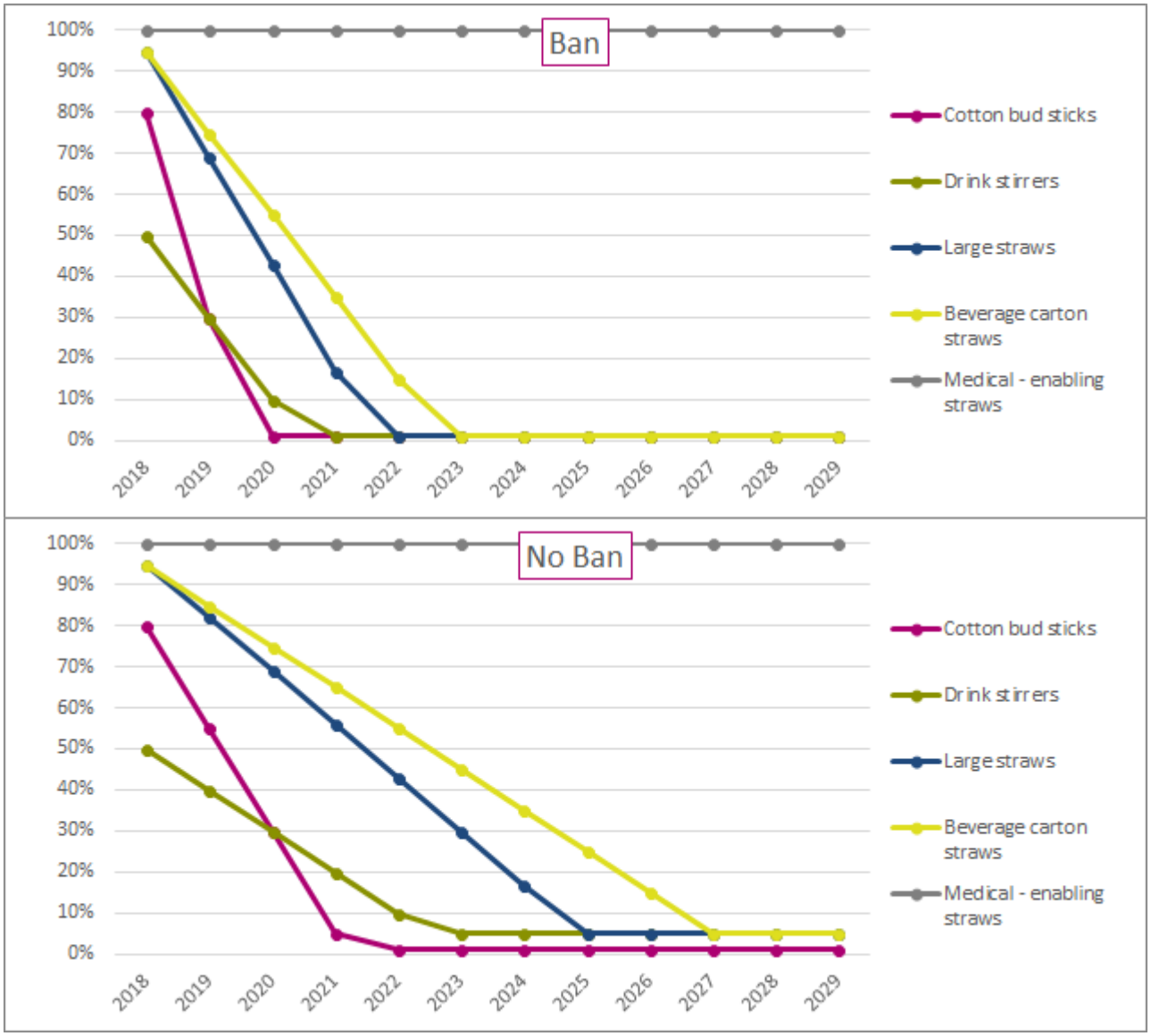


Figure 5: Assumptions for plastic product share of total market in the two modelled scenarios: Ban and No Ban

Figure 5 illustrates the transition in market share from plastic to plastic free for each type of product modelled. In this preliminary research, a linear reduction in plastic market share is represented. In reality, the decline in both types of scenarios is likely to be non-linear. For example, significant and exponential decline in plastics use may occur in the first few years whilst the subject is topical followed by slow and extended declining trajectories thereafter. The linear relation is acknowledged as a simple representation. It concentrates on the speed and depth of market change and anticipated differences between each of the scenarios and markets, given the insights that have been gained in the research. The overriding rationale is that over time, different types of 'consumers' (householder and business buyers) will be affected and will change, and under the Ban scenario the visibility of this will bring about change more quickly and deeply.

3.4 Economic impacts

3.4.1 Summary table

The central estimates for the impacts are presented in Table 3 to Table 7. The values are shown in net present value (NPV) terms over a ten-year period from 2019 to 2028. Column A indicates the impacts associated with the product in the Ban scenario, and Column B shows impacts under the No Ban scenario. The third column estimates the impact of the Ban over the No Ban scenario by subtracting column B from column A. The values represent the impacts associated with the plastic product and the alternative product combined. Model estimates are rounded to **one decimal place**. All figures **exclude VAT** and individual estimates are discussed in more detail in the following section.

Table 3 provides a summary of the combined impact for all products, i.e. the sum of the estimates for all individual products researched.

Table 3: All products, financial impact estimates, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A - B)	Difference - % change from No Ban
Regulatory implementation cost	1.4	none	1.4	n/a
Business implementation cost	4.1	3.6	0.5	+14%
Sales	599.0	523.0	76.0	+15%
Revenues to UK manufacturing	18.9	16.5	2.5	+15%
Waste treatment cost	4.1	3.8	0.3	+8%
Local Authority Clean-up cost	3.1	3.2	-0.1	negligible
Cost to fishing industry	negligible	negligible	negligible	negligible
GVA	90.8	80.2	10.6	+13%
Value of traded CO2e	1.1	1.2	-0.1	-12%
Value of non-traded CO2e	0.4	0.4	negligible	negligible
Terrestrial litter visual disamenity	14.1	14.3	-0.2	negligible
Beach litter visual disamenity	0.1	0.3	-0.2	-53%

Estimated differences in costs between the Ban and No Ban are generally small overall. This is not surprising because our modelling assumes [conservatively in modelling terms] that voluntary action will take place in each of the markets irrespective of a ban – albeit less change and over a longer period.

Sales and associated revenues to UK manufacturing and GVA are increased in the Ban. For example, sales cost (expenditure) is increased by £76 million. This is primarily because large paper-based straws are modelled as approximately four times the cost of large plastic straws (plastic straw approximately 0.6p to 2.5p per unit) and these dominate the overall impacts when combined for all products. The findings indicate this cost would help address the market failure reducing a range of environmental and social impacts and other costs.

3.4.2 Findings by product

This section discusses the difference in costs between the Ban and No Ban scenario, and the main determining factors behind the estimates shown in Table 4 to Table 7 below (Column C). Some of the impacts are repeated for ease of comparison between products. Note that the Ban scenario contains an exemption for medical-enabling straws, therefore no impacts have been estimated for this product.

The main difference is for large drinking straws where sales cost (expenditure) is increased by approximately £75 million per annum. A small cost (reduction in sales over baseline growth) is indicated for cotton bud stems and stirrers in each of the scenarios (Ban and No Ban). This is because it is assumed there will be a reduction in the use of all these single-use products over the plan period under the Ban and due to a differential in sales price for large non-plastic straws. Due to extra public visibility, under a Ban this reduction in overall consumption is assumed to be slightly greater.

The following tables break down the estimated impacts by individual product. Essentially, this indicates that changes are negligible/small in each market apart from large drinking straws where the price differential between plastic and paper-based product is influential.

Table 4: Cotton bud sticks, financial impact estimates, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A - B)	Difference - % change from No Ban
Regulatory implementation cost	0.3	none	0.3	n/a
Business implementation cost	1.0	1.0	negligible	negligible
Sales	59.0	60.0	-0.9	negligible
Revenues to UK manufacturing	1.6	1.6	negligible	negligible
Waste treatment cost	0.5	0.5	negligible	negligible
Local Authority Clean-up cost	negligible	negligible	negligible	negligible
Cost to fishing industry	negligible	negligible	negligible	negligible
GVA	14.4	14.7	-0.2	negligible
Value of traded CO2e	0.1	0.1	negligible	negligible
Value of non-traded CO2e	0.1	0.1	negligible	negligible
Terrestrial litter visual disamenity	negligible	negligible	negligible	negligible
Beach litter visual disamenity	negligible	negligible	negligible	Negligible

Table 5: Drinks stirrers, financial impact estimates, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A - B)	Difference - % change from No Ban
Regulatory implementation cost	0.3	none	0.3	n/a
Business implementation cost	1.0	1.0	0.1	+9%
Sales	6.5	6.6	-0.1	Negligible
Revenues to UK manufacturing	0.2	0.2	negligible	Negligible
Waste treatment cost	0.2	0.2	negligible	Negligible
Local Authority Clean-up cost	negligible	negligible	negligible	Negligible
Cost to fishing industry	negligible	negligible	negligible	Negligible
GVA	1.0	1.0	negligible	negligible
Value of traded CO2e	negligible	negligible	negligible	negligible
Value of non-traded CO2e	negligible	negligible	negligible	negligible
Terrestrial litter visual disamenity	negligible	negligible	negligible	negligible
Beach litter visual disamenity	negligible	negligible	negligible	negligible

Table 6: Large drinking straws, financial impact estimates, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A – B)	Difference - % change from No Ban
Regulatory implementation cost	0.6	none	0.6	n/a
Business implementation cost	1.7	1.4	0.3	+21%
Sales	520.0	445.0	74.5	+17%
Revenues to UK manufacturing	16.6	14.2	2.4	+17%
Waste treatment cost	3.0	2.7	0.3	+11%
Local Authority Clean-up cost	2.4	2.5	negligible	negligible
Cost to fishing industry	negligible	negligible	negligible	negligible
GVA	71.9	61.7	10.2	+17%
Value of traded CO2e	0.8	0.9	-0.1	-9%
Value of non-traded CO2e	0.3	0.3	negligible	negligible
Terrestrial litter visual disamenity	11.0	11.1	-0.2	negligible
Beach litter visual disamenity	0.1	0.2	-0.1	-54%

Table 7: Small beverage carton straws, financial impact estimates, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A – B)	Difference - % change from No Ban
Regulatory implementation cost	0.1	none	0.1	n/a
Business implementation cost	0.4	0.2	0.1	+57%
Sales	14.1	11.5	2.6	+23%
Revenues to UK manufacturing	0.5	0.4	0.1	+23%
Waste treatment cost	0.4	0.4	negligible	negligible
Local Authority Clean-up cost	0.7	0.7	negligible	negligible
Cost to fishing industry	negligible	negligible	negligible	negligible
GVA	3.5	2.9	0.6	+22%
Value of traded CO2e	0.1	0.2	-0.1	-32%
Value of non-traded CO2e	negligible	negligible	negligible	negligible
Terrestrial litter visual disamenity	3.1	3.2	negligible	negligible
Beach litter visual disamenity	negligible	0.1	negligible	negligible

Notably the estimates for large drinking straws and carton straws indicate that the additional sales costs associated with the price differential between paper and plastic straws are be greater in scale than the quantifiable terrestrial litter and beach litter benefit and other costs reduction benefits. We note, however, that with the scaling up of production of paper straws the price differential would be likely to be reduced and that contemporary disamenity impacts may be greater in scale than those in previous research.

Table 8 and Table 9 indicate regulatory and business implementation cost estimates. Regulatory costs will be borne by Local Authorities' trading standards bodies, and there is an estimated small additional burden associated with transition costs, which is represented in the business costs. The exact costs and the period they were incurred over would need to be confirmed in stakeholder consultation.

Table 8: Regulatory implementation cost estimates, NPV 2019 to 2028 (£m)

	Ban
Cotton bud sticks	0.3
Drink stirrers	0.3
Large drinking straws	0.6
Beverage carton straws	0.1

Table 9: Business implementation cost estimates, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A – B)	Difference - % change from No Ban
Cotton bud sticks	1.0	1.0	negligible	negligible
Drink stirrers	1.0	1.0	0.1	+9%
Large drinking straws	1.7	1.4	0.3	+21%
Beverage carton straws	0.4	0.2	0.1	+57%

There is a change in the sales value, shown in Table 10, as a slightly lower sales growth rate is used in the Ban scenario to reflect the greater signalling effect of a government ban on demand (e.g. see reductions in Column C for cotton bud sticks and stirrers).

For large drinking straws, the increase in sales costs is due to the increased unit price of large paper drinking straws. The difference in costs, presented in Column C, relates to manufacturers, retailers and wholesalers that are not already shifting away from the plastic products. The Ban scenario hastens the shift from the plastic product to an alternative, which is happening voluntarily in the No Ban scenario but at a slower pace.

Table 10: Sales estimates, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A – B)	Difference - % change from No Ban
Cotton bud sticks	59.0	60.0	-0.9	negligible
Drink stirrers	6.5	6.6	-0.1	negligible
Large drinking straws	520.0	445.0	74.5	+17%
Beverage carton straws	14.1	11.5	2.6	+23%

Over time, the potential ban causes a decrease in demand for the plastic product and an increase in demand for alternative products that comply with the legislation. As a large proportion of these products are thought to be imported (95% in the central estimates) this will have a limited impact for UK manufacturing firms, as shown in Table 11. Differences are greatest for large drinking straws because paper straws are costlier.

Table 11: Estimated revenues to UK manufacturing, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A – B)	Difference - % change from No Ban
Cotton bud sticks	1.6	1.6	negligible	negligible
Drink stirrers	0.2	0.2	negligible	negligible
Large drinking straws	16.6	14.2	2.4	+17%
Beverage carton straws	0.5	0.4	0.1	+23%

Waste treatment costs are shown in Table 12. These costs are not expected to change significantly as the items will still be disposed of in the same way, irrespective of the material they are made of, as few are thought to be recycled.

Table 12: Waste treatment cost estimates, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A – B)	Difference - % change from No Ban
Cotton bud sticks	0.5	0.5	negligible	negligible
Stirrers	0.2	0.2	negligible	negligible
Drinking straws	3.0	2.7	0.3	+11%
Beverage carton straws	0.4	0.4	negligible	negligible

GVA estimates are shown in Table 13. The values shown are largely associated with retail and wholesale rather than manufacture as most of the products are imported. The estimates also account for whether the product is sold B2B or B2C. Most drinking straws are sold B2B e.g. wholesalers supply the hospitality industry, whereas cotton buds are predominantly B2C. Again, a noteworthy increase in GVA results from the price differential between large paper and large plastic straws.

Table 13: Gross value added estimates, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A – B)	Difference - % change from No Ban
Cotton bud sticks	14.4	14.7	-0.2	negligible
Drink stirrers	1.0	1.0	negligible	negligible
Large drinking straws	71.9	61.7	10.2	+17%
Beverage carton straws	3.5	2.9	0.6	+22%

Local authority (LA) clean-up costs and the cost to the fishing industry caused by littered items are not expected to vary significantly as a result of a Ban. These products account for a small proportion of terrestrial and beach litter. A small change in the litter volume is unlikely to translate to direct cost savings for a local authority as their staff will still be required to clean the same areas and frequency of service.

Carbon emissions are shown in Table 14 and Table 15. These vary due to mass used within products and environmental intensities of different materials, mostly associated with production.

Table 14: Value of traded CO2e estimates, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A – B)	Difference - % change from No Ban
Cotton bud sticks	0.1	0.1	negligible	negligible
Drink stirrers	negligible	negligible	negligible	negligible
Large drinking straws	0.8	0.9	-0.1	-9%
Beverage carton straws	0.1	0.2	-0.1	-32%

Table 15: Value of non-traded CO2e estimates, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A – B)	Difference - % change from No Ban
Cotton bud sticks	0.1	0.1	negligible	negligible
Drink stirrers	negligible	negligible	negligible	negligible
Large drinking straws	0.3	0.3	negligible	negligible
Beverage carton straws	negligible	negligible	negligible	negligible

3.5 Environmental impacts

Appendix A.3 presents a review of evidence on the types of economic and environmental impacts of terrestrial and marine litter, and degradation rates for litter in the environment. The review found that comparatively few data sources were available and appropriate to England. These were briefly reviewed, and some were found to be not robust. Scientific understanding of the exact impacts of plastic waste is still in its infancy and the relative risks associated with different types and sizes of plastic debris is only just beginning to be considered[52]. Taking into account litter composition studies and previous research on direct and indirect economic costs, the following data sources were used to represent impacts. Carbon costs associated with products and disposal of materials were estimated using UK Government Greenhouse Gas (GHG) Conversion Factors for Company Reporting and monetised. Keep Britain Tidy (2014)[53] data was used to represent terrestrial litter disamenity impact (£4.2 billion value for all types of marine litter as the upper estimate, which is £4.4 billion in today's prices).

A historical study, Eftec (2002)[54], was used to quantify beach litter visual disamenity impacts (£220 million to £404m). This value is based on the public's willingness to pay for litter-free beaches. There are many impacts associated with marine litter, and the willingness to pay value reflects, to some extent, how well informed the public is on these issues and their concern for the impacts. It is recognised that the costs of beach litter visual disamenity impacts would benefit from being updated considering recent public

[52]http://ec.europa.eu/environment/integration/research/newsalert/pdf/clarity_needed_plastic_waste_environmental_impact_for_evidence_based_policy_506na3_en.pdf
[53] Keep Britain Tidy (2014), Exploring the Indirect Costs of Litter in England. Values adjusted following methodological improvements in work by Zero Waste Scotland, see Appendices for details.
[54] Eftec (2002), Valuation of Benefits to England and Wales of a Revised Bathing Water Quality Directive and Other Beach Characteristics Using the Choice Experiment Methodology

awareness of the marine damage caused by single-use plastics and these could be much larger than this historical estimate.

3.5.1 Litter environmental impacts

Table 16 presents the central estimate for disamenity cost of terrestrial litter from the model, using the modelling of changes in sales volume and the data regarding items which become litter, disamenity impact and the degradation rates. The estimates show little impact on terrestrial litter the modelling assumes no behaviour change leading to a reduction in littering and in urban areas the littered items are unlikely to decompose before they are cleaned up.

Table 16: Terrestrial litter disamenity cost estimates, NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A – B)	Difference - % change from No Ban
Cotton bud sticks	negligible	negligible	negligible	negligible
Drink stirrers	negligible	negligible	negligible	negligible
Large drinking straws	11.0	11.1	-0.2	negligible
Beverage carton straws	3.1	3.2	negligible	negligible

Table 17 presents the central estimates for disamenity cost of beach litter. The estimated impact on beach litter disamenity is small. Whilst no behaviour change in littering behaviour (or flushing buds down the toilet) is accounted for in the model, non-plastic littered items will decompose much faster than the plastic products and this will lead to fewer being found on beaches and other marine environments. However, beach disamenity costs are small in the central estimates, and values are negligible for cotton bud sticks and stirrers, as these products are relatively small in size and the costs are allocated based on physical volume of littered items.

Table 17: Beach litter visual disamenity cost estimates (central estimate), NPV 2019 to 2028 (£m)

	Ban (Column A)	No Ban (Column B)	Difference - Ban over No Ban (C = A – B)	Difference - % change from No Ban
Cotton bud sticks	negligible	negligible	negligible	negligible
Drink stirrers	negligible	negligible	negligible	negligible
Large drinking straws	0.1	0.2	-0.1	-54%
Beverage carton straws	negligible	0.1	negligible	negligible

3.5.2 Life cycle impacts and risks

This subsection discusses product life cycle related issues since it is understood the government's new Resources and Waste Policy and Strategy will take a life cycle approach to managing resources.

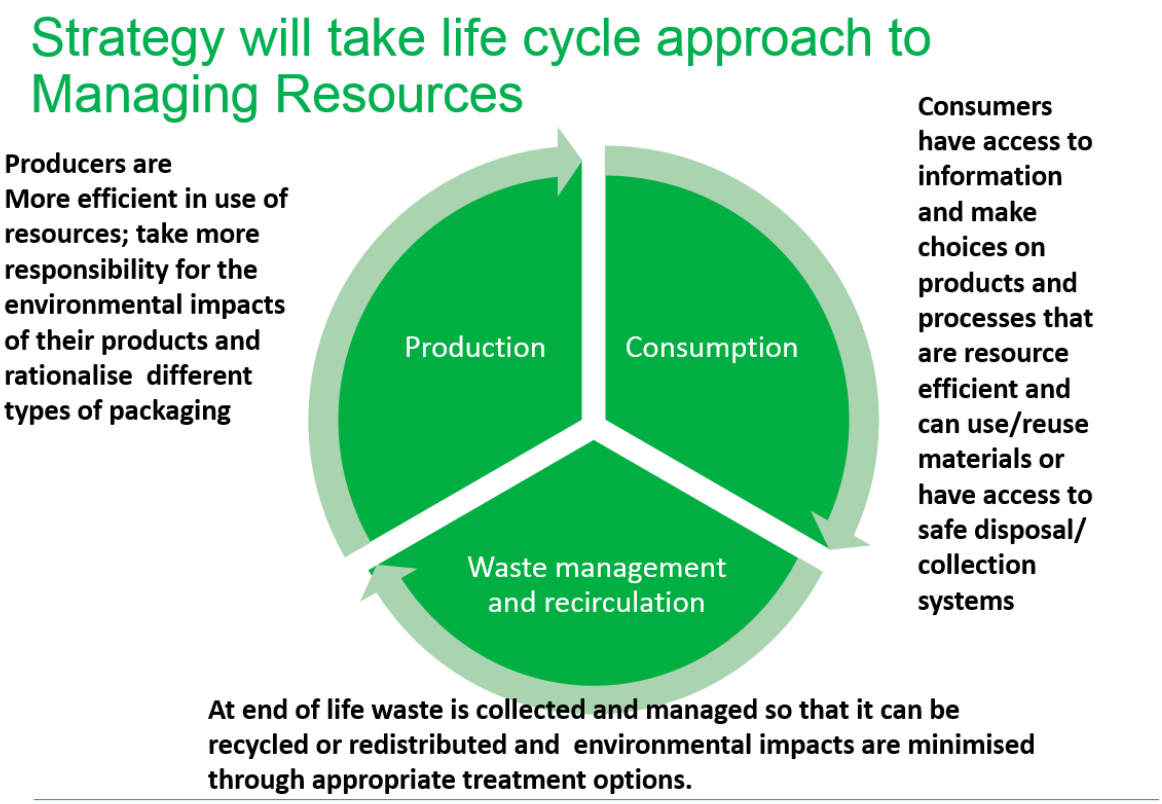


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Figure 6: Unpublished excerpt from draft life cycle thinking approach in Resources and Waste Strategy[56]

A potential risk/unintended consequence of a ban is that avoiding plastics could encourage the use of alternatives and behaviours which cause an impact of greater magnitude elsewhere in the product life cycle. The alternatives and alternative practices that lead to a reduction in plastic use should be less environmentally damaging overall.

Life Cycle Thinking[57] can be used to inform decisions to ensure there is an overall reduction in environmental impact. It can help understand potential risks and prevent potential 'burden-shifting'. Impacts are considered at each stage of the supply and disposal chain to ensure that impacts are not transferred elsewhere in the system. Life Cycle Thinking may be applied qualitatively to better understand the impacts/risks, or quantitatively in detail using detailed Life Cycle Assessment studies (LCAs) which consider the effect on different types of environmental pollution.

3.5.3 Life cycle thinking

A first question when considering life cycle impacts concerns functional equivalence – in this case whether the alternative product performs equally or less well than the plastic product i.e. does it match its rival in terms of its use and strength/durability. In the research, for buds and stirrers no evidence was identified that indicated the plastic-free alternatives were less effective that their plastic counterparts. For drinking

[56] Defra (unpublished) Robert Vaughan, Head of Household Waste and Recycling, Presentation at EIC Waste Management & Resource Efficiency Working Group, Feb 2018
[57] http://ec.europa.eu/environment/waste/publications/pdf/Making_Sust_Consumption.pdf

straws, it was identified that some paper straws may need to be laminated to retain their integrity during use and it is also recommended paper and PLA straws are not used for hot drinks. Doubt was also expressed that there is no functionally equivalent non-plastic product for large flexible straws and small beverage carton straws. The risk is that when a product performs less well, it causes waste with an impact of greater magnitude than the product change/benefit itself (e.g. due to spillages of drinks from inferior straws, shorter-lived product, damage to clothing, health & safety concerns) and this should be considered.

A next question concerns the number of products or the material weight that is required to fulfil the same function. If alternatives are heavier then overall life cycle costs can be increased due to an increase in associated life-cycle impacts [58], but this is also dependent on the type of material. In this research the suggestion is that wooden stirrers are heavier than their large plastic alternative and paper straws may be thicker (approximately double the weight). A very basic life cycle comparison of the impact associated with the different product weights is based on product weight and disposal impact. In carbon terms, findings in Section 3.4.1 suggest that when the carbon-intensity of each material is considered the differences are small overall. This is because both of these products are lightweight so the risk of contributing significant and adverse global warming impact is low relative to other societal choices. The analysis did not account for weight differences and their effect on transport impacts in the supply chain. More detailed LCA research would be needed to consider the efficiency of logistics for the specific products to understand the magnitude of differences across the supply chain.

The choice of design also effects the benefits it has in use – its 'functional benefit'. For example, for small beverage cartons there is a risk a strawless design or paper straw that cannot pierce film could result in product spillages/breakages/losses of greater magnitude than the saving associated with the reduction in plastics. Perverse outcomes are also possible if the potential impacts of decisions are not fully understood. Discouraging or banning plastic straws could, for example, lead to more plastic and glass bottles being sold and littered at greater overall environmental cost, or an increased in chilled (rather than ambient long life) products with consequent life cycle impacts. Life cycle studies show differences between different types and sizes of packaging. A recent example comparative assessment of different types of small beverage containers for Sweden for global warming potential is presented in Figure 7. This illustrates that different types of packaging containers that can have different life cycle impacts (global warming) when compared on an equivalent basis[59].

[58] https://plastics.americanchemistry.com/Plastics-and-Sustainability.pdf
[59] https://www.ifeu.de/oekobilanzen/pdf/LCA_Nordic_final_report_incl_Critical_Review.pdf

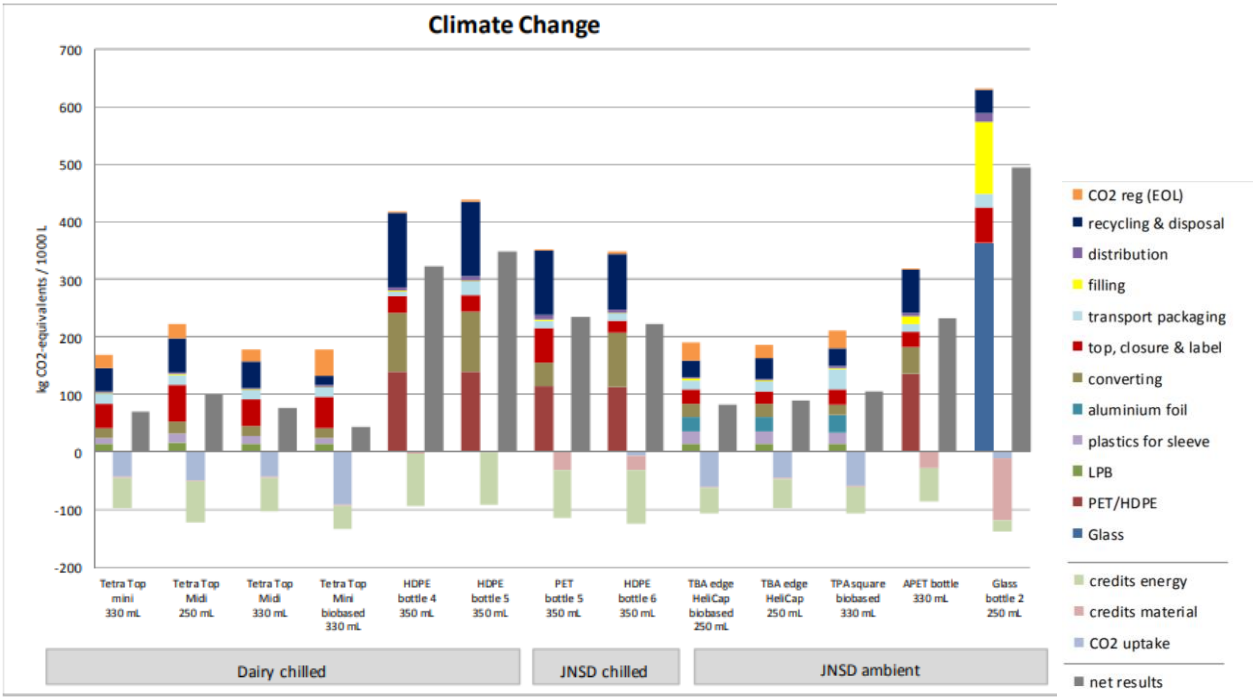

Figure 7: Comparative life cycle global warming impacts for different small beverage containers

3.5.1 Life cycle impacts at start and end of life

Fossil-fuel based products are generally considered less environmentally sustainable than bio-based alternatives because they rely on finite resources and release greenhouse gas emissions at the point of disposal[60].

However, bio-based materials may not be renewable or sustainable if their sourcing significantly changes land use (e.g. to monoculture), or their production is inefficient and reliant on fossil-based energy and fertilisers. Bio-based items should be sustainable sources from land from a carbon management perspective.

At end of life, disposal and recycling behaviours determine the impact associated with resource recovery and waste management. If consumers tend to recycle items, then products should be designed to be compatible with the recycling systems that local authorities and others provide. If overwhelmingly composted, then products should be designed to be compostable. If disposed of, then they should be appropriate for that as the prevailing system.

This research infers that these small products in question are likely to be predominantly disposed of as general waste because they are not valued and hence are likely to be incinerated. Because carbon is 'sequestered' during plant growth in the biomass from sustainable plantations, when bio-based materials are burnt they do not contribute net greenhouse gas emissions.

The scope of the research did not consider the impacts for reusable products such as metal, glass, silicone, bamboo straws etc., or consider any reuse behaviours for plastic disposable products at home. These were judged to be minor/niche products. Nevertheless, relative to single-use plastics reusables do avoid impacts

[60] the carbon they are composed of is not derived from the short-term carbon cycle, whereas plant-based material such as paper and wood is carbon drawn down from the atmosphere in the last 100 years.

associated with production. For example, some retailers are banning disposable coffee cups in favour of ceramic mugs and reusable refillable coffee mugs. With greater emphasis on extended producer responsibility for addressing waste and environmental damage there is scope for promoting reusables and for innovation. The main concern for the products researched here is whether these products can be sufficiently, and hygienically cleaned at low environmental cost (e.g. hot water from low carbon energy sources).

Clearly, further systems thinking and LCA research is required to ensure products are designed appropriately, material choices are sound, and waste and recycling systems are made available and matched to prevalent behaviours. Multi-environmental impact LCA are also appropriate for significant products to ensure favourable environmental outcomes.

3.6 Social/consumer impacts

A quantitative impact on sales expenditure was shown in Table 10. For buds and stirrers, these show a very small reduction in sales expenditure by businesses and consumers due to our assumptions regarding a small reduction in overall consumption of units.

For large straws, if plastic straws were to be replaced by paper-based straws, our analysis indicates that the paper-based substitute product would be costlier than the existing plastic product (at least initially), adding around two pence per individual unit.

Standard economic theory assumes that consumers of goods and services act rationally whilst making decisions about the amounts of goods or services they agree to supply or purchase. Thus, in deciding to purchase or supply an item for a given sum of money (say £1), a consumer is assumed to act rationally. It follows that when buying such an item a consumer must derive an amount of 'utility' (broadly, use or pleasure) from that item which is at least equal to the £1 they spent acquiring it. If the item was worth less to the consumer than £1, then being rational, they would not have bought it. Similarly, if the item is worth more to them than £1, but costs less than £1, then they buy it and experience a 'bonus' for which they have not paid. This 'bonus' is termed 'consumer surplus' and reflects the idea that the consumer derives more pleasure from the item than it actually costs them. The idea that the price of an item can be treated as a proxy for its value is simplistic (and does not take account of any consumer surplus that may be derived) but it is convenient and is often applied, for example in counting the sales of goods.

As the market for straws currently operates, we have (theoretically) rational consumers who are content to part with the present price required to obtain a given quantity of plastic straws. From these straws we assume these rational consumers collectively gain utility worth at least as much to them (maybe more) as the money that the straws cost. Unfortunately, we do not have enough information about the market to know how much (if any) consumer surplus is being created for the consumers by their plastic straw purchases, as this would require detailed knowledge of consumers' spending decisions that even they probably do not have. However, if the price is set right, then the market should be in equilibrium (demand equals supply). If the market is later upset by a ban, with plastic straws being replaced by paper equivalents, then a new equilibrium must be found as consumers (who were previously apparently content to buy plastic straws) switch to paper ones.

The consumer may experience 'disutility' if the alternative product that is provided does not give the same level of functional performance as the original product. For example, in the case of large plastic straws, we understand that some plastic-free alternatives are unsuitable for certain disabled groups who would not be

able to use them effectively (i.e. these people will experience significant disutility from using the current plastic-free straws). Our modelling therefore assumes that a proportion of the straw market sold for clinical reasons will remain plastic for this reason. Other examples of consumer disutility include paper cotton buds which are less rigid and bend more, or paper straws which go soggy or cannot penetrate cartons as effectively.

Some consumers may find that after a change in the product, they now draw less (or more) utility from the purchase of a paper straw. In reality, if they drew less utility than before (and the price of the good has risen) they should not buy it. The market shifts accordingly, supply reduces, and a new equilibrium is found in which fewer straws are produced but their unit price is higher. In reality, we do not know how elastic demand is with respect to price (or quality) – i.e. how much a change in price (or in quality) would affect overall sales. Our stakeholders were not able to shed light on this issue and so our model simplifies the process (losing some 'real world' accuracy in so doing) by treating price as a proxy for consumer satisfaction, and assuming that consumers are happy to simply exchange the substitute good for the existing one – and in the case of straws, at a higher price.

There is some rationale for doing this. Consumer reactions to market changes are very difficult to predict. The prices of cotton buds and stirrers are not expected to be affected and though the price of substitute straws may be dearer, large drinking straws provided as part of a hospitality package (e.g. in bars, restaurants, take away food shops etc.) are given away to the end user, so that any price increase to the bar owner (which would be relatively small anyway) would be passed on to the consumer and hidden within the overall price of the service, so would probably be unnoticeable to the customer. In addition, though our research and discussions suggested there may be price differences for straws in the early stage of a ban, economies of scale would be expected to ramp up with production, meaning that the price differential would reduce over time as production of plastic-free products is scaled up. On the matter of substitute quality, our approach reflects an assumption that plastic-free alternatives are designed to be 'adequate for use' i.e. to only last (be water-resistant) for the necessary short period of use. So, it is not necessary to consider quantifying an estimate of consumer disutility/demand impact caused by the introduction of poorer quality substitute goods.

Despite this, to reflect any potential change in consumer utility which is missing from the modelling, we have undertaken a sensitivity test on the volume growth rate to gauge possible impact. This is shown in Table 31.

Beach litter disamenity impacts have been quantified in this study. However, the social impacts of marine litter (e.g. welfare benefits - knowing and seeing that the sea itself is cleaner, reassurance that marine life is not being impacted) are acknowledged but are not quantified in this research. Further and contemporary 'willingness to pay' research is recommended regarding this subject in Appendix A.6.

3.7 Sensitivity analysis

Several uncertainties were identified during the research. For example, estimates made of the units sold for each type of product are subject to margins of error which we were not able to reduce. Assumptions also had to be made regarding the speed and extent of change in market share in the Ban scenario.

It was decided to undertake sensitivity analysis in two parts:

1. Deterministic analysis around the central estimate
2. Methodological analysis around the central estimate for a key variable

3.7.1 Deterministic analysis around the central estimate

The research team selected plausible upper and lower values for potentially significant data uncertainties and assumptions. Values were changed in the model to represent the potential range in the results in view of the research findings at this preliminary stage. The parameters that were changed are listed in Table 18. Notably, sales units for large drinking straws were doubled to represent the unknown market size of straws use within non-fast food sectors of the hospitality sector and the speed and depth of market change under each of the scenarios were varied to indicate the effect on the model results.

Table 18: Variables tested and results for range analysis around the central estimate

Model variable	Product types	Central est.	Central Value	Lower (Best)	Lower value	Upper (Worst)	Upper value
Sales units p.a.	Buds, stirrers, and carton straws	Item estimates	1	90%	0.9	110%	1.1
Sales units p.a.	Large drinks straws	Item estimates	1	90%	0.9	200%	2.0
Product price	Paper-based straws	Item estimates	1	20%	0.2	100%	1.0
Market base - Ban	Large drinks straws	Plastics to 1% base	1%	100%	1.0%	250%	2.5%
Market base - No Ban	Straws and stirrers	Plastics to 5% base	5%	100%	5.0%	500%	25.0%
Speed of shift - No Ban	Buds	25 point drop in plastic % market share each year, e.g. linear reduction of 80% to 55% to 35%	1	100%	1.0	67%	0.7
Speed of shift - No Ban	Straws and stirrers	10 point drop in plastic % market share each year, e.g. 50% to 40% to 30%. Drinking straws = 13 pt drop.	1	100%	1.0	95%	0.95
Volume growth rate - Ban	All		0%		-1%		0.6%
Volume growth rate - No Ban	All		0.3%		-0.1%		0.6%
% imports	All		95%		90.0%		100.0%
Waste management - flushed	Buds		8.1%	50%	4.1%	150%	12.2%
Waste management - littered	Stirrers	Showing terrestrial litter rate. Beach litter also varied by the same ratio.	0.10%	50%	0.05%	150%	0.15%
Waste management - littered	Straws	Showing terrestrial litter rate. Beach litter also varied by the same ratio.	1.00%	50%	0.50%	150%	1.50%
Waste management - recycling rates	All		0.00%		0.000%		10% of packaging recycling rates
Visual disamenity value - terrestrial and beach litter	All	Terrestrial: Keep Britain Tidy (2014, adjusted as described), Beach: Eftec (2002)	Mid-point		Lower Range		Upper Range

The 'Lower (Best)' and 'Upper (Worst)' columns show how model assumptions are varied from the central estimate. For example, the first line of the table shows that sales units were varied plus and minus 10% of the central value. The third line of the table shows the price of large paper-based straws is reduced to 20% of the central value in the lower estimate, whereas the upper estimate remains unchanged.

Table 19 compares the central value and lower and upper variation where all sensitivities in Table 18 were applied, providing ranges as recommended in HM Treasury's Green Book. The combined results (i.e. cumulative when all individual sensitivities are changed) are presented here in the main body of the report. The results for individual sensitivities and their individual effect is presented in Appendix A.1.

The cumulative effects of all the applied sensitivities are indicated in Table 19. Overall, the estimated results were increased or decreased in the expected direction. The table shows a range in the impact estimates.

It is notable that sales cost/expenditure (row 3) and the closely linked manufacturing revenues (row 4) and GVA metrics (row 6) are significantly affected. Uncertainty in the research regarding the quantity of large drinking straws and the (long term) price differential between large paper and plastic drinking straws were identified as the key determinants of the differences.

Table 19: Cumulative sensitivity analysis, Difference – Ban over No Ban, impact estimates for all products combined; absolute values in central, lower and upper estimates, NPV 2019 to 2028 (£m), and % change on central values in lower and upper estimates

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	1.1	none	+111%
Sales	76.0	-13.9	245.0	-118%	+222%
Revenues to UK manufacturing	2.5	-0.8	none	-134%	-100%
Waste treatment cost	0.3	0.2	0.9	-50%	+210%
Local Authority Clean-up cost	-0.1	-0.1	negligible	-33%	+74%
Cost to fishing industry	negligible	negligible	negligible	+50%	-115%
GVA	10.6	-2.5	30.1	-124%	+184%
Value of traded CO2e	-0.1	-0.2	-0.4	-15%	-164%
Value of non-traded CO2e	negligible	negligible	0.2	-57%	+367%
Terrestrial litter visual disamenity	-0.2	-0.1	none	+59%	+100%
Beach litter visual disamenity	-0.2	-0.1	-0.4	+65%	-178%

Because many of the sensitivities are cumulative (the uncertainties are multiplied together e.g. sales units, price), this represents an extreme lower and upper range. In reality, it is likely each of the 14 sensitivities examined will not all act at the same time or may be cancelled out by each other tending towards the central estimate. Results are presented individually in Appendix A.4 for each identified variant to show the individual effect of each change and to the relative impact each has toward the combined output.

The individual sensitivity analysis in Appendix A.4 shows that many different factors affect sales and GVA estimates, and so it is unsurprising that a large range is shown in the cumulative sensitivity analysis in Table 19. However, as described above, the likelihood of all sensitivities acting together is low, and so the true values are unlikely to be found at the extremes of the range.

The analysis in Appendix A.4 shows key sensitivities are the price of the alternative product (specifically paper straws are tested), the market base that won't shift away from plastic products under any scenario,

and the volume growth rate. The percentage of the market that is imported has a big effect on the revenue to UK manufacturing, and the disamenity costs are also sensitive to the values used.

3.7.2 Methodological sensitivity

Litter disamenity impacts were determined in the research as a key data uncertainty. As described in Section 3.5 terrestrial disamenity impacts for litter can be considerable. There is not yet a consistent methodology and data-set representative of England for marine litter regarding the direct and indirect externality costs on food supply and tourism, let alone non-market costs such as wellbeing, health and impact of witnessing adverse effects on wildlife.

A potentially significant limitation noted for this research is that the source of the data for beach litter disamenity was the Eftec study from 2002[61], research which took place prior to the broadcast of Blue Planet II which is thought to have significantly impacted on public perception of marine litter pollution and hence, the disamenity associated with it. Furthermore, because this study was concerned with only three specific types of marine litter, a methodological choice had to be made in our research to allocate these total disamenity impacts to each of the product types. Since visual disamenity impact is sight and perception-based[62] and different sized objects have different likelihood of being ingested and disrupting marine ecosystem this is not straightforward.

For the modelling central estimate, it was decided to allocate the total disamenity impact to the researched products based on their relative volume compared to the total beach litter volume and a method was devised to do this using estimated average dimensions of litter objects[63]. This method produces the most cautious/conservative estimate. For the central estimates provided in Section 3.4 disamenity impacts for both terrestrial and beach litter disamenity impact were estimated to be small and insignificant using this method.

An alternative method to allocate the terrestrial and beach litter disamenity impacts was also examined for the upper value. The aim was to better represent the visual disamenity caused by each type of litter. The approach was to estimate a long-sectional area of each litter object to approximate how much of a person's view of the beach that litter might take up[64].

Table 20 indicates the estimates when this visual area approach was applied as an upper sensitivity. No other assumptions are changed and so only impacts relating to terrestrial litter and beach litter are affected. Although the overall costs are modest, the method change is shown to be significant, increasing the estimated impact by a factor of 7 in the case of terrestrial litter. The terrestrial and beach litter visual disamenity impacts becomes much more significant under this change, compared to other costs and benefit of a Ban.

[61] Eftec (2002), Valuation of Benefits to England and Wales of a Revised Bathing Water Quality Directive and Other Beach Characteristics Using the Choice Experiment Methodology
[62] http://www.pml.ac.uk/News_and_media/News/Marine_litter_can_undermine_benefits_of_coastal_en
[63] For some litter objects in litter survey data we can estimate an average size with relative confidence, such as crisp packets and cigarette filters. Other objects are more difficult to estimate, such as 'large fishing net', or 'small plastic fragments' where there is great range in the size of items found. Despite the inherent uncertainty we consider this to be an improvement over an 'item count' approach, which would over emphasise the impact of small items found in large items such as plastic fragments and underestimate large objects found in small numbers such as fishing nets.
[64] Average litter object dimensions from the volume estimates were used. It was assumed objects are lying on their largest side.

This sensitivity analysis shows that the method by which disamenity impacts of all litter is allocated to the specific products is important and impacts may be significant, albeit in context these are still dwarfed by changes in costs associated with sales, manufacturing and GVA.

It is possible this impact may be greater in magnitude. Further research is suggested on the disamenity impact of (particularly) beach litter and how this is allocated to the range of plastic products found in beach litter this should be a focus for further research. It is noted that research has recently been commissioned by the Scottish Government which may provide some insights and new data[65].

Table 20: Results for methodological sensitivity analysis around litter visual disamenity impact, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Sensitivity - Central (£m)	Sensitivity - Central - % change from central estimate
Regulatory implementation cost	1.4	1.4	none
Business implementation cost	0.5	0.5	none
Sales	76.0	76.0	none
Revenues to UK manufacturing	2.5	2.5	none
Waste treatment cost	0.3	0.3	none
Local Authority Clean-up cost	-0.1	-0.4	-635%
Cost to fishing industry	negligible	negligible	negligible
GVA	10.6	10.6	none
Value of traded CO2e	-0.1	-0.1	none
Value of non-traded CO2e	negligible	negligible	negligible
Terrestrial litter visual disamenity	-0.2	-1.7	-676%
Beach litter visual disamenity	-0.2	-0.7	-332%

4 Discussion

4.1 Overall findings

A preliminary assessment of the impacts and possible consequences of a legislative ban for the products is provided in the research. The research identified a significant gap in the market information for the products being researched. Through evidence review and stakeholder interviews relevant information was gathered for the research. The modelling filled the gaps with the most logical and most appropriate assumptions.

In terms of behaviours, each type of product examined in the research is bought, used and disposed of differently. Some are littered or are flushed directly into toilets. Few are recycled as they are low weight, contaminated items, so many consumers and businesses will perceive them as worthless and uneconomical to sort and recycle. Despite the differences, the research indicates a Ban on the selected plastic products

[65] Invitation to tender for social research on attitudes in Scotland on the marine environment and marine issues, Marine Scotland, 31 January 2018

would have benefits in terms of the desired reduction in single use plastics and would do so with relatively low negative economic impact. Leading retailers and hospitality sector businesses are presently committed to reducing plastics and are finding plastic-free alternatives for these products, particularly for the cotton buds market where the majority of the market will/is changing voluntarily and is doing so within similar timescales as those envisaged under the ban.

The findings suggest a ban would be likely to bring about market change amongst retailers earlier and more deeply, creating a level playing field across each of the markets. Because the market is already changing, and where plastic-free alternatives are available, it is expected that shifting the market to non-plastic alternatives could be achieved at relatively low business and regulatory cost. For buds and stirrers, a relatively small range of additional quantifiable additional costs and benefits is estimated for the Ban scenario. For large drinking straws, the sales price of paper-based straws is greater (by around two pence per unit) than the alternative and this also increases related manufacturing value and GVA.

The qualitative impacts of a ban (both costs and benefits) may be significant but cannot be quantified. The benefits to terrestrial and marine litter reduction are numerous, including effects on wildlife, fisheries and social wellbeing. However, impact methodologies used to quantify litter impacts appear to be partial and incomplete/embryonic/historical for marine litter. For large drinking straws in cafes etc., disutility is a concern. The paper and bio-based alternatives may be heavier and costlier, with reduced functionality over extended timescales albeit they may still suit the context of their use. Notably, the research did not identify functionally-equivalent alternatives for some straw products (medical use, disability groups, hot drinks and some small beverage containers). Except for plastic straws for disabled groups and medical applications the research assumes the disutility costs would be small. Plastic-free alternatives may not provide identical functionality but will be suitable for most uses. A concern exists for the bio-based plastic straw alternatives regarding whether they will break down readily and innocuously in the marine environment.

The sensitivity analysis around the central estimates confirms that costs are still likely to modest when uncertainties are accounted for. The analysis confirms that if the effects of a ban were felt earlier and deeper and the benefits would be greater.

4.2 Which products could be banned?

Since costs and benefits are both predicted to be modest in the central estimates of the quantitative analyses it is perhaps the following qualitative findings of the research which will be the main determinant of the practicability of a ban.

The research found near universal support for a proposed ban on plastic stem cotton buds and widespread support from stakeholders interviewed, for action on reducing large plastic drinking straws and stirrers across the hospitality sector. A ban would also be likely to be welcomed by leading businesses in the sector who have/are committed to change because it would level the playing field. This would protect markets and ensure implementation amongst smaller players in the market and consistent implementation across large, franchised organisations.

For stirrers, litter is less of an issue because most stirrers are used and discarded indoors. The stirrers market is comparatively small, and a significant proportion of the market is already plastic-free. Given recent media interest, it is likely that further voluntary change will happen in the short to medium term. A ban in this market could serve to prohibit plastic use in the long term, preventing any return to use of plastics or undermining of the plastic-free market from imports.

The drinking straws market is evidently more diverse. Although widespread support for action was identified from stakeholders interviewed, the research indicates there are likely to be concerns raised during consultation which necessitate exemptions (e.g. medical uses and disabled groups). Moreover, concerns were voiced by key players in the market that the alternatives currently offered may not be functionally suitable and could, on balance, cause more environmental harm than the plastic products. The research indicated that plastic-free alternatives would be costlier, at least in the short term, representing an initial cost to internalise the market failure. It is possible a longer lead-in time for a ban for these types of straws would enable better alternatives to be developed, trialled and produced at scale.

This is not to say that a ban could not produce a desirable outcome for most types of plastic straws. There are also practical measures the hospitality sector could take to reduce the quantity of straws used and support for small retailers and hospitality business could be provided. A ban (or the threat of a future ban) would serve as a signal to consumers and the market in this regard. Carefully-written legislation could affect both a reduction in use and a change to plastic-free alternatives with timescales dictated for different types of straws.

4.3 Legislation for implementation of new ban

The recent banning of microbeads in cosmetic products was cited as a proxy for further bans by some of the stakeholders interviewed in the research. Appendix A.5 presents the findings of a brief review of the Microbeads ban. It represents a potential starting point for a new ban on buds, straws and stirrers. The review illustrates the types of changes which may be necessary/possible to bring about the desired change. It could be used as a basis for further discussion/consultation with businesses.

4.4 Complementary/alternative measures

Behaviours is a recurrent theme in the research. If a ban is not readily possible in the short term for some types of straws (and stirrers), then prevention is better than cure. Reducing use and promoting good disposal practices which prevent littering and flushing behaviours are desired outcomes. These reduce the flow of plastic litter to the environment. Action could be targeted at consumption in and out of the home.

For example, in the hospitality sector significant reductions in the use of straws and stirrers may be possible. A challenge to overcome is changing behaviours and practices across this large and diverse sector. Even the largest high-street players in this market are franchised businesses with autonomy at the branch/restaurant level regarding practices. Interviewees from this sector in this research suggested a voluntary code of practice could be established around use - keeping such items hidden behind the counter, together with training for staff to ensure staff do not provide such items as default, reusable products. Notably, from May 2018, McDonalds will reportedly start using large paper-covered and biodegradable paper straws and will run a trial where straws are kept behind the counter to discourage their use[66]. It was not possible to understand and model such voluntary reduction in use scenarios in this preliminary research. Here, monitoring of the effectiveness of trials and dissemination of good practice could be valuable.

On a unit price level, it is striking the plastic products examined in this research are cheap (around half a penny per unit or less). As a way of addressing the litter market failure, funding could also be sought from

[66] https://uk.blastingnews.com/business/2018/03/mcdonalds-to-stop-giving-customers-plastic-straws-002465435.html

the supply chain (extended producer responsibility as promoted in the Circular Economy package) to finance consumer-targeted litter campaigns and better product labelling (e.g. product levies from a range of single-use products). With behaviour change, the environmental damage, indirect costs and disamenity impacts associated with the litter market failure would be reduced. For frequently littered and flushed items, a nationally coordinated campaign could be financed to reduce litter and the flushing of a broad range of single-use plastic. The time may be right for action on a range of toilet-flushed items (including cotton buds) and a significant and national 'do not flush or litter' campaign involving the water industry. Tampon applicators are the most frequently flushed items and wet wipes being a recognised problem. Each of these are also not effectively screened[67].

Changes in product design could also be encouraged. For example, strawless recyclable drinks cup lids and trials of reusable straws (used like cutlery) in pubs and restaurants. WRAP's Courtauld Commitment/Plastic Pact and innovation funding could be used to promote, facilitate and disseminate such change. Industry could be given a grace period (e.g. 2-3 years) from a ban and be supported to develop a roadmap/innovate and find plastic-free alternatives. At a point in the future, the government could review new evidence regarding the outcomes of such a voluntary code and the successes of product innovation and trials to decide when/whether a ban is necessary. Extended producer responsibility instruments such as product levies could be used to address the market failure in this way and fund consumer campaigns to reduce litter and improve waste management and recycling, on pack labelling and improved waste and resources management infrastructure.

4.5 Next steps

4.5.1 Further discussion / direction

This research is strategic and is at the preliminary stage. It is intended to help inform the Government's next stage decision on whether to legislate a ban for the researched products.

The research findings are clear - our discussions with key stakeholders indicate that a **universal ban for plastic stem cotton buds is feasible and would be likely to be welcomed in the immediacy** within this large retailer/brand dominated market. The quantitative research estimates indicate a ban could serve to bring forward the change and harmonise the market at low cost. The action of substituting plastic is at modest cost and since the market is already providing suitable alternatives the more qualitative disbenefits such as disutility are also likely to be small, whilst the benefits to marine life, social wellbeing and the economy could be great. From discussions with stakeholders, the lead-in time for a ban for plastic stem cotton buds could be short (perhaps less than one year) because large retailers are already working with the supply chain.

For stirrers, improper disposal of the product (littering) is less of an issue because most stirrers are used indoors. Because a significant proportion of this market is already plastic-free, and the product groups is well-defined and very visible to the consumer, it is felt this market will probably also experience further change and do so in the short term, irrespective of a ban. In common with cotton buds, **a ban for stirrers would hasten change in the market** (amongst some small businesses especially) and would prohibit any unsustainable plastic use in the long term, preventing any future return to use of plastics. It would also serve to strengthen the plastic-free market and protect it from plastic imports. More detailed LCA research

[67] Personal correspondence, Doreen Bell, Environmental Science & Regulation Analyst - Scottish Water

on disposable and reusable alternatives (plastic, wood and bioplastic) could help inform exactly which alternatives should be encouraged or prohibited under a ban.

Further consultation is recommended for drinking straws because there are not immediately available plastic-free functional alternatives for certain types of straws (medical uses, disabled groups, hot drinks uses and for some types of beverage containers). Longer lead-in times could be consulted upon and set individually for categories of product where no equivalent plastic-free product has yet been identified or developed commercially. Setting such a challenge, with the cooperation of industry, could inspire innovation and enhance competitiveness.

Any legislative ban for these products could be coordinated with other potential bans for different types of single-use plastic products.

4.5.2 Information gaps and further research

Appendix A.6 provides a list of the information gaps and further research which could ideally be addressed ahead of a ban proposal. As is being done in Scotland[68], Defra could work with an industry steering group to seek to overcome such needs and provide an implementation path, gathering further required evidence/primary data, or dismissing the identified needs as unimportant.

[68] https://beta.gov.scot/publications/stemming-the-plastic-tide-ministers-statement/

Appendices

A.1 Modelling and calculations

This appendix outlines the impact model developed for the research and provided an overview of its calculations

A description of the modelling process is illustrated again here in Figure 8. The number of sales was estimated in future years under Ban and No Ban scenarios. This was used to estimate the tonnes of products sold, which in turn was used to estimate the other impacts. The economic and environmental impacts associated with production, waste management and littering of each item were estimated per tonne of product sold.

The indicative model was focussed on single-use products and does not include the impacts associated with reusable products, or indeed the reuse of single-use products e.g. washing of plastic stirrers. The impacts calculated are based on current processes which have not, for example, been modified in future years to account for changes in production processes or decarbonisation of the electricity grid and transport.

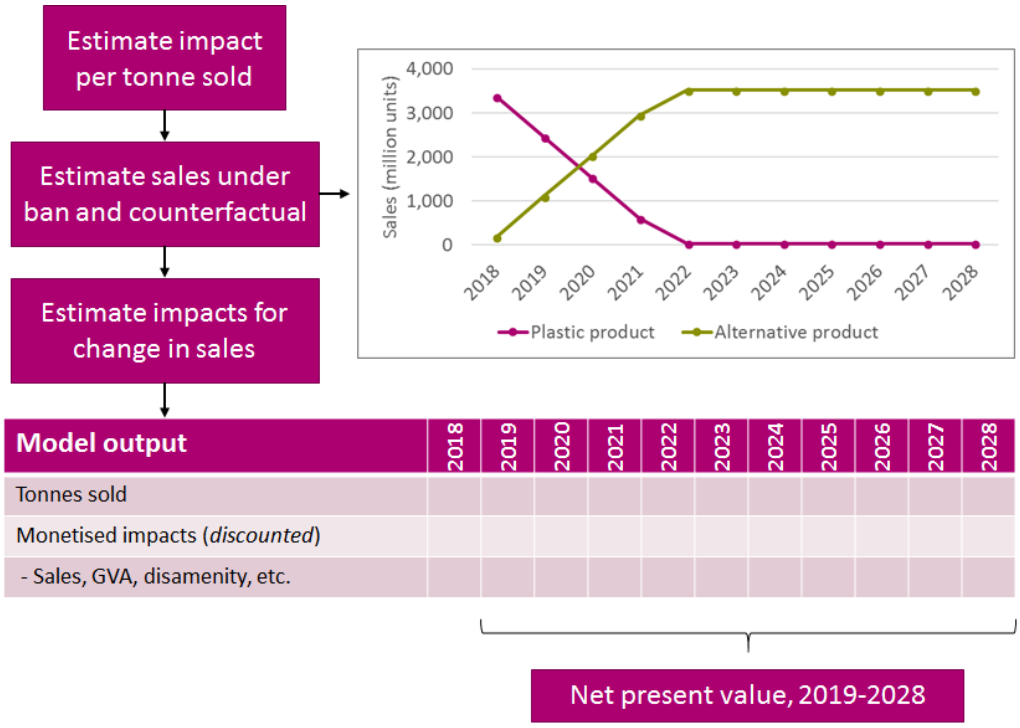

Figure 8: Description of the main structure and calculations in the model

Figure 9 illustrates how the economic impacts were estimated. In terms of model's scope, the quantitative assessment was guided by HM Treasury's Green Book Appraisal Guidance[69]. It focussed on the direct economic impacts to the UK, i.e. the effects on English-based manufacturers, wholesalers and retailers, and did not include impacts on 'rest of the world' businesses. Both direct 'market' impacts for retailers,

[69] https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

wholesalers/importers and English-based manufacturers and were considered, as well as indirect impacts on other markets. Type 1 multipliers were obtained from the ONS to estimate indirect impacts, it was necessary to use figures applying to the wider Standard Industrial Classifications (SIC) to which straws/stirrers/buds belong, rather than figures for those very specific industries, which are not the subject of estimation work by ONS. Example regulatory and business implementation costs were compiled for a Ban and No Ban scenario.

Direct impacts were estimated for the retail/wholesale and manufacturing sectors.

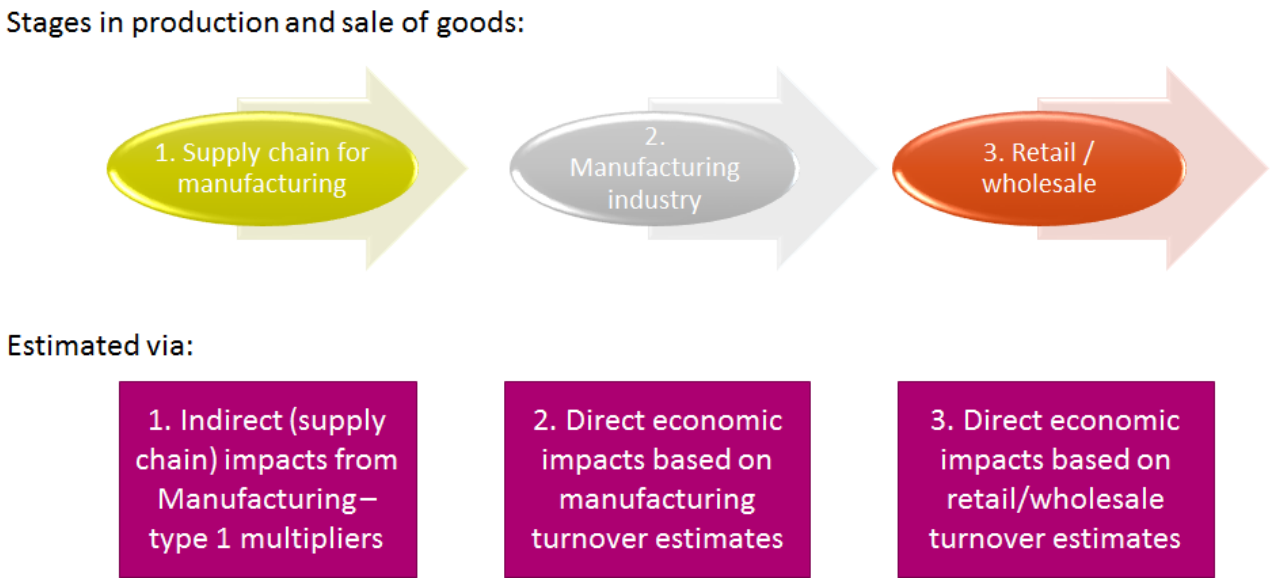

Figure 9: Description of the calculated supply chain and other economic impacts

Figure 10 shows how direct and indirect economic impacts were estimated for retail/wholesale and manufacturing. The value to retail/wholesale is estimated by deducting VAT where appropriate and assumes that 80% of revenues are passed on to manufacturing. Data from the ONS Annual Business Survey (ABS) was used to estimate how a change in turnover results in a change in GVA.

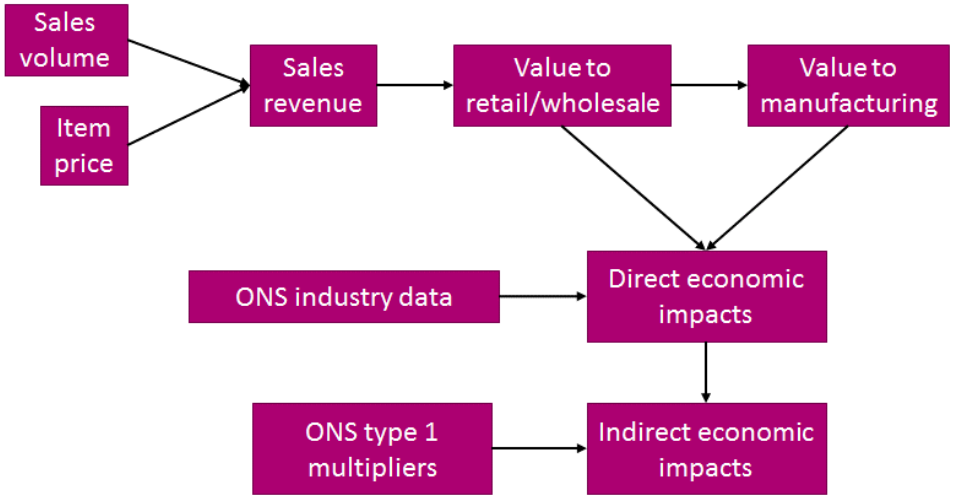

Figure 10: Description of the calculated economic impacts to retail/wholesale and manufacturing

Impact factors were used in the model to estimate overall costs and benefits e.g. the economic contribution from the market (GVA) and the carbon impact of materials used and disposed (CO2e for packaging material used from UK Government GHG Conversion Factors for Company Reporting). The estimates covered the costs of readily quantifiable direct and indirect costs associated with waste management and littering. Indicative environmental impacts were calculated for 'carbon' associated with production of materials and the disposal of products. These were classified into traded and non-traded carbon. Quantifiable social costs also were also examined. These included the change in household expenditure and the visual disamenity costs associated with terrestrial and beach litter, the latter estimated from secondary Willingness to Pay studies.

A simple modelling approach was taken for indirect impacts. For example, potential rebound effects associated with changes in consumption were not considered. Externality costs, for example placed on the tourism sector, were embodied within the visual disamenity cost.

Figure 11 shows how the tonnes of product sold were used to estimate the greenhouse gas (GHG) emissions associated with production of the goods and waste management, as well as the direct costs and economic impacts of waste management.

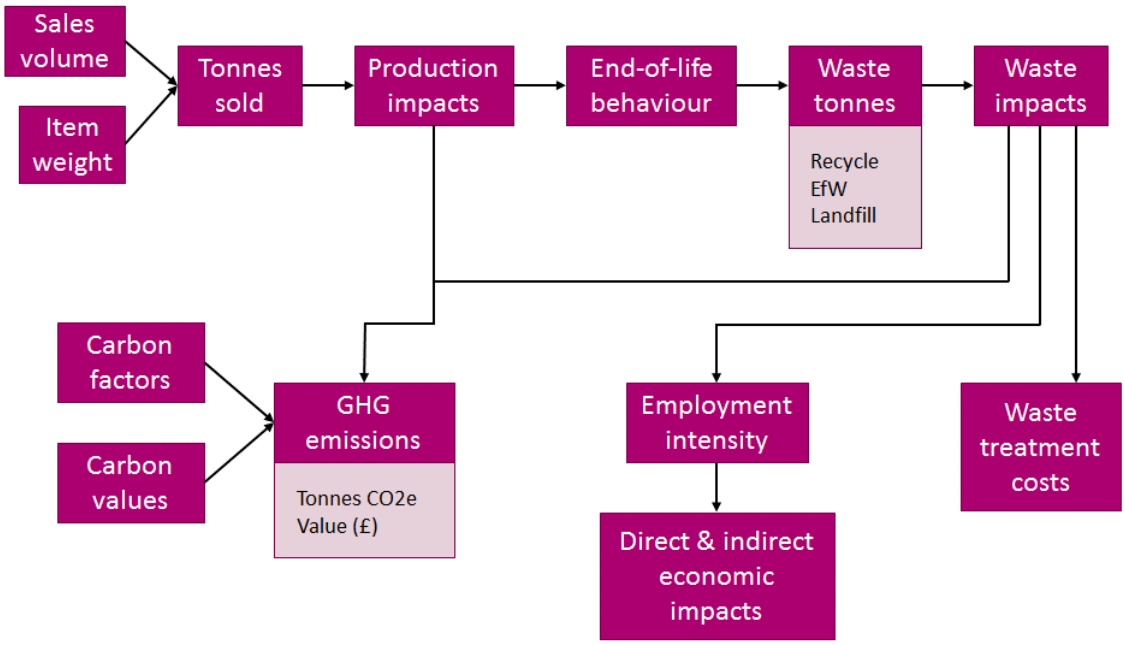

Figure 11: Description of the calculated production and waste management impacts

Figure 12 illustrates how the impacts of terrestrial and beach litter were estimated. Since beach litter visual disamenity effects are presence-based/aesthetic, costs were allocated to each type of product based on their estimates of relative litter volume, rather than beach litter count, surface area, or associated weight.

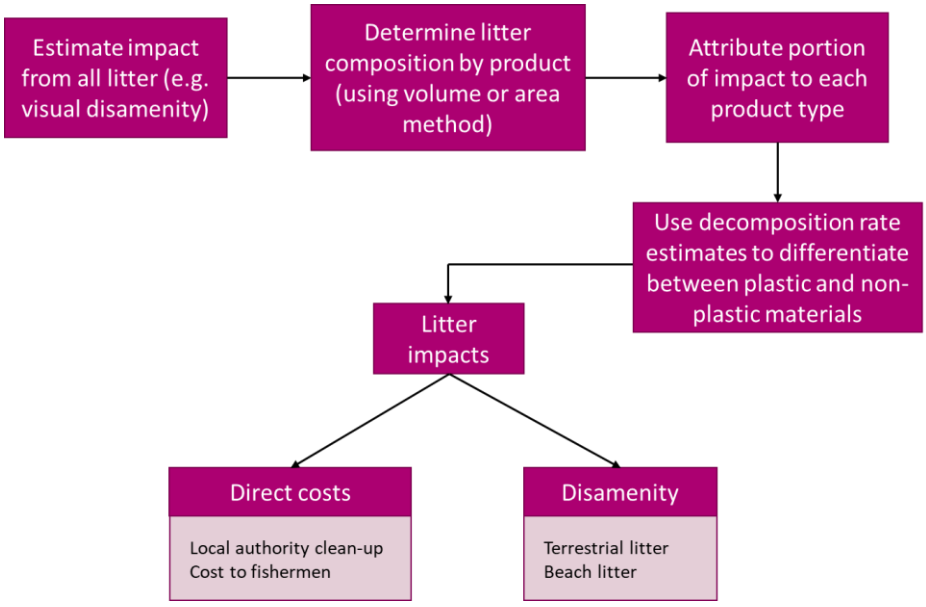

Figure 12: Description of the calculated litter impacts

Key data and uncertainties

The main data and assumptions used in the model and the uncertainties associated with each of them are presented in Table 21 below.

Table 21: Overview of data sources used in the model

Data / assumption	Sources	Level of uncertainty
Sales volume for products	Based on consumption data reported by large companies/estimates for market share, or associated items, e.g. coffee cups/ 'bottom-up' estimates based on likely behaviours.	High uncertainty
Speed of market change	Based on research insight gained on degree of voluntary change and speed of previous bans/proxy policies and through stakeholder interviews	Medium-high uncertainty
Littering and waste management	Mix of data on effectiveness of capture of litter and assumed consumer behaviours at each stage of pathway.	Medium-high uncertainty
Item price and weight	Spot values from main manufacturers and from wholesale and retail websites. Direct alternative products were not found for small beverage carton straws or medical-enabling straws.	Medium uncertainty
Terrestrial and Beach Litter Impacts	From historical, published research studies. KBT (2014) Exploring the Indirect Costs of Litter in England. Eftec (2002) Valuation of Benefits to England and Wales of a Revised Bathing Water Quality Directive and Other Beach Characteristics Using the Choice Experiment Methodology. Methodology underpinning each were examined.	Medium uncertainty
Industrial productivity – how turnover relates to GVA.	ONS Annual Business Survey, using SIC codes: • 16.2 Manufacture of products of wood, cork straw and plaiting materials • 17 Manufacture of paper and paper products • 22.21 Manufacture of plastic plates, sheets, tubes and profiles • 47 Retail trade, except of motor vehicles and motorcycles • 46 Wholesale trade, except of motor vehicles and motorcycles • 38 Waste collection, treatment and disposal activities; materials recovery	Medium uncertainty

Data / assumption	Sources	Level of uncertainty
Type 1 multipliers to calculate indirect (supply chain) impacts	ONS Input-Output Analytical Tables, matching SIC codes to those used above.	Medium uncertainty
Business and regulatory costs	Default/proxy costs informed by costs from impact assessments for bans for Microbeads and an assessment for introducing open scope categorisation for waste electrical and electronic equipment (WEEE), and they include annual cost and one-off costs over the period. No associated costs with exempting medical-enabling straws were included in the analysis.	Low uncertainty/low significance
Carbon emission factors	UK Government GHG Conversion Factors for Company Reporting, Defra/DECC GHG Protocol, Carbon Valuation in UK Policy Appraisal traded and non-traded prices	Low uncertainty/low significance

A.2 Record of data and assumptions

This appendix provides screenshots from the model illustrating the main data sources used to generate the central estimate.

Product sales data was not available for each of the different types of products examined. So, estimates had to be gathered from stakeholder discussions or derived from available information available suitable for preliminary indicative modelling domain. This appendix includes discussion around some of the key sales data used for the quantitative research. Uncertainty surrounding the estimates is examined through sensitivity analysis.

Table 22: Model assumptions for baseline product sales, central estimate

Product	Volume (million units per annum)
Cotton bud sticks	1,780[70]
Drink stirrers	202[71]
Large drinking straws	3,550[72]
Beverage carton straws	1,010[73]
Medical-enabling straws	44[74]

[70] Waitrose has estimated 21 tonnes of plastic saved by eliminating plastic-stemmed buds. https://www.cottonbudproject.org.uk/news/item/63-johnsons-paper-cotton-bud.html
At 5.1% of market a crude estimate for the total plastic placed on market would be ~412 tonnes. http://www.bbc.co.uk/news/business-41011259. Volume estimate assumes 1 unit is 0.25g and 75% of the weight is polypropylene stem. The estimated is scaled down for England based on its relative population.
[71] 2.5 billion coffee cups used each year in the UK http://www.independent.co.uk/news/business/latte-levy-government-rejects-25p-charge-disposable-coffee-cups-starbucks-costa-nero-pret-a-manger-a8247201.html. This is representative of single use drinks stirrers. It is realised that this estimate does not include reusable cocktail stirrers used in pubs and homes.
The volume estimate assumes a stirrer is used in 10% of purchases and allocates the estimate for England on population basis.
[72] 4.4 billion fast food drinking straws have been estimated as used in the UK each year (from http://www.bbc.co.uk/news/science-environment-43825197) x 81% representing the relative population of England.
[73] A large carton producer interviewed in the research estimated consumption to be between 1-1.5 billion in the UK per year in three main channels a) retail: lunchboxes/cars/picnics (50%) b) school milk (20%) c) Hospitality sector (30%). A value of 1.25 bn is used in the modelling and scaled for England on population basis.
[74] Bottom up estimate based on population and potential consumption behaviours. If 1% of each of the following groups required one straw each day:

Published estimates were also examined for the research for 'large drinking straws'. An estimate of 8.5 billion drinking straws has been made for the fast food market which is now believed to be erroneous. 42 billion straws a year used in the UK (640 per person)[75] has also been estimated which intuitively feels high. A conservative 3.5 billion drinking straws is used in this modelling to represent the large drinking straws market in England. This value (which is derived from the straw consumption of McDonalds (the largest player in the market) extrapolated for England) represents the fast food and drinks sector.

It is felt this most likely represents the majority of drinking straws consumed in the hospitality sector. Branded restaurants dominate this market[76] and McDonalds dominate this market by value, followed by JD Wetherspoon[77], with many hundreds of thousands of small and medium-sized businesses are also present in the hospitality sector. However, it is acknowledged as an uncertain value since the estimate is derived from a single large user and scaled based on what is known about this market. Moreover, it is a conservative value as it does not include large straw use in hospitality subsectors such as cinemas, events, pubs, other restaurants and hotels. It also does not include an estimate for large household and party drinking straws is also not included (this is anticipated to be small with some reusable products).

ONS data[78] on business statistics was examined in the research for the hospitality subsectors which are likely to consume significant straws. These were identified as SIC codes 56101: Licensed restaurants, 56102 : Unlicensed restaurants and cafes, 56103 : Take away food shops and mobile food stands, 56210 : Event catering activities, 56290 : Other food service activities, 56301 : Licensed clubs, 56302 : Public houses and bar, 5100 : Hotels and similar accommodation and 55201 : Holiday centres and villages.

~4.4% (2.8m of 63.26m) have manual dexterity disabilities https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/321594/disability-prevalence.pdf
~18.04% of the UK population are 65 years and over https://www.indexmundi.com/united_kingdom/age_structure.html (required for prescription medicine and/or manual feeding)
~ 0.1% severe dexterity difficulties. Parkinson's disease (PD) affects 1-2 per 1000 of the population at any time and 1.5-4 per 1000 live births are affected by Cerebral Palsy. PD prevalence is increasing with age and PD affects 1% of the population above 60 years [albeit only a small proportion of these will need feeding by mouth]

[75] http://www.bbc.co.uk/news/science-environment-43825197
[76] https://www.statista.com/statistics/711976/fast-food-market-value-united-kingdom-uk-by-type/
[77] https://www.bighospitality.co.uk/Article/2012/08/08/Technomic-Top-100-restaurant-chains
[78] https://www.nomisweb.co.uk/

It was not possible to use the data to make a more accurate estimate because the turnover value of the largest dominant businesses within each sector is withheld due to commercial confidentiality. Moreover, the use of large straws per unit turnover will vary depending on the type of hospitality business. For example, the pub chain All Bar One, which has around 50 premises, has estimated it uses large straws in 25% of its drinks, the equivalent of 13,000 a day across all its venues[79] The recent data for McDonalds suggests more straws are consumed per drink/meal[80]

Further research (primary data collection) is clearly required if more precision is required. The sensitivity analysis in this assessment considers uncertainty in this number, doubling the value to 7 billion straws representing a potential upper value for large drinking straws for England.

Table 23: Model assumptions for plastic products

Product	Cost per item (£ incl. VAT)	Per unit weight (g)
Cotton bud sticks	0.0050	0.25
Drink stirrers	0.0048	0.32
Large drinking straws	0.0065	0.55
Beverage carton straws	0.0006	0.50
Medical-enabling straws	0.0065	0.50

Table 24: Model assumptions for alternative products

Product	Sales price per unit (£ incl. VAT)	Per unit weight (g)
Cotton bud sticks	0.0050	0.44
Drink stirrers	0.0048	1.09
Large drinking straws	0.0248	1.18

[79] https://www.thedrinksbusiness.com/2017/09/wetherspoon-confirm-the-end-of-plastic-straws/
[80] http://www.mcdonalds.co.uk/ukhome/whatmakesmcdonalds/questions/running-the-business/facts-&-figures/how-many-meals-does-mcdonalds-serve-each-day-in-the-uk.html

Beverage carton straws	0.0025	0.50
Medical-enabling straws	0.0248	0.50

Economic data used for estimates

Model inputs, assumptions and estimates

Data and estimates

	Representative
	Based on example spot data or proxy data
	Based on assumptions

Economic data	2016 - Annual Business Survey							Type I Multipliers and effects (product)		From 2014 Input-Output Analytical Tables	
SIC & description	Employment	Turnover (£m)	GVA (£m)	Gross wages and salaries (£m)	Employment / turnover (£m)	Average salary (£)		SIC & description	Jobs Multiplier (assume same as employment cost)	Employment Cost Multiplier	GVA Multiplier
16.2 Manufacture of products of wood, cork straw and plaiting materials	72,000	7,722	3,206	1,347	9	18,708		16 Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	1.760	1.760	1.785
17 Manufacture of paper and paper products	56,000	10,967	3,508	1,555	5	27,768		17 Manufacture of paper and paper products	1.501	1.501	1.604
22.21 Manufacture of plastic plates, sheets, tubes and profiles	26,000	4,619	1,811	716	6	27,538		22 Rubber and plastic products	1.410	1.410	1.511
47 Retail trade, except of motor vehicles and motorcycles	3,157,000	383,189	87,703	43,072	8	13,643		47 Retail trade, except of motor vehicles and motorcycles	Not needed	Not needed	Not needed
46 Wholesale trade, except of motor vehicles and motorcycles	1,207,000	673,712	80,651	32,973	2	27,318					
38 Waste collection, treatment and disposal activities; materials recovery	105,000	18,057	6,742	2,759	6	26,276		38 Waste collection, treatment and disposal activities; materials recovery	2.148	2.148	1.887

Value added by retail	20%		
	VAT	Retail/wholesale	Manufacturer (and suppliers)
Split of final retail value	20%	16%	64%

Product data used in the assessment (for England)

A. Product data

	Total market - Baseline			Plastic product												
	Million units p.a.	Baseline plastic share	Proportion domestic B2C	Million units p.a.	Per unit weight (g)	of which is plastic	Material	Sales price per unit, incl. VAT	Gross cost to consumers (£m)	Annual value of retail/wholesale (£m)	Annual value of UK manufacturing (£m)	Tonnes placed on market p.a.	Consumed/disposed	Jobs - Retail/wholesale - Direct	Jobs - Manufacturing - Direct	Jobs - Manufacturing - Indirect
Cotton bud sticks	1,775	80%	100%	1,420	0.25	75%	Polypropylene	0.0050	7.1	5.7	0.1	266	Plastic - Often flushed	47	1	0
Stirrer	202	50%	0.1%	101	0.32	100%	Polystyrene	0.0040	0.5	0.4	0.0	33	Plastic - Indoor	1	0	0
Straw1 - drinking straws	3,553	95%	1%	3375.71296	0.55	100%	Polypropylene	0.0065	21.8	17.4	0.6	1857	Plastic - Mixed consump	32	3	1
Straw2 - beverage cartons	1009	95%	100%	959	0.5	100%	Polypropylene	0.0006	0.6	0.5	0.0	480	Plastic - Mixed consump	4	0	0
Straw3 - medical	44	100%	10%	44	0.5	100%	Polypropylene	0.0065	0.3	0.2	0.0	22	Plastic - Indoor	1	0	0
				Alternative product												
				Million units p.a.	per unit weight (g)	of which is alternative	Material	Sales price per unit, incl. VAT	Gross cost to consumers (£m)	Annual value of retail/wholesale (£m)	Annual value of UK manufacturing (£m)	Tonnes placed on market p.a.	Consumed/disposed	Jobs - Retail/wholesale - Direct	Jobs - Manufacturing	Jobs - Manufacturing - Indirect
English population	53.01		Cotton bud sticks	355	0.44	86%	Paper	0.0050	1.77	1.42	0.04	135	Biodegradable - Often flu	12	0	0
Ratio English to UK populati	81%		Stirrer	101	1.09	100%	Wood	0.0048	0.48	0.39	0.01	110	Wood - Indoor	1	0	0
Ratio NI to UK population	2.8%		Straw1 - drinking straws	178	1.18	100%	Paper	0.0248	4.41	3.52	0.11	210	Paper - Mixed consumpt	7	1	0
			Straw2 - beverage cartons	50	0.500	100%	Paper	0.0025	0.13	0.10	0.00	25	Paper - Mixed consumpt	1	0	0
			Straw3 - medical	0	0.500	100%	Paper	0.0248	0.00	0.00	0.00	0	Paper - Indoor	0	0	0

Implementing a ban / no ban

Annual costs	Share of costs	Ban - Regulatory cost (£m)	Ban - Direct cost to business per year	No ban - Regulatory cost (£m)	No ban - Business cost (£m)
Cotton bud sticks	25%	0.04	0.13	0.00	0.13
Stirrer	25%	0.04	0.13	0.00	0.11
Straw1 - drinking straws	40%	0.06	0.20	0.00	0.17
Straw2 - beverage cartons	9%	0.01	0.05	0.00	0.03
Straw3 - medical	1%	0.00	0.01	0.00	0.01

One-off cost	Ban - One-off regulatory cost (£m)
Cotton bud sticks	0.04
Stirrer	0.04
Straw1 - drinking stra	0.06
Straw2 - beverage ca	0.01
Straw3 - medical	0.00

Changes in the market under each of the scenarios

B. Scenario data			2018	2019	2020	2021	2022	2023	2024	2025
		Linear drop in % share each year	Baseline	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Cotton bud sticks	Plastic share - ban	50.0%	80%	30.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Stirrer	Plastic share - ban	20.0%	50%	30.0%	10.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Straw1 - drinking straws	Plastic share - ban	26.0%	95%	69.0%	43.0%	17.0%	1.0%	1.0%	1.0%	1.0%
Straw2 - beverage cartons	Plastic share - ban	20.0%	95%	75.0%	55.0%	35.0%	15.0%	1.0%	1.0%	1.0%
Straw3 - medical	Plastic share - ban	0.0%	100%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Cotton bud sticks	Plastic share - no ban	25.0%	80%	55.0%	30.0%	5.0%	1.0%	1.0%	1.0%	1.0%
Stirrer	Plastic share - no ban	10.0%	50%	40.0%	30.0%	20.0%	10.0%	5.0%	5.0%	5.0%
Straw1 - drinking straws	Plastic share - no ban	13.0%	95%	82.0%	69.0%	56.0%	43.0%	30.0%	17.0%	5.0%
Straw2 - beverage cartons	Plastic share - no ban	10.0%	95%	85.0%	75.0%	65.0%	55.0%	45.0%	35.0%	25.0%
Straw3 - medical	Plastic share - no ban	0.0%	100%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Ban - Product growth/reduction	0.0%
No ban - Product growth/reduction	0.3%
Proportion of plastic packaging market which is imports	95%

End of life management assumptions

Consumed/disposed	Plastic - Indoor	Plastic - Mixed consump	Plastic - Often flushed	Paper - Indoor	Wood - Indoor	Paper - Mixed consumpt	Biodegradable - Often
Recycle	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
EfW	71.02%	70.37%	65.32%	71.02%	71.02%	70.38%	71.02%
Landfill	28.88%	28.62%	26.57%	28.88%	28.88%	28.62%	28.89%
Sewage Treatment	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.01%
Terrestrial litter	0.10%	1.00%	0.00%	0.10%	0.10%	1.00%	0.00%
Marine litter	0.001%	0.01%	8.100%	0.00001%	0.00012%	0.00010%	0.08100%
Total	100%	100%	100%	100%	100%	100%	100%

		Consumed/disposed	% to terrestrial litter	% to marine litter
Cotton bud sticks	Plastic	Plastic - Often flushed	0.0%	8.100%
Stirrer	Plastic	Plastic - Indoor	0.1%	0.001%
Straw1 - drinking straws	Plastic	Plastic - Mixed consump	1.0%	0.010%
Straw2 - beverage cartons	Plastic	Plastic - Mixed consump	1.0%	0.010%
Straw3 - medical	Plastic	Plastic - Indoor	0.1%	0.001%
Cotton bud sticks	Alternative	Biodegradable - Often flu	0.0%	0.081%
Stirrer	Alternative	Wood - Indoor	0.1%	0.000%
Straw1 - drinking straws	Alternative	Paper - Mixed consumpt	1.0%	0.000%
Straw2 - beverage cartons	Alternative	Paper - Mixed consumpt	1.0%	0.000%
Straw3 - medical	Alternative	Paper - Indoor	0.1%	0.000%

Impact factors

C. Impact factors								
Production	Direct jobs / £m turnover	Direct salaries (£m) / £m turnover	Direct GVA (£m) / £m turnover	Direct cost	Indirect jobs / £m turnover	Indirect salaries (£m) / £m turnover	Indirect GVA (£m) / £m turnover	Traded T-CO2e / T
Polypropylene	6	0.155	0.392	N/A	2	0.064	0.200	3.1
Polystyrene	6	0.155	0.392	N/A	2	0.064	0.200	3.8
Paper	5	0.142	0.320	N/A	3	0.071	0.193	0.9
Wood	9	0.174	0.415	N/A	7	0.133	0.326	0.4

Visual disamenity (£m)				**Litter - Direct costs (£m)**			
£m / yr	Terrestrial litter	Marine litter		£m / yr	Terrestrial litter - LA clean-up cost	Marine litter - LA clean-up cost	Cost to fishing industry
Cotton bud sticks	0.0000000000	0.0104803653		Cotton bud sticks	0.0000000000	0.0004580185	0.0002035003
Stirrer	0.0019141285	0.0008334459		Stirrer	0.0004196036	0.0000364237	0.0000161833
Straws	1.7090433119	0.0825111471		Straws	0.3746460706	0.0036059460	0.0016021428

Visual disamenity and direct costs

Visual disamenity & litter direct costs (£m) - for current estimated share of litter items (by count)							
		Material	Terrestrial litter (£m)	Beach litter (£m)	Terrestrial litter - LA clean-up cost	Beach litter - LA clean-up cost	Cost to fishing industry
Cotton bud sticks	Plastic	Polypropylene	0.0000000000	0.0104542297	0.0000000000	0.0004568763	0.0002029928
Stirrer	Plastic	Polystyrene	0.0009570643	0.0007441482	0.0002098018	0.0000325212	0.0000144493
Straw1 - drinking straws	Plastic	Polypropylene	1.2524189484	0.0636146386	0.2745476575	0.0027801207	0.0012352238
Straw2 - beverage cartons	Plastic	Polypropylene	0.3558008376	0.0180723405	0.0779964936	0.0007898070	0.0003509159
Straw3 - medical	Plastic	Polypropylene	0.0161803792	0.0007811748	0.0035469642	0.0000341393	0.0000151683
Cotton bud sticks	Alternative	Paper	0.0000000000	0.0000261356	0.0000000000	0.0000011422	0.0000005075
Stirrer	Alternative	Wood	0.0009570643	0.0000892978	0.0002098018	0.0000039025	0.0000017339
Straw1 - drinking straws	Alternative	Paper	0.0659167868	0.0000334814	0.0144498767	0.0000014632	0.0000006501
Straw2 - beverage cartons	Alternative	Paper	0.0187263599	0.0000095118	0.0041050786	0.0000004157	0.0000001847
Straw3 - medical	Alternative	Paper	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000

End of life impacts

End of Life							
Recycle							
	Jobs / T-waste	Direct salaries (£m) / T-waste	Direct GVA (£m) / T-waste	Direct cost / T-waste	Indirect jobs / T-waste	Indirect salaries (£m) / T-waste	Indirect GVA (£m) / T-waste
Polypropylene	0.0093	0.0002	0.00060	0	0.0107	0.000	0.001
Polystyrene	0.0093	0.0002	0.00060	0	0.0107	0.000	0.001
Paper	0.0018	0.0000	0.00012	0	0.0021	0.000	0.000
Wood	0.0008	0.0000	0.00005	0	0.0009	0.000	0.000
Other waste management	Jobs / T-waste	Direct salaries (£m) / T-waste	Direct GVA (£m) / T-waste	Direct cost / T-waste	Indirect jobs / T-waste	Indirect salaries (£m) / T-waste	Indirect GVA (£m) / T-waste
EfW	0.00017	0.0000	0.00001	91	0.0002	0.000	0.000
Landfill	0.00007	0.0000	0.00000	107	0.0001	0.000	0.000
Sewage Treatment				107			
Energy from Waste (kWh / T)	Plastic	Paper	Wood				
All waste types	1,273	611	935		1 MJ to kWh	0.2778	
					EfW fuel to energy efficie	20%	
GHG Emissions, T-CO2e / T							
Traded	Polypropylene	Polystyrene	Paper	PLA	Wood		
Recycle	-0.60	-0.60	-0.13	-0.92	-0.31		
EfW	-0.45	-0.45	-0.21	-0.45	-0.33		
Landfill							
Sewage Treatment							
Terrestrial litter							
Marine litter							
Non-traded	Polypropylene	Polystyrene	Paper	PLA	Wood		
Recycle	0.02	0.02	0.02	0.02	0.02		
EfW	0.02	0.02	0.02	0.02	0.02		
Landfill	0.01	0.01	1.04	0.82	0.82		
Sewage Treatment							
Terrestrial litter	0.01	0.01	1.04	0.82	0.82		
Marine litter							

Example data held in model

Economic Data

Global Assumptions

Cost year	2018
Index	100

Discounting

Discounting is a technique used to compare costs and benefits that occur in different time periods. It is a separate concept from inflation, and is based on the principle that, generally, people prefer to receive goods and services now rather than later.This is known as 'time preference'.
Values are discounted from 2019 onwards as the model was written in FY 2018 and presents all monetary values as £ 2018 real terms.

Source: HM Treasury, THE GREEN BOOK, Appraisal and Evaluation in Central Government
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

	0 to 30 years
Discount rate	3.50%

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Year index	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Discount factor	1.00	0.97	0.93	0.90	0.87	0.84	0.81	0.79	0.76	0.73	0.71	0.68	0.66	0.64	0.62	0.60	0.58	0.56	0.54	0.52	0.50	0.49	0.47	0.45	0.44	0.42	0.41

Imports of data

Input Output Analytical Tables, 2014
https://www.ons.gov.uk/economy/nationalaccounts/supplyandusetables/datasets/ukinputoutputanalyticaltablesdetailed

Using Input Output Analytical Tables to compare household consumption of domestic vs. imported products.

SIC 22 Rubber and plastic products

2014	Households	%
Imports use	2072	99%
Domestic use	12	1%

Model assumptions to use:

	Low	High	Central
% imports	90%	100%	35%

... Upper (4) | Inflation | Economic Data | Litter | Waste Data | ZWS Carbon Factors | GHG UK e ...

A.3 Terrestrial and marine litter impacts and costs

This appendix provides a review of terrestrial and marine composition, costs and impacts.

Terrestrial litter composition

The most recent Local Environmental Quality Survey of England (LEQSE), covering terrestrial litter, was undertaken by Keep Britain Tidy (KBT) in 2014/15[81]. This found that 90% of sites examined met an acceptable standard in terms of overall litter and 10% of sites are of an unacceptable standard. The survey found that 53% of sites were affected by non-alcoholic drinks-related litter (which includes drinks carton straws), and 32% of sites were affected by fast food-related litter (which includes large drinking straws and stirrers from fast food outlets and coffee shops).

The previous year, the KBT 2013/14 litter composition survey of England[82] found the composition of terrestrial litter, by item count, was:

- 2.0% non-alcoholic straws;
- 1.2% non-alcoholic cartons (some containing straws) and
- 6.4% fast food packaging (fast food straws and stirrers are not individually reported).

This suggests that plastic straws are likely to be between 2% and 10% of litter items, but most likely in the lower part of this range around 2-4%. The prevalence of plastic stirrers is harder to gauge but this is likely to be much lower than straws.

Straws and stirrers are relatively small litter items and so would be expected to represent a small proportion of litter when calculated by volume rather than item count. The KBT terrestrial litter data does not report the volume of different litter items collected. The New South Wales Environment Protection Authority provides a calculator (which is usable in a UK context) to convert litter counts to volume estimates[83]. We assume straws to be 3% of terrestrial litter by item count (based on the KBT 2014/15 litter composition survey of England) and assume that one stirrer is littered for every hundred straws based on less frequent outdoors consumption of these items. Using these assumptions with the NSW EPA tool and the KBT litter data, the terrestrial litter composition (by item) is assumed to be:

- 0.087% straws,
- 0.00015% stirrers, and
- We assume a negligible volume of cotton bud sticks because these items are predominantly used in the home.

Cotton bud sticks are not separately reported in terrestrial litter surveys as they are not a commonly found item but are much more prominent on beaches where they account for 3.7% of litter items.[84] This indicates that they enter the marine environment through another pathway. Experts consulted[85] suggest that cotton buds are flushed down the toilet after use into sewerage and are not screened out of the waste water

[81] Keep Britain Tidy (2015), How clean is England? The local environmental quality survey of England 2014/15. Results excluding cigarette ends, chewing gum staining and solid gum.
[82] Keep Britain Tidy (2014), Litter composition study of England, http://www.incpen.org/docs/KBTINCPENLitterComposition2014.pdf
[83] NSW EPA, Do a local litter check, https://www.epa.nsw.gov.au/your-environment/litter-and-illegal-dumping/epa-work-prevent-litter/run-litter-prevention-project/local-litter-check
[84] Marine Conservation Society (2016), Great British Beach Clean 2016
[85] Personal communication with Laura Foster, MCS; Sarah Archer, Fidra; and Tony Harrington, Welsh Water and 21st Century Drainage.

further down the pipe due as their small diameter allows them to pass through the screens or are discharged directly to rivers and the sea during rainstorms.

Small plastic/polystyrene pieces are the most common item found on beaches (225 pieces / 100m length of beach), cotton bud sticks are the 8th most common (27 items / 100m) and cutlery (including stirrers)/trays/straws are the 10th most common (15 items / 100m). [86]

The costs of terrestrial litter

The indirect costs of terrestrial litter in England were explored in a report commissioned by Keep Britain Tidy[87]. The study identifies sixteen impacts in which litter is thought to be a significant contributing factor. These factors are listed in Figure 13 and highlight the far-reaching impact of litter. Many of these costs are internalised in market transactions whereas others are externalities felt by society such as the sense of welfare loss from a park strewn with litter. The study estimates costs for nine of the sixteen indirect impacts, which ranged from £8 million per year for litter impacts on road traffic accidents to £526 million per year for the cost to mental wellbeing.

Figure 13: Description of the different types of Indirect impacts of terrestrial litter[88]

The indirect costs of terrestrial litter study[89] estimated the local disamenity of litter in England to be between £702 million and £7.6 billion based on willingness to pay studies, with a best estimate of £5.1

[86] Marine Conservation Society (2017), Great British Beach Clean 2017 Report, https://www.mcsuk.org/media/GBBC_2017_Report.pdf
[87] Keep Britain Tidy (2014), Exploring the Indirect Costs of Litter in England
[88] Keep Britain Tidy (2014), Exploring the Indirect Costs of Litter in England
[89] Keep Britain Tidy (2014), Exploring the Indirect Costs of Litter in England

billion. An earlier study[90] applied a similar methodology to estimate the disamenity of terrestrial litter in Scotland to be £73m to £770m, with a best estimate of £513m. In 2016, Zero Waste Scotland reviewed the evidence and subsequently adjusted the way in which these willingness to pay values are aggregated to a national level, arguing the value is based on willingness to pay additional council tax and so should be aggregated based on household numbers rather than a population basis[91]. This reduces the upper value in Scotland from £770m to £361m. There may be a case for adjusting the disamenity costs for terrestrial litter in England accordingly. This adjustment would reduce the upper value of disamenity for terrestrial litter in England from £7.6 billion to £4.2 billion (2014 prices). The model conservatively uses the £4.2 billion value as the upper estimate, which is £4.4 billion in today's prices.

The disamenity cost encompasses external costs not represented in market transactions. It also includes many of the internalised costs shown in Figure 13 where citizens are aware of the wider impact of litter, e.g. on crime, wellbeing, and property values, and these costs are reflected in their willingness to pay to improve terrestrial litter. The indirect costs and disamenity cost estimates cannot therefore be summed together without risking double counting. The disamenity cost is the most representative overall cost of terrestrial litter. However, not all impacts will be represented in disamenity estimates based on willingness to pay. For example, the cost of ingestion of litter by livestock, as the average citizen is unlikely to see the impact or be able to estimate the cost.

The costs of marine litter

Litter also has a broad range of direct and indirect impacts on the marine environment. Some of the main market impacts are listed in Figure 14. Scientific understanding of its exact impacts of plastic waste is still in its infancy and the relative risks associated with different types and sizes of plastic debris is only just beginning to be considered[92] The impacts are the subject of on-going scientific research, and whilst understanding is improving many impacts are still not fully understood.

[90] Zero Waste Scotland (2013) Exploring the Indirect Costs of Litter in Scotland, https://www.zerowastescotland.org.uk/sites/default/files/Exploring%20the%20Indirect%20Costs%20of%20Litter%20in%20Scotland.pdf
[91] ZWS (2017), Deposit Return Evidence Summary, https://www.zerowastescotland.org.uk/sites/default/files/Deposit%20Return%20Evidence%20Summary.pdf
[92]http://ec.europa.eu/environment/integration/research/newsalert/pdf/clarity_needed_plastic_waste_environmental_impact_for_evidence_based_policy_506na3_en.pdf

Marine life

- Birds, mammals, fish, plankton, filter feeders
- Ingestion, starvation, choking, entanglement
- Invasive species (rafting)
- Biodiversity

Food web

- Affecting non-marine species
- Bio-accumulation of toxins
- Availability of food & prey

Human health

- Impacts not fully understood

Habitats

- Supporting marine life
- Quality of natural capital

Ecosystem services

- Tourism and recreation
- Physical and mental wellbeing
- Climate regulation
- Nutrient cycling
- Food provision
- Drinking water
- Biotic materials
- Cultural services
- Photosynthesis
- Primary production

Fisheries

- Stock and health of catch species
- Consumer confidence in product
- Interference with boats and gear

Remediation

- Local authority clean-up
- Volunteer efforts
- Fishing for litter

Figure 14: Description of the different types of impacts of marine litter

A 2010 study by KIMO into the economic impacts of marine litter[93] estimates costs of marine litter as follows:

- €18 million per annum cost of beach litter removal by coastal municipalities in the UK.
- Volunteer time, valued at the national minimum wage, equates to €131,000 for the MCS Beachwatch and Keep Scotland Beautiful (KSB) National Spring Clean coastal clean-ups.
- Between €11.7 million and €13 million per annum cost to the Scottish fishing industry[94], equivalent of 5% of the total revenue of affected fisheries. Some of these costs are related to impacts of larger litter items that cause ghost fishing, entangle propellers, damage boats and gear, or contaminate the catch (e.g. paint and oil). However, most of the costs relate to time lost clearing nets, which is relevant to all litter items larger than a few millimetres.
- €2.4 million per annum cost to UK harbours associated with marine litter removal to ensure their facilities are safe and attractive to use.
- An unquantified impact on the coastal tourism industry. Two estimates are given for the total value of coastal tourism between €7-11 billion annually.

[93] KIMO (2010), Economic impacts of marine litter, http://www.kimointernational.org/wp/wp-content/uploads/2017/09/KIMO_Economic-Impacts-of-Marine-Litter.pdf
[94] The range of costs to the fishing industry relates to how time spent by fishing vessels clearing litter from nets is attributed to specific issues caused by marine litter.

Regarding beach litter disamenity, several studies are noted. Eftec conducted a willingness to pay study for DEFRA in 2002[95], which found households were willing to pay £5 to £11 to see litter free beaches. Respondents were asked what level of extra water charges they were willing to pay for improvements (e.g. having no litter/dog mess). The authors analysed the socio-economic characteristics of the respondents and found them to be representative of the population of England and Wales, including both people who make use of beaches and bathing waters as well those who do not. The willingness to pay value therefore reflects both the use and non-use value. Aggregated to the number of households in England, and inflated to today's prices, this equates to an estimate of £220 million to £404 million. These values are used to estimate the visual disamenity of all beach litter, a small portion of which is then attributed to plastic cotton bud sticks, straws and stirrers in the model.

A second study from 2013[96]also investigated the willingness for collection and prevention of beach litter on the west coast of Ireland. However, the survey population of the study only includes beach users, whose willingness to pay is likely to be much higher than the general population. The willingness to pay values could be aggregated to a national level based on beach visits/visitors but this would not account for the non-use value, e.g. those who haven't visited the seaside but nevertheless place a value on its cleanliness and environmental quality.

A third estimate of £521 million to £1.1 billion disamenity cost per annum is given for beach litter in KBT research on the indirect costs of litter[97], based on an unpublished willingness to pay study for the general public in Scotland. However, the values appear to be erroneous. When contacted, Nick Hanley one of the authors of the cited willingness to pay study, reported that these figures appeared to be an order of magnitude larger than his own data.

Following an assessment of evidence, the values from the Eftec estimates of £220 million to £404m have been used for all marine litter and allocated to the individual products in the study. However, it is noteworthy all willingness to pay estimates are outdated, particularly as media coverage and public interest in marine litter and plastic waste has intensified in recent years. For example, in 2015, a 5p levy was introduced on single-use plastic carrier bags in large businesses. In the same year, evocative photos and video of a plastic straw being removed from the nose of a turtle[98] were circulated online. In 2016, a ban on plastic microbeads in cosmetic products was announced. In 2017, the popular BBC natural history program Blue Planet II narrated by David Attenborough focussed on marine plastic pollution in its final episode, leading to widespread discussion of the issue[99]. In January 2018, the EU launched its Plastics Strategy[100], with many actions focussed on reducing marine litter impacts, and UK Government published its 25 year environmental plan[101] in which eliminating avoidable plastic waste and pollution featured strongly and generated media coverage of proposals such as plastic-free supermarket aisles. As mentioned previously,

[95] Eftec (2002), Valuation of Benefits to England and Wales of a Revised Bathing Water Quality Directive and Other Beach Characteristics Using the Choice Experiment Methodology
[96] Hynes et al. (2013) Estimating the value of improvements to coastal waters resulting from revisions of the EU Bathing Waters Directive
[97] Keep Britain Tidy (2014), Exploring the Indirect Costs of Litter in England
[98] The Leatherback Trust (2015), Removing a plastic straw from a sea turtle's nostril - Short Version, https://www.youtube.com/watch?v=d2J2qdOrW44
[99] Radio Times (2018), Viewers react to David Attenborough's final Blue Planet II conservation rallying cry, http://www.radiotimes.com/news/tv/2018-03-28/blue-planet-2-plastic-waste-final-episode/
[100] European Commission (2018), A European Strategy for Plastics in a Circular Economy, http://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy-brochure.pdf
[101] HM Government (2018), A Green Future: Our 25 Year Plan to Improve the Environment https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf

several large retailers and manufacturers have already announced phasing out plastic cotton buds, straws and stirrers in response to public interest.

One study found that litter from public consumption sources such as on-the-go packaging had a greater psychological impact than fishing industry litter such as rope, nets and packaging[102]. The reasons for this were explored and participants in the study commented that the public litter was more intrusive, indicative of people being careless and disrespectful, out of place as those items should only be seen in a city, and that non-biodegradable objects (plastics) are harmful to ocean life. Visual disamenity is likely to be related to the size of the items, their location, how much they stand out visually (e.g. bright colours), and how 'out of place' they appear in the environment.

For the central estimates, the model uses the relative volume of different litter items to allocate the visual disamenity value. As straws, stirrers and cotton bud sticks are relatively small items the visual disamenity cost attributed to them is less when estimated on a volume basis. Due to uncertainty, an alternative long-sectional area allocation method is examined in this research within the sensitivity analysis provided in the study.

Decomposition of marine debris

Decomposition rates for common types of marine debris are shown in Table 25. The alternative products that would replace plastic are made from paper or wood, reducing the decomposition period from tens or even hundreds of years to a matter of weeks or months for paper and a few years for wood.

Table 25: Decomposition rates for common types of marine debris [103]

Item	Decomposition rate
Paper towel	2-4 weeks
Newspaper	6 weeks
Wax carton	3 months
Plywood	1-3 years
Plastic grocery bag	10-20 years*
Styrofoam cup	50 years*
Plastic beverage bottle	450 years*
Fishing line	600 years*
Apple core	2 months

* NOAA comments: Many scientists believe plastics never entirely go away. These decomposition rates are estimates for the time it takes for these items to become microscopic and no longer be visible. Sources: EPA, Woods Hole Sea Grant

[102] Wyles et al. (2015), Factors That Can Undermine the Psychological Benefits of Coastal Environments, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5066481/

[103] Talking trash & taking action, Ocean Conservancy & NOAA Marine Debris, https://marinedebris.noaa.gov/sites/default/files/publications-files/talking-trash-educational.pdf. Note that these values have not been verified. We were unable to find the original source of this data table online, and so we cannot be certain it is from a study by the US EPA, nor can we check the methods used to estimate the decomposition rates. As noted in the footnote to the table, decomposition rates for plastics are estimates only. Actual decomposition rates cannot have been measured yet as the polymers used in these

Where regular litter removal occurs on land, such as in public places and urban centres, the alternative products are unlikely to decompose before they are cleared. In harder to reach places, such as rural areas, and alongside rural road and rail lines, litter is cleared much less frequently. Based on an assessment of research and the fact that paper and wood substitutes degrade much quickly, the impact of shifting to the alternative products is therefore unlikely to have a large impact in urban areas but will have a much more prominent impact in the countryside. The main impact will be felt in the marine environment, where litter is more difficult to clear and plastic material can remain indefinitely. The model assumes that switching from plastic straws and cotton bud sticks to paper reduces the marine litter impact of that product to 1% of the plastic product, due to the difference in decomposition rates of these materials. Table 25 suggests wood takes around 12 times longer to decompose than paper (comparing upper decomposition estimates: 3 years plywood, 3 months wax carton), and so switching from plastic to wood stirrers is assumed to reduce the impacts to 12% of that of the plastic product.

products have been used in manufacturing for less time than the decomposition rates shown. 'Wax carton' is thought to refer to a Tetrapak-style container of card with laminates of plastic film and aluminium.

A.4 Full results from the sensitivity analysis

This appendix provides the full results from the sensitivity analysis.

Impact analysis findings are presented using ranges, as recommended in HM Treasury's *Green Book*. A lower and upper value for the key model inputs and assumptions are tested. This sensitivity analysis shows the effect that uncertainty in model input and assumptions has on the impact analysis.

Model inputs are varied one at a time to understand how 'sensitive' the impact analysis is to each model input. The results are shown in the tables below. For each model input tested, the central, lower and upper values are shown in the first table. The second table shown in each group displays the impact analysis resulting from the sensitivity test.

Sales units

This sensitivity test indicates what happens to the modelled variables when the number of units of product sold changes by 10% around the central point for buds, stirrers, and beverage carton straws. The large drinking straws estimate is based on the number of straws used by McDonalds scaled up by their market share of the fast food industry. This estimate is used to represent all large drinking straws as party straws are estimated to be sold in low volumes. The upper estimate for drinking straws is therefore set at 200% of the central estimate to test the impact analysis if large straws from retail and other hospitality are a much larger market than expected. Medical-enabling straws are not considered since these are exempted from the ban.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Sales units p.a.	Buds, stirrers, and carton straws	Item estimates	1	90%	0.9	110%	1.1
Sales units p.a.	Large drinking straws	Item estimates	1	90%	0.9	200%	2.0

Table 26: Sales units sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	0.5	none	none
Sales	76.0	68.4	151.0	-10%	+98%
Revenues to UK manufacturing	2.5	2.2	4.8	-10%	+98%
Waste treatment cost	0.3	0.3	0.6	-10%	+96%
Local Authority Clean-up cost	-0.1	-0.1	-0.1	negligible	negligible
Cost to fishing industry	negligible	negligible	negligible	negligible	negligible
GVA	10.6	9.5	20.8	-10%	+97%
Value of traded CO2e	-0.1	-0.1	-0.2	+10%	-63%
Value of non-traded CO2e	negligible	negligible	0.1	-10%	+87%
Terrestrial litter visual disamenity	-0.2	-0.2	-0.2	negligible	negligible
Beach litter visual disamenity	-0.2	-0.2	-0.1	negligible	negligible

Product price

This sensitivity test indicates what happens when the price of large paper-based straws drops as demand increases and economies of scale are realised. Reducing the product price makes large paper-based straws cheaper than plastic, for example £4.96 per 1,000 large paper-based drinking straws and £6.45 per 1,000 plastic-based drinking straws. In the central estimate it is more expensive to shift to paper-based straws, as reflected in the impact estimates for sales, revenue to UK manufacturing, and GVA. In the sensitivity test it becomes slightly cheaper to use the paper-based alternative.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Product price	Paper-based straws	Item estimates	1	20%	0.2	100%	1.0

Table 27: Product price sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	0.5	none	none
Sales	76.0	-10.0	76.0	-113%	none
Revenues to UK manufacturing	2.5	-0.3	2.5	-112%	none
Waste treatment cost	0.3	0.3	0.3	none	none
Local Authority Clean-up cost	-0.1	-0.1	-0.1	none	none
Cost to fishing industry	negligible	negligible	negligible	none	none
GVA	10.6	-1.5	10.6	-114%	none
Value of traded CO2e	-0.1	-0.1	-0.1	none	none
Value of non-traded CO2e	negligible	negligible	negligible	none	none
Terrestrial litter visual disamenity	-0.2	-0.2	-0.2	none	none
Beach litter visual disamenity	-0.2	-0.2	-0.2	none	none

Market base

The market base refers to the share of the market that will not shift to non-plastic materials, for example small operators that may not be subject to a ban if a de-minimis is set in legislation, and traders that do not voluntarily shift in the No Ban scenario. For example, under the Ban scenario the market for drinking straws is expected to change to 99% alternative materials within 5 years. Two sensitivity tests are applied. The first tests what happens when, under the Ban scenario, the market for drinking straws changes to 97.5% alternative materials but no further. The second test indicates what happens when, under the No Ban scenario, the market for straws and stirrers changes to 75% alternative materials but no further.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Market base - Ban	Drinking straws	Plastics to 1% base	1%	100%	1.0%	250%	2.5%
Market base - No Ban	Straws and stirrers	Plastics to 5% base	5%	100%	5.0%	500%	25.0%

Table 28: Market base (for straws and stirrers) sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	1.1	none	+108%
Sales	76.0	76.0	108.0	none	+42%
Revenues to UK manufacturing	2.5	2.5	3.5	none	+41%
Waste treatment cost	0.3	0.3	0.4	none	+48%
Local Authority Clean-up cost	-0.1	-0.1	-0.1	none	-4%
Cost to fishing industry	negligible	negligible	negligible	none	-32%
GVA	10.6	10.6	15.0	none	+42%
Value of traded CO2e	-0.1	-0.1	-0.2	none	-69%
Value of non-traded CO2e	negligible	negligible	0.1	none	+128%
Terrestrial litter visual disamenity	-0.2	-0.2	-0.2	none	none
Beach litter visual disamenity	-0.2	-0.2	-0.2	none	-32%

Speed of shift – No Ban - Buds

The speed of shift refers to the rate at which the market shifts from plastic products to alternative materials. This sensitivity tests what happens when there is a slower shift for cotton buds in the No Ban scenario. This is modelled by adjusting the value used for the upper estimates. The results show this sensitivity test has almost no effect on the impact estimates.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Speed of shift - No Ban	Buds	25 point drop in plastic % market share each year, e.g. linear reduction of 80% to 55% to 35%	1	100%	1.0	67%	0.7

Table 29: Speed of shift - Buds sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	0.5	none	none
Sales	76.0	76.0	76.0	none	none
Revenues to UK manufacturing	2.5	2.5	2.5	none	negligible
Waste treatment cost	0.3	0.3	0.3	none	+7%
Local Authority Clean-up cost	-0.1	-0.1	-0.1	none	negligible
Cost to fishing industry	negligible	negligible	negligible	none	-5%
GVA	10.6	10.6	10.6	none	negligible
Value of traded CO2e	-0.1	-0.1	-0.1	none	negligible
Value of non-traded CO2e	negligible	negligible	negligible	none	+3%
Terrestrial litter visual disamenity	-0.2	-0.2	-0.2	none	none
Beach litter visual disamenity	-0.2	-0.2	-0.2	none	-5%

Speed of shift – No Ban – Straw and stirrers

This sensitivity test alters the speed of shift, from plastic product to alternative material, for straws and stirrers in the No Ban scenario. More straws are sold than any other item in the model and so altering the speed of the shift from plastic to alternative materials has a pronounced effect. The sensitivity test slows the speed of shift in the No Ban scenario, whilst the speed of shift in the Ban scenario remains the same. The amplified difference between the two scenarios shows in the results below, where this sensitivity test is applied in the upper estimates. For example, the difference in sales is increased due to the slower shift in the No Ban scenario, and this has ripple effects on the other impact estimates.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Speed of shift - No Ban	Straws and stirrers	10 point drop in plastic % market share each year, e.g. 50% to 40% to 30%	1	100%	1.0	95%	0.95

Table 30: Speed of shift – Straw and stirrers sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	0.6	none	+15%
Sales	76.0	76.0	83.6	none	+10%
Revenues to UK manufacturing	2.5	2.5	2.7	none	+10%
Waste treatment cost	0.3	0.3	0.3	none	+10%
Local Authority Clean-up cost	-0.1	-0.1	-0.1	none	negligible

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Cost to fishing industry	negligible	negligible	negligible	none	-8%
GVA	10.6	10.6	11.7	none	+10%
Value of traded CO2e	-0.1	-0.1	-0.2	none	-10%
Value of non-traded CO2e	negligible	negligible	negligible	none	+15%
Terrestrial litter visual disamenity	-0.2	-0.2	-0.2	none	negligible
Beach litter visual disamenity	-0.2	-0.2	-0.2	none	-8%

Volume growth rate - Ban

Volume growth rate refers to how the market for cotton buds, straws and stirrers grows or shrinks in future years, irrespective of materials used. In the central estimates the model assumes a small market growth of 0.3% per annum in the No Ban scenario, less than the 0.6% population growth anticipated. The central estimate assumes there is no market growth under the Ban, or in effect a slight drop in consumption per person as market growth doesn't keep up with population increase. The lack of growth under the Ban reflects the signalling effect to the market and consumers about the possible environmental risks associated with these products.

In this sensitivity test the growth rate is varied in the Ban scenario, as outlined below. As a compound growth rate, the effect is relatively large, as can be seen in the results table.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Volume growth rate - Ban	All		0%		-1%		0.6%

Table 31: Volume growth rate - Ban sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	0.5	none	none
Sales	76.0	43.4	96.6	-43%	+27%
Revenues to UK manufacturing	2.5	1.4	3.1	-42%	+27%
Waste treatment cost	0.3	0.1	0.4	-73%	+46%
Local Authority Clean-up cost	-0.1	-0.2	negligible	-283%	+178%
Cost to fishing industry	negligible	negligible	negligible	negligible	negligible
GVA	10.6	5.7	13.7	-47%	+29%
Value of traded CO2e	-0.1	-0.2	-0.1	-52%	+33%
Value of non-traded CO2e	negligible	negligible	0.1	-83%	+52%
Terrestrial litter visual disamenity	-0.2	-0.9	0.2	-321%	+202%
Beach litter visual disamenity	-0.2	-0.2	-0.2	negligible	negligible

Volume growth rate - No Ban

This second sensitivity test on volume growth rates tests the effect of different growth rates in the No Ban scenario. The values tested are shown below. As with the sensitivity test above, the effect of the different compound growth rates is considerable.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Volume growth rate - No Ban	All products		0.3%		-0.1%		0.6%

Table 32: Volume growth rate - No Ban sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	0.5	none	none
Sales	76.0	88.2	66.7	+16%	-12%
Revenues to UK manufacturing	2.5	2.8	2.2	+16%	-12%
Waste treatment cost	0.3	0.4	0.2	+28%	-22%
Local Authority Clean-up cost	-0.1	negligible	-0.1	+117%	-90%
Cost to fishing industry	negligible	negligible	negligible	negligible	negligible
GVA	10.6	12.4	9.2	+18%	-13%
Value of traded CO2e	-0.1	-0.1	-0.2	+23%	-18%
Value of non-traded CO2e	negligible	negligible	negligible	+32%	-24%
Terrestrial litter visual disamenity	-0.2	0.1	-0.4	+133%	-102%
Beach litter visual disamenity	-0.2	-0.1	-0.2	negligible	negligible

% imports

This sensitivity investigates uncertainty around what proportion of consumption is met by imported goods. The central estimate assumes 95% of products are imported. Testing values of 90% and 100% effects the revenue to UK manufacturing and the GVA generated, as shown in the table below.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
% imports	All		95%		90.0%		100.0%

Table 33: Imports sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	0.5	none	none
Sales	76.0	76.0	76.0	none	none
Revenues to UK manufacturing	2.5	4.9	none	+100%	-100%
Waste treatment cost	0.3	0.3	0.3	none	none

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Local Authority Clean-up cost	-0.1	-0.1	-0.1	none	none
Cost to fishing industry	negligible	negligible	negligible	none	none
GVA	10.6	11.8	9.4	+11%	-11%
Value of traded CO2e	-0.1	-0.1	-0.1	none	none
Value of non-traded CO2e	negligible	negligible	negligible	none	none
Terrestrial litter visual disamenity	-0.2	-0.2	-0.2	none	none
Beach litter visual disamenity	-0.2	-0.2	-0.2	none	none

Buds waste management - flushed

This sensitivity indicates how the results are affected by using different assumptions around the disposal of cotton buds, specifically what proportion are flushed down the toilet. Varying the central assumption by plus and minus 50% has almost no effect on the impact estimates, as shown below.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Waste management - flushed	Buds		8.1%	50%	4.1%	150%	12.2%

Table 34: Buds waste management - flushed sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	0.5	none	none
Sales	76.0	76.0	76.0	none	none
Revenues to UK manufacturing	2.5	2.5	2.5	none	none
Waste treatment cost	0.3	0.3	0.3	negligible	negligible
Local Authority Clean-up cost	-0.1	-0.1	-0.1	negligible	negligible
Cost to fishing industry	negligible	negligible	negligible	negligible	negligible
GVA	10.6	10.6	10.6	negligible	negligible
Value of traded CO2e	-0.1	-0.1	-0.1	negligible	negligible
Value of non-traded CO2e	negligible	negligible	negligible	negligible	negligible
Terrestrial litter visual disamenity	-0.2	-0.2	-0.2	none	none
Beach litter visual disamenity	-0.2	-0.1	-0.2	negligible	negligible

Stirrer waste management - littered

This sensitivity test indicates the effect of different littering rates for stirrers. The results show there is almost no effect on the impact estimates from varying the littering rate by plus and minus 50% from the central estimate.

Central, lower and upper estimate values are presented below for terrestrial litter rate sensitivity tests. Beach litter is also varied by the same ratio.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Waste management – littered	Stirrer		0.10%	50%	0.05%	150%	0.15%

Table 35: Stirrer waste management - littered sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	0.5	none	none
Sales	76.0	76.0	76.0	none	none
Revenues to UK manufacturing	2.5	2.5	2.5	none	none
Waste treatment cost	0.3	0.3	0.3	negligible	negligible
Local Authority Clean-up cost	-0.1	-0.1	-0.1	negligible	negligible
Cost to fishing industry	negligible	negligible	negligible	negligible	negligible
GVA	10.6	10.6	10.6	negligible	negligible
Value of traded CO2e	-0.1	-0.1	-0.1	negligible	negligible
Value of non-traded CO2e	negligible	negligible	negligible	negligible	negligible
Terrestrial litter visual disamenity	-0.2	-0.2	-0.2	negligible	negligible
Beach litter visual disamenity	-0.2	-0.2	-0.2	negligible	negligible

Straws waste management - littered

This sensitivity test indicates the effect of different littering rates for straws. The varying the littering rate by plus and minus 50% from the central estimate carries through to the litter-related impact estimates. Straws are dominant in the litter impacts as they are more commonly found in litter surveys and tend to be larger than the other plastic products considered in this study.

Central, lower and upper estimate values are presented below for terrestrial litter rate sensitivity tests. Beach litter is also varied by the same ratio.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Waste management – littered	Straws		1.00%	50%	0.50%	150%	1.50%

Table 36: Straws waste management - littered sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	0.5	none	none
Sales	76.0	76.0	76.0	none	none
Revenues to UK manufacturing	2.5	2.5	2.5	none	none
Waste treatment cost	0.3	0.3	0.3	negligible	negligible
Local Authority Clean-up cost	-0.1	negligible	-0.1	+50%	-50%
Cost to fishing industry	negligible	negligible	negligible	+47%	-47%
GVA	10.6	10.6	10.6	negligible	negligible
Value of traded CO2e	-0.1	-0.1	-0.1	negligible	negligible
Value of non-traded CO2e	negligible	negligible	negligible	negligible	negligible
Terrestrial litter visual disamenity	-0.2	-0.1	-0.3	+50%	-50%
Beach litter visual disamenity	-0.2	-0.1	-0.2	+47%	-47%

Waste management - recycling rates

This sensitivity test indicates the effect of different recycling rates. Higher recycling rates reduces waste management costs and produces some savings on carbon emissions.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Waste management - recycling rates	All		0.00%		0.000%		10% of reported packaging recycling rates

The central estimate assumes that these products are not recycled, on the basis that most are consumed in the bathroom, outdoors or in restaurants, cafes and takeaways where typically there is limited provision for recycling facilities. The sensitivity analysis uses the material-specific packaging recycling rates for the UK reported to Eurostat. However, these recycling rates are not directly applicable to cotton buds, straws and stirrers as they are estimates for a broad range of packaging materials. Furthermore, the plastic packaging recycling rates have recently been the subject of some debate, alternative estimates are shown in the last two columns of the table below. The products are therefore assumed to achieve a recycling rate of 10% of the general packaging recycling rates reported to Eurostat.

Table 37: Packaging recycling rates reported to Eurostat and alternative estimates

Waste type	Eurostat[104]	Eunomia[105] - low	Eunomia - high
Plastic packaging	39%	23%	29%
Paper & cardboard packaging	77%		
Wood packaging	29%		

Table 38: Recycling rates sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	0.5	none	none
Sales	76.0	76.0	76.0	none	none
Revenues to UK manufacturing	2.5	2.5	2.5	none	none
Waste treatment cost	0.3	0.3	0.3	none	-13%
Local Authority Clean-up cost	-0.1	-0.1	-0.1	none	none
Cost to fishing industry	negligible	negligible	negligible	none	none
GVA	10.6	10.6	10.5	none	negligible
Value of traded CO2e	-0.1	-0.1	-0.1	none	negligible
Value of non-traded CO2e	negligible	negligible	negligible	none	-8%
Terrestrial litter visual disamenity	-0.2	-0.2	-0.2	none	none
Beach litter visual disamenity	-0.2	-0.2	-0.2	none	none

Visual disamenity value

A range of values is given in willingness to pay studies used to calculate the visual disamenity value for terrestrial and beach litter. This sensitivity test indicates the effect of using the lower and upper bounds of the willingness to pay values.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Visual disamenity value - terrestrial and beach litter	All	Terrestrial: Keep Britain Tidy (2014, adjusted as described), Marine: Eftec (2002)	Mid-point		LRange		U'Range

[104] Eurostat: Packaging waste by waste operations and waste flow [env_waspac], http://ec.europa.eu/eurostat/web/waste/key-waste-streams/packaging
[105] Eunomia (2018), Plastic Packaging Shedding Light on the UK Data, http://www.eunomia.co.uk/reports-tools/plastic-packaging-shedding-light-on-the-uk-data/

Table 39: Visual disamenity value sensitivity, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Lower (£m)	Upper (£m)	Lower - % change from central estimate	Upper - % change from central estimate
Regulatory implementation cost	1.4	1.4	1.4	none	none
Business implementation cost	0.5	0.5	0.5	none	none
Sales	76.0	76.0	76.0	none	none
Revenues to UK manufacturing	2.5	2.5	2.5	none	none
Waste treatment cost	0.3	0.3	0.3	none	none
Local Authority Clean-up cost	-0.1	-0.1	-0.1	none	none
Cost to fishing industry	negligible	negligible	negligible	none	none
GVA	10.6	10.6	10.6	none	none
Value of traded CO2e	-0.1	-0.1	-0.1	none	none
Value of non-traded CO2e	negligible	negligible	negligible	none	none
Terrestrial litter visual disamenity	-0.2	-0.1	-0.4	+72%	-72%
Beach litter visual disamenity	-0.2	-0.1	-0.2	+29%	-29%

Methodological sensitivity- Attribution of visual disamenity value

The methodological sensitivity test indicates the effect of using different methods to attribute the visual disamenity value for the littered items relating to cotton buds, straws and stirrers. This sensitivity is described in detail in Section 3.7.2. The effect on the impact estimates is significant, as shown in the table below.

Model variable	Product types	Central est.	CValue	Lower (Best)	Lvalue	Upper (Worst)	Uvalue
Visual disamenity value - terrestrial and beach litter	All		Volume-based		Volume-based		Area-based

Table 40: Methodological sensitivity- Attribution of visual disamenity value, Difference – Ban over No Ban, NPV 2019 to 2028 (£m)

	Central (£m)	Sensitivity - Central (£m)	Sensitivity - Central - % change from central estimate
Regulatory implementation cost	1.4	1.4	none
Business implementation cost	0.5	0.5	none
Sales	76.0	76.0	none
Revenues to UK manufacturing	2.5	2.5	none
Waste treatment cost	0.3	0.3	none
Local Authority Clean-up cost	-0.1	-0.4	-635%
Cost to fishing industry	negligible	negligible	negligible
GVA	10.6	10.6	none
Value of traded CO2e	-0.1	-0.1	none
Value of non-traded CO2e	negligible	negligible	negligible
Terrestrial litter visual disamenity	-0.2	-1.7	-676%
Beach litter visual disamenity	-0.2	-0.7	-332%

A.5 Potential considerations for legislation for ban

The recent banning of microbeads in cosmetic products was cited as a proxy for a new ban by some of the stakeholders interviewed in the research. A brief review of the English legislative ban on Microbeads[106] was undertaken, as a potential starting point for a new ban on buds, straws and stirrers. The review illustrates some of the many considerations and the types of changes which may be possible.

Overview of the microbeads bans as a potential proxy

The Microbeads ban is a complete product ban on the use of microbeads is cosmetics. Legislation was passed in January 2018 in both England and Scotland and the ban itself will come into force in July 2018. It is suggested these legislations and the definitions and offences contained within them could provide an analogy for a new legislative ban.

These legislations make it an offence to manufacture or supply (sell, present or promote) rinse-off cosmetic products containing microbeads. Both "manufacturers" and "suppliers" (which is not defined specifically in the legislation) may be found guilty of an offence. Plastic is defined within the legislation as a "synthetic polymeric substance".

Required additions for a ban – product definitions and exemptions

If a ban were to be introduced, the scope of products covered would need to be defined. A clear scope definition would both include and exclude certain types of products. For example, if the legislation was drafted for only single-use products it would enable effective controls over such disposable products, whilst permitting specifically-designed durable reusable alternative products to be developed in the market. This could encourage further reusable plastic straws and stirrers designs to be developed (whether these be bio-based or fossil-based), affecting an overall reduction in plastics use.

Each banned product would also need to be defined by function in legislation. For example, drinking straws might be defined by their function e.g. "a long thin hollow paper or plastic tube, used for sucking up cold/hot liquids into the mouth". Stirrers might also be defined by function, so they include cover coffee stirrers and include single use plastic teaspoons but exclude reusable teaspoons.

Uses could also be defined for each product e.g. "use in bars, restaurants, hotels and domestic consumption in and out of the home", or by size. This would solve exemptions to the legislation e.g. for the administration of granulated medication and for disabled groups requiring flexible plastic straws.

A threshold for 'plastic-free' products may also need to be considered in the legislation. An absolute ban on plastics from fossil-derived sources could be proposed, or a threshold/percentage content approach to allow for trace fossil content by weight (e.g. for laminated straws/plastic-based cotton adhesive) at a level which did not compromise subsequent waste management and recycling. Radiocarbon dating could be used by manufacturers to prove only trace levels of fossil carbon within their products.

Required additions for a ban – acceptable alternative materials

[106] https://www.legislation.gov.uk/uksi/2017/1312/contents/made

The legislation could seek to promote plastic-free alternatives that are better over the life cycle. For instance, the legislation might permit only the use of sustainably-sourced bio-based products and ensure the composability of bioplastics in a terrestrial environment/biodegradability in a marine environment[107 108.] A prerequisite for bio-based alternatives might be that products are made from accredited 'sustainable' sources e.g. Forest Stewardship Council (FSC), or equivalent business-to-business procurement sustainability standard. Fossil-fuel based oxo-biodegradable plastics could be discouraged since these can contribute to greenhouse gas emissions at end of life.

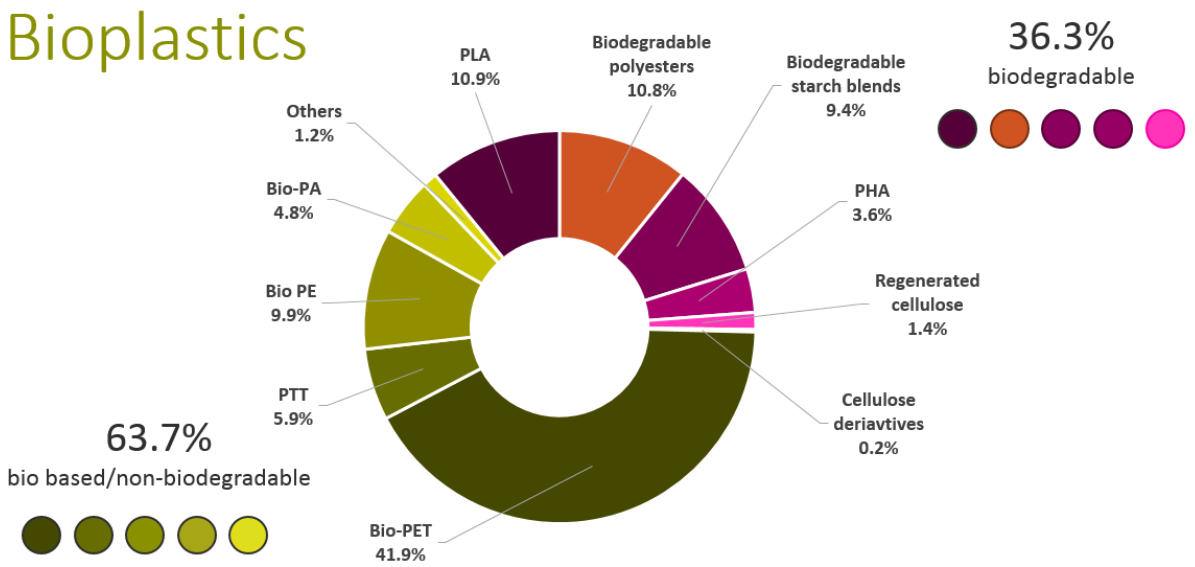

Figure 15: Breakdown of global bioplastics production types by volume[109]

The legalisation could be drafted to promote behaviours in line with predominant end of life practices/practicability and recycled content thresholds could even be set for some types of reusable products (glass, metals) to enhance their sustainability. At public consultation a call for life cycle-based evidence could be made to support or refute any requirements.

Lead-in times could be set in the legislation for categories of product where no equivalent plastic-free product has yet been identified but where research and product development are expected to provide a solution in the future

[107] Organisation for Economic Co-operation and Development (Unpublished). Review of Secondary Plastics Markets. Presented at 10th Meeting of the Working Party on Resource Productivity and Waste, 4-6 December 2017
[108] https://wedocs.unep.org/bitstream/handle/20.500.11822/7468/-Biodegradable_Plastics_and_Marine_Litter_Misconceptions,_concerns_and_impacts_on_marine_environments-2015BiodegradablePlasticsAndMarineLitter.pdf.pdf?sequence=3&isAllowed=y
[109] Institute for Bioplastics and Biocomposites (2016), Biopolymers facts and statistics, http://bit.ly/2meEh7C

A.6 List of information gaps and further research

This appendix provides a list of the data gaps and suggested further research actions.

Table 41: Data gaps/further research needs

Data gap/uncertainty	Further research needs
Improved estimates for the starting volume of products to improve precision of quantitative modelling	Primary market research/questionnaire regarding procurement of large drinking disposable straws and reusable drinks straws and stirrers by key players in each of the submarkets (fast food and drink, cinemas, pubs, hotels, events etc.) and scaling by share to make sector-wide estimates. Corroboration of other estimates for sales in UK/England for the other researched products.
Improved estimates for the sales price and weight of products	Telephone survey on costs and weights (prices from suppliers and large business-to-business buyers). Weighing of a sample of products in the market.
Confirmation of variables – implementation costs, necessary exemptions and lead-in times, pace of market transition, depth of market change, understanding supplementary/alternative measures	Steering/consultation group to review research findings and recommendations
Improved knowledge of predominant waste management, littering behaviours and pathways to marine litter for single-use plastics and their alternatives	Behavioural insights consumer research for different types of single-use plastics Mass flow (Sankey) estimates by product type for disposal and littering routes
Quantify impact of national campaign aimed at improving litter/flushing behaviours	Impact assessment of a national campaign aimed at improving litter/flushing behaviours as a complementary option for reducing avoidable plastics use i.e. campaign cost required to reduce littering behaviours by 1%
Confirmation of feasible plastic-free alternatives for drinking straws in predominant single-use markets	Innovation/ trials of non-plastic/strawless alternatives in takeaway sector and beverage cartons to feasible, equivalent alternatives. Research into decomposition rates of waxed / laminated and oxy-biodegradable straws.
Comparative environmental life cycle assessments regards single-use drinking straw alternatives – paper, bioplastic, titanium, pasta, straws and reusable such as metal, glass and bamboo	Review of current life-cycle research. Call for evidence and work with retailers and encourage main producers to provide multi-impact (carbon and other eco-toxicological consequences) comparative product LCAs to ensure low overall environmental outcomes. For reusable items, identify critical determinants of whether reusable product conveys environmental advantage over single-use products (e.g. how many times reused, resource intensity of cleaning).

Data gap/uncertainty	Further research needs
Price elasticity of supply and demand / effects of voluntary reduction scenarios	Manufacturer and other stakeholder consultations/questionnaires to establish whether increased unit costs for non-plastic products would be short-lived or long term. Consumer surveys (of both businesses and domestic consumers) to assess buyer/consumer attitudes to potential new materials, and how these would affect demand. What reduction in use of straws and stirrers is possible through reduced use behaviours in the hospitality sector (e.g. availability on request evidence from trials, reuse behaviours). Further modelling/sensitivity analysis could indicate these affects in the scenarios.
Valuing the costs and impacts of marine litter – direct costs, externalities and disamenity	Detailed literature review and compilation of data estimates to a structured approach to cover market and non-market costs such as disamenity and avoid any double counting. New primary 'Willingness to pay' research may be relevant for England (Noting that Scotland has recently commissioned social research on attitudes in Scotland on the marine environment and marine issues).
Evidence on which sizes and types of marine debris are most environmentally and socially significant – volume, size or count-based allocation	Which types of marine litter are most visible/socially undesirable? How robust is the evidence-base on marine litter disamenity? Which size plastic objects are most deleterious to the marine supply chain and to higher forms of marine life? e.g. in terms on ingestion and chemical migrations. New primary willingness to pay research is suggested for England to the product level (all single-use plastics could be covered at both the terrestrial and beach litter level).
Evidence of causality / the impact of bans in UK waters	Further counts of carrier bags in the environment and other items such as plastic stem cotton buds. Comparison of presence of Microbeads pre and post ban.
Upcoming bans for other types of single-use plastics	Preliminary impact assessment for other types of single-use plastics e.g. wet wipes, tampon applicators etc.

Glossary

Term	Definition
Allocation/Attribution	The process of sharing out/estimation based on a relative approach e.g. allocating total UK sales of a product to England based on the relative population of each country
Beach litter visual disamenity	The economic disadvantage/lowered amenity caused visually specifically at beaches
Bio-based/Biogenic	Products whose main constituent substance is originally derived from a recent living organism such as plant matter
Biodegradable	A substance or object of any material capable of being decomposed by bacteria or other living organisms
Bioplastic	Plastics derived from renewable biomass sources, such as vegetable fats and oils, corn starch, or microbiota or agricultural by-products
CO2e	A universal unit of measurement that allows the global warming potential of different Greenhouse Gases (GHGs) to be compared
Deterministic sensitivity analysis	Analysis of how the uncertainty in the output of a mathematical model or system can be apportioned to different sources of uncertainty in its inputs. Deterministic sensitivity analysis changes one or more input parameters to determine the extent the change has an impact on the output values
Disamenity	The economic disadvantage or reduced level of amenity, for example in a place, area or job
Disutility	In economics disutility represents the dissatisfaction experienced by the consumer from a good
Large drinking straws	Straight, or flexible straws typically provided with takeaway drinks and at pubs, restaurants etc.
Fossil material/resources	Material/resources used to produce items such as products whose main constituent substance is originally derived from fossil fuels such as oil, coal and gas
Functionality	The purpose that something is designed or expected to fulfil
Gross Value Added (GVA)	the total value of output of goods and services produced less the intermediate consumption (goods and services used up in the production process to produce the output)
Lead-in time	A lead-in time is the time interval between initiation and full implementation
Life cycle assessment (LCA)	A technique to assess environmental impacts associated with all the stages of a product's life from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, disposal, re-use or recycling
Life cycle thinking	An approach which considers how an entire product or activity system impacts the environment

Term	Definition
Medical-enabling straws	In our research, these are straws used for dispensing prescription medicines and flexible plastic straws used by people with specific needs
Net Present Value (NPV)	A measurement of worth calculated by subtracting the present values of cash outflows (including initial cost) from the present values of cash inflows over a period
Sales	The monetary value of items sold each year excluding sales tax
Single use plastics	Disposable plastics which are used only once before they are thrown away or recycled. These items are things like plastic bags, straws, drinks stirrers, water bottles and most food packaging.
Small beverage carton straws	Straws associated with small beverage cartons and pouches used to dispense drinks such as juices and milk e.g. for on-the-go consumption, packed lunches etc.
Terrestrial litter visual disamenity	The economic disadvantage/lowered amenity caused by visual litter on land (not in the marine environment/at beaches)
Type 1 multiplier	An economic multiplier used to estimate the indirect economic benefits to the wider economy of an increase in consumption of a specific product or service. The indirect effects relate to activity in the manufacturing supply chain
Value of traded CO2e	Monetary value of greenhouse gas equivalent emissions that can be traded under the European Union Emissions Trading System