Written evidence submitted by the Environmental Investigation Agency

Executive Summary

Microplastics are a cause for concern because their small size (<5mm) means that they can be ingested by organisms throughout the marine food chain. Studies have now documented ingestion of microplastics by a range of species, including seabirds, marine mammals, fish and invertebrates.[1] There is clear evidence of adverse effects at the individual level, with impacts on growth and reproduction. Such effects could potentially cause population and community level impacts and affect ecosystem wide processes through negative effects on primary and secondary producers at the base of the food chain. In addition, there is a clear risk that microplastics in seafood could compromise food safety, however the complexity of estimating microplastic toxicity means that the potential risks to human health are currently difficult to quanitfy.

Concerns regarding the environmental impacts of microplastics and potential economic costs resulting from damage to commercial fisheries and marine ecosystems have driven a number of Governments to establish legislation banning plastic microbeads in personal care products. Although microbeads in personal care and other consumer products do not represent the largest source of primary microplastics, they represent a readily preventable source of microplastic pollution. Legislation is urgently needed to speed up the phase-out of microbeads, maintain long-term industry commitments, ensure a level playing field for UK manufacturers and prevent additional microplastic pollution from entering UK seas. There also remains considerable scope to prevent other sources of microplastics, including through the EU Circular Economy Package and actions at the UK level, recommendations for which are included in our response.

Introduction

The Environmental Investigation Agency (EIA) is an independent organisation working to combat environmental crime and protect threatened species and habitats. EIA uses evidence gathered through its investigations to campaign for change, raise public awareness, and advocate practical solutions that ensure the protection of threatened species and habitats. EIA's international oceans campaign includes a programme of work on marine plastic pollution.

1. a) How do microplastics impact on marine plants and animals? What economic consequences could result from increased microplastic pollution in the ocean?

Marine plastic pollution poses a global threat to marine biodiversity due to its abundance, widespread distribution (both geographically and within the water column) and persistence in the marine environment.[2] Macroplastics impact on marine species such as birds, marine mammals and turtles where ingestion or entanglement can cause physical injury and death. Microplastics are a cause for concern because their small size (<5mm) means that they can be ingested by organisms throughout the marine food chain, including those at the base of the food web. Studies have now documented ingestion of microplastics by a range of species, including seabirds, marine mammals, corals, fish and invertebrates (see Table 1). The latter include pelagic and demersal fish species and suspension and filter-feeding invertebrates, many of which perform vital ecosystem functions and are important in commercial fisheries.[3]

The impacts of microplastic ingestion on marine fauna include gut blockage, physical injury, oxidative stress, altered feeding behaviour and reduced energy allocation, with resulting impacts on growth and reproduction.[4] In addition to physical impacts there is the potential for transfer of toxins associated with plastics. Microplastics can concentrate persistent, bioaccumulative and toxic (PBT) chemicals such as PCBs (polychlorinated biphenyls) and DDEs (metabolites of DDT, dichloro-diphenyl-trichloroethane) from seawater and often also contain additives with endocrine disrupting properties.[5] The transfer of chemicals from microplastics to biological tissue has been demonstrated and correlated with adverse effects in invertebrates, fish, seabirds and fin whales (see Table 1). However, the extent to which plastics contribute to trophic transfer of such chemicals, compared to transfer via prey, is as yet largely unknown.[6]

In a recent paper 'Marine microplastics spell big problems for future generations' Galloway & Lewis (2016)[7] outline how legislation to restrict sources of marine plastic pollution is often restricted by a lack of evidence of ecological harm. Building upon work by Sussarellu *et al*. (2016)[8] and a number of other studies they review existing evidence that ingestion of microplastics can impact on feeding, energy allocation and reproduction, all key components of an organism's fitness. Table 1 below includes a range of the existing studies which have been undertaken and a summary of their findings. These indicate that microplastics can cause adverse effects in a range of species and that the presence and severity of negative impacts varies between species and life stages. Trophic transfer of microplastics has also been demonstrated, including within the planktonic food web.[9] A recent review of the 'Sources, fate and effects of microplastics in the marine environment'[10] by the UN Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) states that in addition to impaired health at the organism level, the ingestion of microplastics could potentially cause population and community level effects and affect ecosystem wide processes through negative effects on the photosynthesis of primary producers and the growth of secondary producers. Although negative effects have been demonstrated at the individual organism level, few studies have yet to look for population-level effects from microplastic ingestion. The scale and implications of effects on species at the base of the food chain for the productivity and resilience of ecosystems in the long term is unknown.

With regards to economic consequences, conservative estimates of the overall financial damage of plastics to marine ecosystems stand at US$13 billion each year, but this assessment excluded the impact of microplastic.[11] Concern from EU Member States regarding economic impacts from microplastics in the marine environment has driven four countries to call for a ban on microplastics in detergents and cosmetics, stating that while there was still some scientific uncertainty about the sources of contamination, "what we already know is sufficient to take action". The Netherlands is particularly concerned that commercial seafood – including its national production of mussels – could be impacted by microplastic pollution.[12] While there has been little quantification of the economic consequences of microplastic pollution, the scientific evidence indicates the potential for significant costs resulting from damage to biodiversity and ecosystem function, as well as commercial fisheries and the seafood industry.

Table 1: Summary of findings from scientific studies of the impact of microplastics on marine and freshwater species.

Species	**Summary of findings**
Zooplankton	Microplastics shown to be ingested by zooplankton and impede feeding, with prolonged exposure significantly decreasing reproductive output in *Calanus helgolandicus*.[13] Negative effects on survival and fecundity have also been observed in *Tigriopus japonicas*.[14]
Water fleas	Water fleas shown to ingest microplastic particles, with short-term exposure of *Daphnia magna* to high concentrations of microplastic particles limiting their mobility and as a result reducing nutrient intake.[15]

Species	Summary of findings
Marine worms	Microplastic ingestion was shown to decrease energy reserves and reduce feeding activity in marine worms (lugworm, *Arenicola marina*), a keystone species inhabiting intertidal sediments in Northern Europe.[16] A second study also found that polystyrene ingestion reduced feeding activity, increased weight loss and increased bioaccumulation of PCBs. There were statistically significant effects on the organisms' fitness but the magnitude of the effects was not high.[17]
Mussels	Microplastics identified in two species of bivalve (*Mytilus edulis, Crassostrea gigas*) cultured for human consumption[18] and found to translocate from the gut to the circulatory system[19] and cause inflammation at the tissue /cellular level.[20]
Oyster	Ingestion of microplastics shown to interfere with energy uptake and allocation and reproduction, with negative impacts on adult fecundity and offspring quality.[21] No measurable effects were found on oyster (*Crassostrea gigas*) larvae.[22]
Crab	Microplastics shown to be both ingested via prey and through inspiration across the gills in shore crabs (*Carcinus maenas*).[23] Ingestion of rope microfibres reduced food consumption and resulted in a significant reduction in energy available for growth.
Sea urchin	Adverse effects on embryonic development observed in the sea urchin *Lytechinus variegatus*.[24]
Corals	Experimental feeding trials revealed that corals mistake microplastics for prey. Ingested microplastics were found wrapped in mesenterial tissue within the coral gut cavity, suggesting that ingestion of high concentrations of microplastic debris could potentially impair the health of corals.[25]
Fish	Exposure of rainbow fish (*Melanotaenia fluviatilis*) to contaminated microbeads from personal care products resulted in accumulation of organic pollutants associated with the microbeads, providing evidence that microbeads from personal care products are capable of transferring sorbed pollutants to fish.[26]
	Sticklebacks (*Gasterosteus aculeatus aculeatus*) shown to actively ingest microplastics from the water column in addition to consuming them via their prey. Although ingestion did not appear to have negative impacts on the health of adult fish, at least in the short term, results indicated changes in body condition of larvae.[27]
	1203 individual fish of seven common North Sea species - herring, gray gurnard, whiting, horse mackerel, haddock, Atlantic mackerel and cod – were investigated. Plastic particles were found in 2.6% of examined fish and in five of the seven species. No relationship was found between the condition factor (size−weight relationship) of the fish and the presence of ingested plastic particles.[28]
	Fish (Japanese medaka, *Oryzias latipes*) exposed to polyethylene microplastics with pollutants sorbed from the marine environment bioaccumulated the pollutants and suffered liver toxicity and pathology. Those fed uncontaminated microplastics showed less severe signs of stress.[29]
	Polystyrene nanoparticles that were transported through an aquatic food chain from algae to zooplankton to fish, affected lipid metabolism and feeding behaviour of the top consumer fish, a carp species *Carassius carassius.*[30]
	Uptake and tissue accumulation of polystyrene microplastics was observed in zebrafish (*Danio rerio*). After 7 days of exposure, microplastics had accumulated in fish gills, liver, and gut. Effects included inflammation, oxidative stress and potential disturbance of lipid metabolism.[31]
Fulmars	No significant difference in pollutant concentrations in fulmars with higher microplastic ingestion, suggesting that microplastics did not significantly increase contaminant load and that the major source of contaminants was prey species.[32]

Species	Summary of findings
Fin whales	Mediterranean fin whales (*Balaenoptera physalus*) showed a temporal increase in toxicological stress correlated with feeding in areas contaminated with high densities of microplastics. High concentrations of Persistent, Bioaccumulative and Toxic (PBT) chemicals, plastic additives and biomarker responses were detected in the biopsies of Mediterranean fin whales as compared to those in whales inhabiting the Sea of Cortez (where microplastic densities are lower). Authors believe that exposure to microplastics from both direct ingestion and consumption of contaminated prey poses a major threat to the health of fin whales in the Mediterranean Sea.[33] Mediterranean fin whales were estimated to consume over 3,600 microplastic particles per day.

2. How do the main sources of microplastics differ in (a) scale of output and (b) the importance of their environmental impacts? How should these relative impacts direct policy priorities?

Based on a recent study by Eunomia, the principal sources of primary microplastics[1] in Europe include tyre dust, pellet spills, textiles, building paints, road paint, personal care products and marine paint (see Table 2 below, based on Table 23 in Sherrington et al., 2016).[34] However, the authors note the considerable caveats regarding the overall reliability of estimates, as indicated in the table below, where green = Reliable/representative, Yellow = Questionable, Red = Unreliable/unrepresentative.

Table 2: Summary of European estimates of primary microplastic emissions based on Sherrington et al. 2016.[35]

Emission Source	Upper Estimate (tonnes)	Lower Estimate (tonnes)
Tyre dust	58,424	25,122
Marine paint	4,056	825
Pellet spills	48,450	24,054
Textiles	52,396	7,510
Building paints	28,600	12,300
Road paint	18,069	7,770
Personal care and cosmetic products	8,627	2,461
Total	**218,622**	**80,042**

These primary sources are estimated to contribute 80,000-219,000 tonnes annually to the marine environment, while secondary microplastics (defined as plastics with the potential to fragment into microplastics) are estimated to contribute 68,500-275,000 tonnes.[36] Combined, it is estimated that Europe contributes between 148,500 and 494,000 tonnes of plastics to the oceans every year.

Microplastics from personal care products are estimated to comprise 3.2 - 4.1% of primary microplastics or 2,461-8,627 tonnes annually in Europe. However, this is likely an underestimate as Cosmetics Europe does not recognise plastic particles smaller than 0.001mm as microbeads. Such ‘nanoplastics’, which are also found in personal care products, would further increase the quantity of plastics originating from personal care products. It should be noted that this estimate does not

[1] Primary microplastics are purposefully manufactured, whereas secondary microplastics arise from the breakdown of larger plastic items on land or at sea. We use the term “microbeads” to refer to primary microplastics that are used as ingredients in consumer products. The term “microplastic” refers to the full range of primary and secondary microplastics. Pellets (also known as nurdles) refer to the microplastics used in plastic manufacturing.

include microplastics added to consumer products other than cosmetics, such as those in cleaning detergents.

With regard to pre-production plastic pellets (also known as nurdles), analysis shows that UK pellet loss to the environment is likely to be at least 105 tonnes, and possibly as high as 1,054 tonnes, each year,[37] equating to 5 billion and 53 billion pellets per annum respectively.

Microplastics from textiles are another major source of primary microplastics. These are created when synthetic fibres such as nylon, polyester and acrylic fragment during washing and are flushed into sewerage. Thousands of these tiny fibres can be washed down the drain with each wash. An EU study is looking at potential mitigation measures.[38]

Once in the marine environment, microbeads are indistinguishable from other microplastics, and it is therefore very difficult to distinguish the specific impact that particular sources/types of microplastics are having; laboratory studies (see Table 1) have covered a range of microplastic polymer types.[39] Policy priorities should therefore initially be directed towards the most easily preventable sources of microplastics, as well as those that represent significant point sources. Eliminating microplastic pollution at source is the only way forward financially, technically, and environmentally. Although microplastics in personal care and other consumer products do not represent the largest source of primary microplastic, they represent a readily preventable source of microplastic pollution (see Question 4 below for further information).

Similarly there is considerable scope for immediate action to prevent sources of pre-production pellets and sources of secondary microplastics (see Question 5 below for further information on prevention of secondary microplastic sources). Operation Cleansweep is a voluntary industry initiative aimed at preventing pellet loss. However, there has been limited uptake and there is no industry-wide auditing of the efficacy of measures put in place, or monitoring of progress towards the zero pellet loss goal. Further work is needed to establish the effectiveness of the pellet loss reduction measures contained in Operation Clean Sweep and determine how best to focus further action. There is also a need to establish a monitoring and enforcement mechanism, either through legislative tools or industry funded self-regulation, involving third party measurements and spot checks on facilities.[40]

3. What impact could microplastics have on human health? Are there knock-on impacts for Government policies, on e.g. food standards?

The accumulation of microplastics in the food chain, particularly in fish and shellfish, could have consequences for the health of human consumers.[41] Market surveys of fish being sold for consumption in the U.S. found plastic in 67% of all species and 25% of individual fish.[42] In the UK, 83% of Norway lobster (typically sold as scampi) sampled contained microplastics[43] and sampling of 10 species of pelagic and demersal fish in the English Channel found plastics found in the gastrointestinal tracts of 36.5% of the 504 fish sampled.[44] Microplastics have also been found in brands of sea salt from supermarkets throughout China, with a microplastics content of 550–681 particles/kg.[45] Studies of commercially grown shellfish in Europe estimated that the annual dietary exposure for European shellfish consumers can amount to 11,000 microplastics per year,[46] whilst concentrations of microplastics in wild mussels from the Dutch coast were found to be one order of magnitude higher than those in the commercially reared mussels.[47]

There is a clear risk that marine microplastics in seafood could pose a threat to human health, however the complexity of estimating microplastic toxicity means that quantification of the risks is not yet possible. The precautionary principle dictates that action should be taken to eliminate microplastics from human food wherever possible. Future studies should focus on assessing the fate and toxicity of microplastics in humans and assessing dietary exposure across a range of foods.[48]

4. Other countries, including the USA, have taken action against microbeads in personal care products. What kind of impact would a similar ban in the UK have on the environmental situation around microplastics?

Following the passage of the Microbeads-free Waters Act 2015 in the United States, the Canadian and Australian governments, as well as a number of European countries (including Belgium, Sweden, Austria and the Netherlands) are also considering legislation on microbeads in personal care products. The Netherlands, Austria, Belgium and Sweden issued a joint call in 2014 to ban the microplastics used in detergents and cosmetics in order to protect marine life from contamination, stating that whilst there was still "some scientific uncertainty" about the sources of contamination, "what we already know is sufficient to take action". The Netherlands is particularly concerned that seafood – including its national production of mussels – could be impacted by microplastic pollution. A 2016 European Parliament declaration is also calling for action.

A number of UK high-street brands and retailers, such as Boots, Asda and Unilever, have already made public commitments to end solid microplastic use in their products and Cosmetics Europe has released a recommendation that its members phase out the use of solid microbead ingredients from wash-off cosmetics products. However, this recommendation is not binding, is limited to exfoliating and cleansing products, and there are still many manufacturers that have failed to make a commitment, despite alternatives to microplastics being available. As a result thousands of tonnes of microplastics are still being released onto the EU market each year in personal care products.[49]

With variable timescales and commitments from companies, legislative action is essential to speed progress, maintain long-term commitments and ensure a level playing field for manufacturers. Although microplastics in personal care and other consumer products do not represent the largest source of primary microplastic, they are a readily preventable source of microplastic pollution. A ban on microbeads in consumer products in the UK would prevent additional microplastic pollution entering UK waters, as well as helping prompt further industry initiatives, government action and public awareness across the world.

5. To what extent do larger pieces of plastic in the ocean contribute to microplastic pollution, and how can this be dealt with?

An estimated 68,500-275,000 tonnes of secondary sources of microplastics (secondary being defined as larger plastics with the potential to fragment into microplastics) enter the marine environment annually in Europe, compared to 80,000 — 219,000 tonnes from primary sources (see Question 2).[50] Larger pieces of plastic may ultimately therefore contribute to microplastic pollution almost as much as primary microplastic sources, and potentially even more.

The EU Circular Economy Package provides considerable potential to prevent secondary sources of microplastic pollution, through legislative amendments to the Waste Directives aimed at increasing waste prevention, reuse and recycling, as well as through a forthcoming EU Strategy on Plastics. Maintaining a high level of ambition throughout negotiations will be vital to preventing sources of marine plastic pollution. Both the Resource Association and the Chartered Institution of Wastes Management have criticised Defra for a lack of leadership and ambition in their approach to waste management and recycling, and for a lack of transparency regarding the UK's position on the EU circular economy package.[51] Devolved Administrations have demonstrated greater leadership, with Scotland announcing a Circular Economy Strategy for Scotland and initiating an inquiry into establishing a deposit-return scheme for beverage packaging in order to increase collection rates and reduce littering.

Over the past 20 years, UK beach litter levels have increased by 135% and plastic litter by 180%.[52] However, the recently adopted UK Programme of Measures for marine litter under the Marine Strategy Framework Directive relies predominantly on existing measures, many of which have been in place for a number of years and have thus far failed to achieve a downward trend in marine litter.[53] As well as improved implementation and enforcement of existing legislation, new measures are required to prevent specific sources and types of litter. At a UK level, there remains considerable scope for further action, which could include actions such as:

- Ban plastic/non-biodegradable components in sewage related debris (e.g. cotton buds, sanitary and personal care items);
- Establish container deposit schemes on beverage packaging, a highly prevalent component of marine litter;[54]
- Improve and harmonise local authority waste collection systems such that they incentivise household and commercial recycling and increase collection rates of plastic packaging[55] e.g. collection of a wider variety of plastics for recycling with collection systems and fees that encourage recycling;
- Promote a high level of ambition within the EU circular economy package and incentivise voluntary circular economy industry initiatives in the UK. The latter could include, for example, the development of eco-design guidelines for packaging to improve recyclability and increase recycled content, and promotion of the use of reusable packaging in business-to-business applications (e.g. transport of retail goods).
- Expand the 5p bag charge to cover all sizes of businesses and all single use bags, as in Scotland and Wales.
- Work with manufacturers and retailers to reduce use of single-use packaging for take-away food and beverages, particularly non-recyclable and non-biodegradable items e.g. disposable coffee cups, polystyrene fast food packaging;
- Strengthen UK implementation of the Marine Strategy Framework Directive and the OSPAR Regional Action Plan.

6. How comprehensive and certain is our knowledge about the scale of microplastics and their effects on the natural environment? What should research priorities be, and who should fund this research?

Microplastics are now ubiquitous throughout the marine environment; at the sea surface, in the water column, in sediments and even in Arctic Sea ice. Scientific studies continue to refine estimates of plastic waste inputs to the marine environment and the abundance of floating microplastics. Recent studies include estimates that 4.8 to 12.7 million tonnes enter the ocean annually worldwide[56], the equivalent in layman's terms of one garbage truck every minute.[57] A 2014 study estimated a minimum of 5.25 trillion particles to be floating in the world's oceans but subsequent analyses assessing a global dataset provided a much higher estimate of 15 to 51 trillion particles, weighing between 93 and 236 thousand tonnes.[58] Furthermore, deep-sea sediments and polar sea ice have been found to have abundances of microplastics orders of magnitude greater than those in surface waters.[59] Plankton sampling off the UK coast demonstrates a significant increase in the abundance of microplastics from the 1960s to the present day.[60]

Knowledge regarding the impacts of microplastics on humans remains inadequate, however there is growing evidence of impacts on a range of marine fauna. Establishing the risk of harm at a population level and the potential ecosystem consequences remains a key priority for future research. The recent UN GESAMP report points to a number of additional research priorities, including the transfer of contaminants and impacts of nano-plastics. [61] It is clear that knowledge regarding the impact of both macro and microplastics is sufficient to justify immediate action,[62] particularly given that preventing marine plastic pollution at source represents the most, and often only, economically, environmentally and practically feasible solution.

7. How effective is international cooperation around these issues, and what more can be done?

Recent UN resolutions, global environmental agreements and decisions of international agencies have raised awareness of the issue of marine plastic pollution.[63] The UN Global Partnership on Marine Litter is one of the central forums for coordinating international activities, with other IGOs such as the UN Environment Assembly (UNEA), Convention on Biological Diversity (CBD), Convention on Migratory Species (CMS), International Union for Conservation of Nature (IUCN), International Whaling Commission (IWC) and G7 all having specific programmes of work on the issue. The UN Sustainable Development Goal's include a specific target under Goal 14 to "By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution".

Regionally, cooperation is coordinated through the EU Marine Strategy Framework Directive (MSFD) and OSPAR Regional Action Plan. However, implementation of the MSFD so far has shown many weaknesses. In February 2014, the Commission published its review; the 'Article 12 report' stating that *"The EU is still very far from enjoying healthy oceans and seas. Meeting this objective by 2020, in less than seven years, implies renewed and intensified efforts and rapid and important change in the way Member States, the European Commission, Regional Seas Conventions and other relevant organisations work together".*[64]

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