Commonwealth Marine Plastics Research & Innovation Framework Report

Marine Plastics Stakeholders, Key Organisations and Research Themes

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This report provides an overview of the context, national strategies, policies and Research and Innovation (R&I) activities in each of the four pilot countries identified: India, South Africa, Canada and the UK. R&I activity is divided into specific themes, and this has enabled gaps and common areas to be identified between each of the four countries. The recommendations set out potential areas for follow on and also how this could occur.

The sections for each country are shortened versions taken from more extensive individual country reports. These reports are available through the contacts named on the back page.

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Introduction

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2.1 Scope of work

The scope of this work is marine pollution from marine plastic with a focus on four Commonwealth nations, namely the pilot countries: Canada, India, South Africa (SA) and the United Kingdom (UK).

For the purpose of this work an 'actors' tier system was developed as a means to categorise and identify key pilot country actors within the scope of this work and develop a methodology for targeted engagement (as described in the complementary 'process report').

Table 1: Tier system table and indication of actors in/out of scope for this report.

Actors group	Actors, categories & description	In scope for this report
Tier 1	UK Innovation enablers actors in pilot country: UK government departments in pilot countries	Yes
Tier 2	Pilot country, Innovation enablers actors: Relevant government agencies	Yes
Tier 3	Pilot country, Innovation enablers actors: Relevant/key national R&I Innovation Enablers (government agencies and non-government) Organisations focus on enabling R&I at TRLs 3-6, facilitating/ enabling knowledge transfer (especial academia industry), and involved in creating/enabling bi/multi-lateral collaborations	Yes*
	Pilot country, Key research and science enablers actors: Relevant (National) Centres of Excellence, Research Institutes, R&I Hubs, relevant Academia-industry networks/partnerships, etc	Yes*
	Pilot country, Sector value chain actors: Relevant Business Trade Associations (with focus on those already engaged/with an interest in relevant R&I topics), Chambers of Commerce	No
	Pilot country, 3rd sector actors enabling R&I: Relevant Charities, NGOs, etc. (with focus on those already engaged/ with an interest in the pilot country R&I)	Yes
Tier 4	Pilot country, Research actors: wider research community	No
	Pilot country, Sector value chain actors: Individual businesses (with focus on business where R&I in marine plastics/plastic waste is at the core of the business, not just a side project),	No
	Pilot country, Community actors: Community groups engaged in the topic/projects	No

* Note: For reference, in the UK, some of those organisations (e.g., Innovate UK KTN, NOC), focused on accelerating R&I, technology transfer and the commercial exploitation of research, are registered as charities or not-for profit. Such 'charities, not-for-profit' are within scope. These are different from 3rd sector charities (voluntary/community organisations, social enterprises type organisations) which are focus on 'social good'.

The aim of this report is to provide an overview on the current landscape of key actors, key knowledge and initiatives in marine plastics research and innovation (R&I), the national strategies, frameworks and policies guiding marine plastics R&I, identify where research gaps and synergies exist and possibly recommend where bi/multi-lateral research will be most useful. Additional detail for each of the pilot countries can be found in country specific report.

This report provides **key** information of research and innovation in the pilot countries. It focusses on the role and activities of government and non-government R&I enabling agencies as well as key research and science enabling actors with the topic of marine plastic pollution. However, it is not exhaustive as it does not seek to identify all actors in academia, value chain actors' sector, third actors (e.g., NGOs, community groups) or relevant initiatives by any of those actors. Such an analysis would be a useful complement to this report, especially if it was to be done with comparable methodology for information gathering and analysis.

This includes a review of:

- relevant national strategy, roadmaps, framework, policy landscape guiding R&I to tackle marine plastics pollution, in each pilot country
- key national initiatives and/or programmes relevant to marine plastics R&I, in each pilot country
- key actors and organisations enabling marine plastics R&I, in each pilot country
- recent marine plastics scientific research by each of the pilot countries
- key international collaborations (actors and initiatives) in each pilot country
- an analysis of R&I synergies and gaps across the pilot countries
- relevant initiatives, policies and research interests on this topic by international and regional intergovernmental bodies, and initiatives interested in marine plastics

As acknowledged throughout this report, marine plastics are the subject of numerous research initiatives and political attention in a large number of private and public institutions. The data collated in this report is based on information available as of 30th April 2021.

2.2 Research methodology

Both primary and secondary research methodologies were used in this report, and although these varied slightly across the four countries, in general a combination of the following keywords “marine plastic“, “marine plastics”, “plastic production”, “plastic impacts”, “plastic research”, “marine litter”, “plastic litter” “plastic leakage” “Country Name”, “legal frameworks”, “regulation” was entered in major literature databases such as Google Scholar, JSTOR, PubMed, ScienceDirect and Research Gate.

Where this search revealed only limited results, a wider range of keywords from the research sub-themes for each of the six main research themes were combined to broaden the search. For example, “vector”, “pathogens”, “marine litter” and “marine debris”. The retrieved information included in this report comes in a range of forms, including peer-reviewed publications, proceedings, dissertations, books, manuals, technical reports, and reports of intergovernmental meetings and working groups.

For South Africa the Circular Plastics Economy programme and the Marine programme have an existing repository of South African research and information on marine plastics pollution. This information repository includes peer-reviewed publications, dissertations, online books and technical and government reports. In order to access additional information and research that has been conducted in South Africa on marine plastics, where appropriate, further primary research was conducted to seek clarity on policies and programmes and research and innovation funded projects through individual discussion with relevant people from a variety of organisations.

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Contextualizing this work within the fields on marine plastics R&I

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R&I on marine plastics includes a variety of topics. A recently published list of the main research areas on marine plastics as a 'checklist' guide to determine which of the main research themes on marine plastics have received attention in the pilot countries. However, the 'checklist' does not rank issues according to their respective importance or urgency. The list is outlined in the table below.

Table 2: The outlines of Research and Innovation theme and sub-themes.

Main Research Theme	Research Sub-themes
Marine plastic from waste	Composition of plastics in solid waste generated Collection and sorting efforts (including port/harbour waste reception facilities) Recycling and trade in plastic waste Source differentiation: land leakage, rivers, coastal, sea-based sources Abandoned, lost or otherwise discarded fishing gear (ALDFG)
Distribution, abundance, identification and fate of marine plastic	Standardising methodologies – constructing internationally accepted categories and analysis approaches Survey and monitoring (e.g., distribution, abundance, type) in different environments (e.g., coastal, water surface, water column, sea floor, sediment, biota) Optimising the extraction procedures and identification methods (e.g. extraction and identification of marine plastics from marine litter, mixed waste) Deposition, accumulation, hotspots, transportation and movement (e.g., numerical models) Building a marine plastics data platform (e.g., fingerprint repository for microplastics, marine plastic debris abundance and distribution) Removal and recyclability of marine plastics Degradation and fragmentation (e.g., rates, mechanisms, products)
Impact of marine plastic on the environment	Uptake, egestion, assimilation, accumulation and transfer of ingested plastics by marine organisms Occurrence of plastics across taxa and trophic levels Effect on particular taxa, communities and ecosystems (e.g., toxicity, productivity, food chain) Effect on marine environment (e.g., physical, chemical, level of absorption) Marine plastics as a vector/pathway for pathogens and toxic components (e.g., microbes, additives and Persistent Organic Pollutants [POPs]) Monitoring of impact on marine ecosystems (e.g., numerical models)
Socio-economic impact of marine plastic	Economic loss (e.g., plastic in fishing gear, threat on tourism) Food security Human health Plastic as a vector/pathway for pathogens
Upstream production – manufacture and use of plastic	Development of new polymers Ban on specific polymers: manufacture, import or use and their impact on marine plastic pollution Limitation in use (i.e., specific polymers for specific application, for example include packaging) and their impact on marine plastic pollution
Governance and regulation of marine plastic at international and regional levels	Outcomes/impacts of relevant policies, regulations Changes to (national/international) trade regulations and their impact on marine plastic pollution in the pilot country Outcomes/impacts of relevant frameworks in development (expected outcomes), being developed.

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Marine Plastics R&I in India

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4.1 Context in India and Southeast Asia

One of the emerging global issues over recent years has been that of marine plastic pollution (MPP), with the World Bank identifying the South Asian Region (SAR) as the third largest regional contributor to plastic waste globally.

With cumulative global plastic consumption at 8.3 billion metric tons in 2017 and a projected growth in plastic production expected to reach 34 billion metric tons by 2050, this issue is only likely to be exacerbated without a significant change in behaviour. The impact is keenly felt in the oceans, with plastic leakage into the marine environment estimated to be in the order of 10 million tonnes per year (Mt/y).

In the SAR, all coastal nations, aside from the Maldives, are ranked amongst the top twenty most polluting nations by volume of mismanaged plastic waste, with modelled estimates of floating micro-plastic (4.75 mm) abundance (items per square kilometre) suggesting that the Bay of Bengal Large Marine Ecosystem has the highest oceanic plastic concentration. In addition, the Indian Ocean is also host to one of the world's largest plastic gyres with 80% of that plastic pollution originating from land-based sources via transboundary river systems.

This includes the Indus (India, Pakistan, with the Kabul, Khurram, and Gumal riverine systems feeding into it from Afghanistan, Ganga (Nepal, India, Bangladesh) and Brahmaputra (India, Nepal, Bangladesh with riverine systems feeding into it from Bhutan). Key sea-based sources of marine plastic pollution (MPP) include shipping and fishing and fishing related activities.

Recognising the importance of the issue, the Commonwealth Clean Ocean Alliance (CCOA), an action group of the Commonwealth Blue Charter, is working to address the problem through the inception of the Commonwealth Marine Plastics Research and Innovation Framework (CWPRIF); intended to stimulate R&I throughout the Commonwealth and beyond. The subject of MPP provides for a diversity of perspectives and is both transdisciplinary and transboundary in nature. As a result, it is inevitably cross jurisdictional from the perspective of governance. This assignment is aimed at supporting the work of the CCOA by providing a summary intelligence report on the status of R&I activities in India in relation to the many facets of marine plastics pollution.

4.2 Marine plastics R&I strategy and priorities in India

4.2.1 Institutional & legislative context

India or Bharat Ganrajya is a federal democratic republic with 28 States and 8 Union Territories. The Government of India (GoI) operates through a complex structure of governance modelled on the Westminster parliamentary system and a legal system based on English Common and Statutory Law. Ministries provide jurisdiction over specific areas of governance with 57 Union Government Ministries operating currently.

In terms of protecting the marine environment, there is a clear enabling legislative framework that has been developing over many years in conjunction with international agreements. For example, the Indian Coast Guard have responsibility for enforcing the Territorial Waters, Continental Shelf, Exclusive Economic Zone and Other Maritime Zones Act, 1976. This Act enables the United Nations Convention on the Law of the Sea (UNCLOS) and provides the Government of India (GoI) with measures for inter alia the protection of the marine environment. The Coast Guard come under the auspices of the Ministry of Defence and were enacted by the Coast Guard Act, 1978 which stipulates that it is the duty and function of the Indian Coast Guard to take the necessary measures to preserve and protect the marine environment and prevent and control marine pollution. At present however, legislation and regulations only make provision for the prevention of pollution that physically occurs within the coastal and marine environment. The Merchant Shipping Act, 1958 directly empowers the Coast Guard to take necessary action against polluters within the maritime zones of India, though this is largely in relation to oil pollution. As a Member of the International Maritime Organization (IMO), India has ratified all the annexes of MARPOL 73/78, though the attention given to oil pollution is perhaps not surprising given that this has been a key focus for global governance far longer than most other forms, with plastics pollution only relatively recent.

Protection of the marine environment is cross jurisdictional, coming under the auspices of a number of ministries and not just the responsibility of the Coast Guard under the Ministry of Defence. The Environment (Protection) Act 1986 for example provides the GoI with the powers to protect and improve the quality of the environment and prevent, control and abate environmental pollution. This Act comes under the jurisdiction of the Ministry of Environment, Forests and Climate Change (MoEFCC). The MoEFCC is the nodal agency within the Central Government for overseeing the implementation of policies and programmes relating to the prevention and abatement of pollution, including Marine Protected Areas (MPAs). It is also the nodal agency for the United Nations Environment Programme (UNEP), the South Asia Co-operative Environment Programme (SACEP) and the United Nations Conference on Environment and Development (UNCED). The Ministry also coordinates with multilateral bodies such as Global Environment Facility (GEF) and regional bodies such as the Economic and Social Council for Asia and Pacific (ESCAP) and the South Asian Association for Regional Cooperation (SAARC) on environmental matters.

The Coastal Zone Regulation (CRZ) Notification, 2019 also comes under the responsibility for MoEFCC demonstrating cross-ministerial responsibility for the marine environment. The Notification states that “in order to safeguard the aquatic system and marine life, disposal of plastic into the coastal waters shall be prohibited and adequate measures for management and disposal of plastic materials shall be undertaken in the CRZ”. However, as yet there is no specific national policy or strategy to address either marine plastics or marine litter. Furthermore, India’s current legislative landscape does not fully recognise that marine plastic pollution is a transboundary issue and one that is caused largely by plastic waste from a terrestrial source, rather than a marine or coastal one.

In addition to MoEFCC, there is also the Ministry of Earth Sciences (MoES). MoES is the nodal ministry for providing services relating to the weather, climate, ocean and coastal state, organising and promoting sustainable ocean development activities, in addition to R&I related to ocean sciences. To this end, in June 2018, soon after India announced that it had joined the UNEP

Clean Seas Campaign, the MoES stated its intention to begin work on a comprehensive study to identify the sources of marine litter, especially the plastic waste that flows into India's coastal waters, with the objective of developing a national marine litter policy. This development also coincided with a country report on the development of a regional action plan for marine litter that was released by SACEP as part of the South Asia Seas Programme (SASP) in May 2018. This report was prepared in conjunction with the MoES and three of its affiliates; the National Centre for Coastal Research (NCCR), Chennai - an attached office of the MoES; the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad; and the National Institute of Ocean Technology (NIOT), Chennai.

The current status of this study on the sources of marine litter is unclear though according to the MoES' 2020-21 annual report "marine plastics research is in progress involving international collaboration covering the Indian coastline to prepare the data for evolving marine litter policy and management and to identify the hot spots". With respect to marine plastic pollution, both the MoEFCC and the MoES have a stake in tackling it. However, it is at present unclear as to how a future national marine litter policy might reflect its transboundary nature.

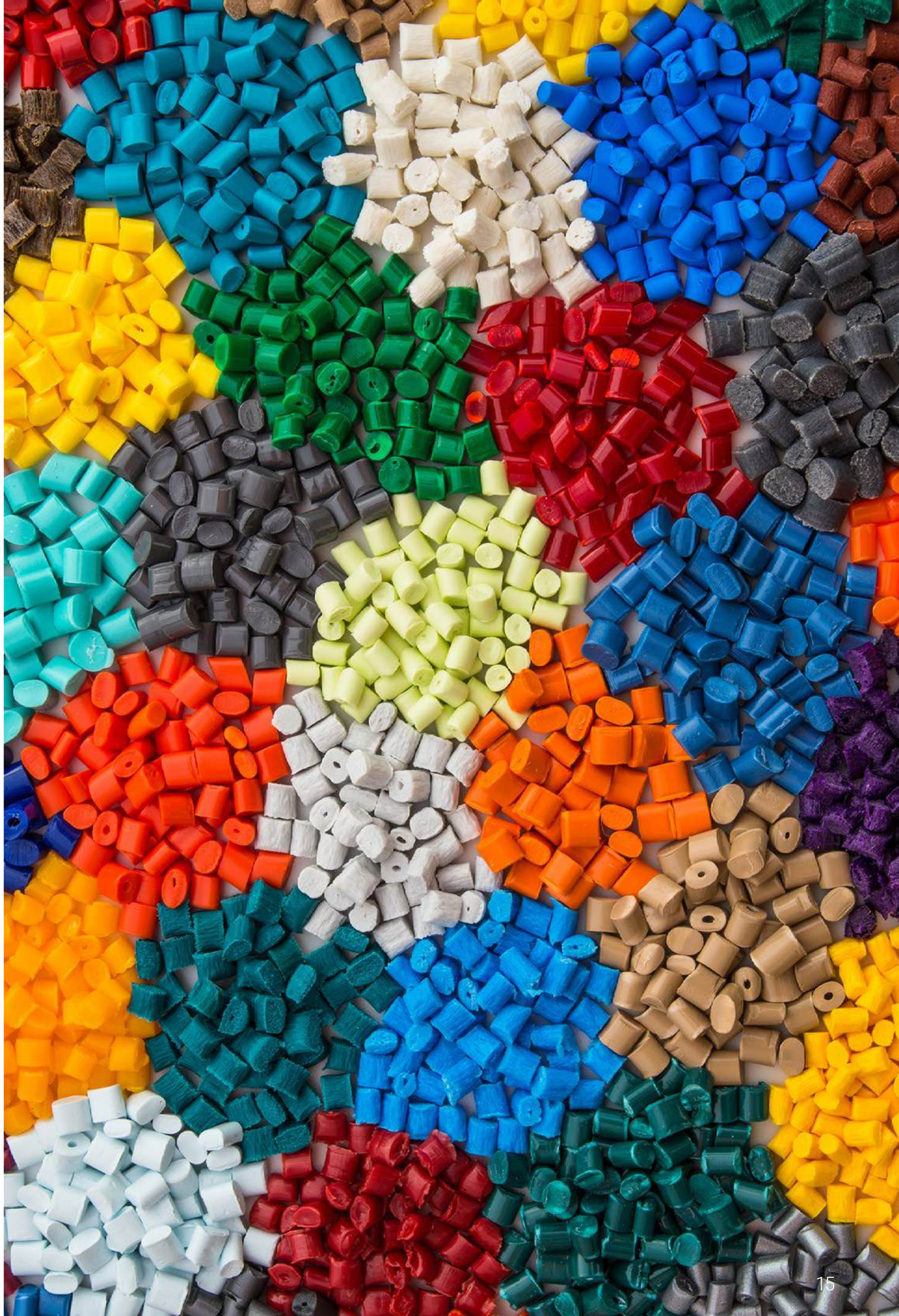
The situation regarding plastic waste however is slightly different. Despite the size of the economy and geographical variations between different states, India has a relatively comprehensive policy on plastic waste management. Existing regulatory measures introduced by the GoI to address the issue of plastic waste come under the umbrella legislation of the Environment (Protection) Act, 1986. The Plastic Waste Management (Amendment) Rules, 2018 were formulated by the MoEFCC and focus on the prohibition of certain plastic products and the management of plastic waste. Similarly, the Solid Waste Management Rules, 2016, which also fall under the same legislative framework and authority of the Central Pollution Control Board (CPCB), focus on the management of urban waste and set out specific standards for waste treatment and disposal. However, as these are formulated by the MoEFCC, these sets of regulations indicate that plastic waste is largely considered as an environmental policy issue and not as a cross-cutting socio-economic and environmental challenge, with wider collaboration across different sectors and government ministries. Furthermore, whilst these rules have garnered positive international attention, there are also serious questions about their implementation and general suitability.

The CPCB functions through delegated responsibilities to the State Pollution Control Boards. The policy implementation, data collection and state level monitoring are delegated to the state Pollution Control Committees (PCC), statutory bodies operating at the level of states and union territories responsible for the implementation of legislation related to environment and natural resources. Within the context of plastic waste, it is responsible for state level stock taking and data collation; registration of producers, manufacturers, recyclers, and annual reporting of number of industries involved; estimates of quantum of annual plastic waste generation.

Other than considering marine plastics either as source of pollution or as a waste management issue, there are numerous other perspectives that can be taken when reviewing the issue. For instance, India has a multitude of stakeholders, including private sector, informal sector, and non-government organisations. It has a large manufacturing base to produce plastics with all manufacturers associated as part of the All-India Plastic Manufacturer's Association (AIPMA). AIPMA is one of the oldest and largest apex bodies of the plastic industry in India. The association is active in almost all fields of plastics and has a countrywide presence. It is working towards making India an international sourcing base for plastics by supporting development in the sector.

It is also mandated to "remain alert on various environmental issues and anti-plastic campaigns." AIPMA is a key stakeholder, in the policies concerned with the reduction of plastics and plastic wastes.

For the purposes of this report, a further consideration is that of the R&I landscape, as a driver for change. The effectiveness of this framework can provide a stimulus for delivering innovation and adds an additional layer to work on marine plastics. The R&I landscape in India is driven by the Ministry of Science and Technology (MoST). MoST is charged with delivering innovation and facilitates programmes aimed at technology and R&D that might be relevant to resolving the issue of marine plastics.



4.2.2 Legislative framework for plastic waste management

4.2.2.1 Plastic waste management (amendment) rules, 2018

In 2016, the Ministry of Environment, Forest and Climate Change (MoEFCC) introduced the Plastic Waste Management (Amendment) Rules, 2018, which were subsequently amended in 2018. These rules apply to every waste generator, local body, Gram Panchayat (village governing authority), manufacturer, importer and producer within India and set out a framework for the disposal and management of plastic waste for Urban Local Bodies and other generators of plastic waste.

The rules also prohibit the manufacture, distribution, sale and use of plastic bags made of virgin or recycled plastic less than 50 microns in thickness, in addition to other measures such as the prohibition of sachets that use plastic materials for the storage, packaging or sale of gutkha, tobacco and pan masala. They also set out a centralised registration system to be developed by the Central Pollution Control Board (CPCB) for all producers, importers and brand owners.

4.2.2.2 Proposed Amendment to the Plastic Waste Management (amendment) rules, 2021

A proposed amendment to these rules is scheduled for 2021. This amendment will see the rules extended to apply to any person or company that sells commodities under a registered brand label, in addition to waste processors, and the ban on plastic bags increased to include all those under 120 microns in thickness. The amendment also proposes, from 1st January 2022, a ban on the manufacture, import, stocking, distribution, sale and use of the following single-use plastic commodities: earbuds with plastic sticks, plastic sticks for balloons, plastic flags, candy sticks, ice-cream sticks, polystyrene (thermocol) for decoration. Further to this, from 1st July 2022, it is proposed that this ban be extended to include the following single-use plastic (including polystyrene and expanded polystyrene) items: plates, cups, glasses, cutlery such as forks, spoons, knives, straw, trays, wrapping/ packing films around sweet boxes, invitation cards, cigarette packets, plastic/PVC banners less than 100 microns and stirrers.

4.2.2.3 Implementation and efficacy of plastic waste management rules

Recent research suggests that the Plastic Waste Management (Amendment) Rules, 2018, have not been implemented effectively and calls into question whether they are fit for purpose. For example, research indicates that despite the ban, plastic bags which are less than fifty microns in thickness have continued to be manufactured and sold in the majority of states and union territories across India. Furthermore, there has been no reduction seen in the amount of plastic litter being dumped in public spaces, with normal practices continuing unchallenged. In addition to this, the vast majority of Municipal Authorities across India have yet to develop a proper system for plastic waste management.

Similarly, additional research indicates that there are four main barriers to eliminating the use of single-use plastics in India, namely:

- a lack of manufacturing facilities to meet the demand for biodegradable single-use products
- a lack of financial support for developing alternatives to single-use products
- a lack of government initiatives to promote biodegradable single-use products
- the high cost of technologies to produce alternatives to single use plastics

Therefore, although India has legislative measures in place to eliminate certain single-use plastics and better manage plastic waste, these measures are seen to be ineffective unless they are properly enforced and affordable alternatives to single-use plastics made widely available.

4.3 Legislative framework for research & innovation

4.3.1 Science, Technology and Innovation Policy, 2013

The Department for Science and Technology (DST) published the Science, Technology and Innovation Policy in 2013. The main function of this policy was to promote a science and technology led innovation ecosystem in India that would attract private sector investment in research and development, in addition to providing a direct link between science, technology and innovation and critical national priorities, which included water management, materials, the environment and climate variability and change.

The policy itself was broad and aside from outlining the aforementioned priorities did not have any direct or specific links to marine plastics or details of how the policy was going to be implemented. However, it is now in the process of being phased out and replaced with a new and significantly more detailed Science, Technology and Innovation Policy, a draft version of which was published in December 2020.

4.3.2 Draft Science, Technology and Innovation Policy, 2020

The draft Science, Technology and Innovation Policy (STIP), 2020, is part of a wider strategy to achieve an 'Atmanirbhar Bharat' (self-reliant India). The overarching aim of the policy is to 'foster, develop, and nurture a robust system for evidence and stakeholder-driven Science, Technology and Innovation (STI) planning, information, evaluation, and policy research in India'. However, it is noted that the policy states that STI is key to addressing socio-economic challenges related to health, environment, education, food, energy, climate change and water.

The policy has a range of key objectives, with the following directly relevant to marine plastics:

- To ensure a clean environment for the country's people and its future generations, through green initiatives based in science that promote sustainability and clean energy, water, air, rivers, forests, parks, and neighbourhoods.
- To strengthen national water, agriculture, food, and nutrition security as well as ensuring employment generation through a robust STI enabling the environment to ensure better lives for citizens, enhancing incomes for farmers, labourers and artisans, and to create resilient and liveable human settlements, while sustaining natural resources and safeguarding public health.

In addition to this, there are a range of key deliverables mentioned in the policy and those which are relevant to marine plastics R&I are summarised below.

- The establishment of a National STI Observatory to collate and store data, including that relating to all financial schemes, programmes, grants and incentives within the STI ecosystem.
- The development of an Open Science Framework to provide open access to scientific data, information, knowledge and resources to those within India and those engaging with the Indian STI ecosystem on an equal partnership basis.
- The creation of 'Engaged Universities' to promote interdisciplinary research to address community needs, in addition to Higher Education Research Centres (HERC) and Collaborative Research Centres (CRC) to inform policy.
- The earmarking of a percentage of each state's allocation for STI-related activities under a separate budget head and hybrid funding models with enhanced participation from public and private sectors will be created through the Advanced Missions in Innovative Research Ecosystem (ADMIRE) initiative. In addition to this, an STI Development Bank will be set up to facilitate direct long-term investments in select strategic areas.
- The development of Research and Innovation Excellence Frameworks (RIEF) to enhance research quality and promote stakeholder engagement.
- The establishment of International Knowledge Centres, preferably virtual, to promote global knowledge and talent exchange and an STI collaboration framework to promote collaboration at domestic and global levels, in line with national priorities.
- The establishment of mission mode programmes with deliverables for technology and innovation in the priority sectors (e.g., Agriculture, Water, Health, Energy and Environment) and the identification of challenges and opportunities in these sectors based on current and future needs.

4.4 National programmes and initiatives

Whilst the issue of plastic waste has seen its profile raised, this approach is fragmented, with different stakeholders undertaking activities and missions independent of each other, with no apparent central or strategic coordination. An integrated governmental approach to plastic waste management has yet to be achieved.

However, there are a number of national initiatives, outlined in the following section that relate both directly and indirectly to marine plastics, driven very often by global and regional initiatives.

4.4.1 Sea Water Quality Monitoring (SWQM)

One of the key functions of the National Centre for Coastal Research (NCCR), as part of the MoES, is to conduct the Sea Water Quality Monitoring Programme (SWQM). This has been operational since 1990 and involves the following:

- The monitoring of coastal water quality and alerting the government and other stakeholders on the status of coastal health.
- The detection of periodical changes in coastal water quality, prediction of pollution levels and provision of real-time information on water quality and status of the coastal waters.
- The development of a numerical model for the prediction of coastal water quality and dissemination of water quality information via web and mobile application.
- The development of Seawater Quality Criteria (SWQC) for coastal waters, waste disposal zones, fishing ports, harbours and ecologically sensitive habitats for protection of marine life.

4.4.2 Coastal Clean-up Campaign

In addition to its responsibility for the SWQM, the NCCR is also responsible for the delivery of the coastal clean campaign for Indian beaches as part of the Coastal Clean Seas campaign of the UNEP.

Each year there is also an international coastal clean-up day across India, which is in part coordinated by the Indian Coast Guard, in addition to a range of other affiliated agencies such as the Integrated Coastal and Marine Area Management Project Directorate of the MoES. However, these are in general one-off annual events and whilst they may be useful in raising awareness of the issue of marine plastic pollution, are obviously not a solution to the problem.

4.4.3 Swachh Bharat Mission

The Swachh Bharat Mission (Clean India Mission) was launched by the Prime Minister of India in 2014, with the objective of achieving universal sanitation coverage across India. The programme is driven by the Ministry of Jal Shakti's Department of Water Resources, River Development and Ganga Rejuvenation. Under the premise of this mission, greater attention has been given to the issue of solid waste management and plastic waste across a range of government departments and ministries. For example, in 2019, the Ministry of Housing and Urban Affairs (MoHUA) published a handbook on Plastic Waste Management: Issues, Solutions and Case Studies.

4.4.4 National Mission for Clean Ganga

The National Mission for Clean Ganga (NMCG) is a society formed in 2011 to act as the implementation arm of the National Ganga River Basin Authority (NGRBA), with the objective of ensuring the effective abatement of pollution, improving water quality and rejuvenating the River Ganga (Ganges) by adopting a river basin management approach.

The governance structure for delivering the objectives is complex. At present, the NGRBA has been replaced by the National Ganga Council (NGC), beneath which a task force from the Ministry of Jal Shakti's Department of Water Resources, River Development and Ganga Rejuvenation exists, in addition to the NMCG.

The 'Namami Gange Programme' was established in 2014 as an integrated conservation mission - approved and funded as a flagship programme of the GoI - to accomplish the objectives of the NMCG. The Second National Ganga River Basin Project for India is scheduled to run from 2021 to 2026, funded by the World Bank, with the Ministry of Jal Shakti's Department of Water Resources, River Development and Ganga Rejuvenation as the implementing organisation.

This project has the specific objective of reducing point-source pollution from targeted urban areas of the Ganga River basin and supporting the Central Ministry of the GoI to strengthen the institutional framework for Ganga river basin management. Assessing the current progress of this initiative is challenging, although it is apparent that the issue of water pollution from land-based sources seems to be high on the agenda of the GoI.

4.5 Key actors and organisations

4.5.1 UK enabling agencies

4.5.1.1 UK Science and Innovation Network (SIN) in India

The Science and Innovation Network engages with the local science and innovation community in support of UK policy overseas and works to create strategic relationships.

The UK and India are established partners in science and innovation with this partnership having been strengthened by a number of high-profile bilateral initiatives including the UK-India Education and Research Initiative (UKIERI), the establishment of a biannual India-UK Ministerial Science and Innovation Council (SIC) and the creation of the Research Councils UK (RCUK) India office (now UK Research and Innovation (UKRI)) in 2008.

In October 2016, SIN and Innovate UK produced the India-UK Future Manufacturing Report which highlights that the UK's expertise in advanced manufacturing and its well-developed innovation programmes alongside the scale and the ambitions of India's manufacturing sector presents an opportunity for both countries. The report identified areas of potential collaboration including waste treatment, pollution control and sustainable packaging and the need to establish new long-term collaboration and partnership models and proposed a number of potential mechanisms to do this.

The UK and India have also agreed on a set of grand societal challenges that formed the basis for negotiating the Indian elements of the Newton-Bhabha Fund, to support the UK's research engagement with developing countries. The current priority areas are sustainable cities and urbanisation, public health and wellbeing, energy-water-food nexus and understanding oceans, with two underpinning capabilities of high value manufacturing and big data. This is part of the wider Global Challenges Research Fund (GCRF) - a £1.5 billion fund that supports cutting-edge research to address challenges faced by developing countries - and is part of the UK's official development assistance (ODA). The fund addresses the United Nations sustainable development goals and aims to maximise the impact of research and innovation to improve lives and opportunity in the developing world.

4.5.1.2 UK Research and Innovation (UKRI) India office

Research and innovation collaboration between the UK and India drives shared prosperity and advances joint development goals and UKRI India plays a key role in enhancing this partnership by working with a range of UK partners including the British Council, UK Science and Innovation Network, India, the Department for Business and Trade (DBT) and the Foreign, Commonwealth and Development Office.

In terms of R&I to tackle marine plastic pollution, UKRI are partnering with the Waste and Resources Action Programme (WRAP) to develop and deliver the India Plastics Pact and UKRI will invest £250,000 in this project.

Despite the significant challenges of plastics pollution in Asia and SE Asia, there are no Plastics Pacts yet fully launched, and so a Plastics Pact in India could be the first in the whole Asia region and act as a beacon for other countries in the region to learn from and replicate. WRAP is finalising the selection of a respected Indian partner to work with and will then engage with major Indian companies to explore the scope, targets and priorities for an Indian Plastics Pact. The aim is to launch a Pact in 2021.

4.5.1.3 UK-India Education and Research Initiative (UKIERI)

The UK-India Education and Research Initiative (UKIERI) started in April 2006 with the aim of enhancing educational linkages between India and the UK. Since then, UKIERI has been recognised as a key multi stakeholder programme that has strengthened the research, leadership, education and skill sector relations between the two countries. The project is funded by a range of UK government partners including Department for Science, Innovation and Technology (DSIT), the FCDO and this is matched by funding from India.

In relation to marine plastics R&I, UKIERI facilitate Partnership Development Workshops (PDW) across India and the UK that aim to support international development-relevant research on a range of thematic areas, which include water management (improving its access and quality) and waste management and urban design.

4.5.2 India enabling agencies (government and non-government)

4.5.2.1 High Commission of India in London

Responsible for UK-India missions and maintaining bilateral relations between India and the UK. Emphasises the importance of education and R&I in maintaining bilateral relations between the two nations and highlights the UKIERI and the Newton-Bhabha fund as examples of good practice.

4.5.2.2 Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India

The MoEFCC is the nodal agency within the Central Government for overseeing the implementation of policies and programmes relating to the prevention and abatement of pollution, including Marine Protected Areas (MPAs). It is also the nodal agency for the United Nations Environment Programme (UNEP), the South Asia Co-operative Environment Programme (SACEP) and the United Nations Conference on Environment and Development (UNCED). The Ministry also coordinates with multilateral bodies such as Global Environment Facility (GEF) and regional bodies such as the Economic and Social Council for Asia and Pacific (ESCAP) and the South Asian Association for Regional Cooperation (SAARC) on environmental matters.

4.5.2.3 Ministry of Earth Sciences (MoES), Government of India

The MoES is the nodal ministry for providing services relating to the weather, climate, ocean and coastal state, organising and promoting sustainable ocean development activities, in addition to R&I related to ocean sciences.

4.5.2.4 Ministry of Science and Technology (MoS&T), Government of India

The MoS&T works through three main wings, two of which are relevant to marine plastics R&I; the Department of Science and Technology (DST) and the Department of Scientific and Industrial Research (DSIR) / Council of Scientific and Industrial Research (CSIR). These institutions will be discussed in this section of the report.

4.5.2.5 Department of Science and Technology (DST), GoI

The DST was established with the objective of promoting new areas of Science & Technology and to play the role of a nodal department for organising, coordinating and promoting S&T activities in India.

4.5.2.6 Department of Chemicals and Petro-Chemicals

The department aims to formulate and implement policy and programmes for achieving growth and development of the chemical and petrochemical sectors in the country and has the mandate to deal with plastics including the fabrication of plastic and moulded goods.

4.5.2.7 Indian Centre for Plastics in the Environment (ICPE)

The Indian Centre for Plastics in the Environment (ICPE) is a body registered under the Society Act of India and was established on the recommendation of the Ministry of Environment and Forests (MoEF). It is a nodal agency recognised by the GoI to handle all issues related to plastics and the environment and has a wide range of objectives, which include sponsoring and undertaking R&D work in plastics in general and plastics waste management more specifically.

4.5.2.8 Technology Development Board, Government of India

The Technology Development Board (TDB) provides financial assistance to Indian industrial concerns and other agencies, attempting development and commercial application of indigenous technology, or adapting imported technology to wider domestic applications.

4.5.2.9 Global Innovation and Technology Alliance (GITA)

GITA is a Public Private Partnership (PPP) between the Technology Development Board (TDB), Department of Science & Technology (DST), Government of India (GoI) and India's apex industry association Confederation of Indian Industry (CII).

4.5.2.10 Science and Engineering Research Board, Government of India

The Science and Engineering Research Board (SERB) aims to build up the best management systems to match the best global practices in the promotion and funding of basic research.

4.5.2.11 Office of the Principal Scientific Adviser to the Government of India (PSA)

The Office of the PSA to the GoI is, in addition to other responsibilities, responsible for driving innovation and technology to solve socio-economic challenges in order to ensure sustainable growth.

4.5.2.12 Council of Scientific and Industrial Research (CSIR)

The Council of Scientific & Industrial Research (CSIR) is a contemporary R&D organisation. It has a pan-India presence, with has a dynamic network of 38 national laboratories, 39 outreach centres, 3 Innovation Complexes and 5 units.

4.5.3 Research and science actors working on Marine Plastics.

Below is the list of research centres including universities and institutions working on research on marine plastics.

1. National Centre for Coastal Research (NCCR), Ministry of Earth Sciences
2. Indian National Centre for Ocean Information Services (ESSO-INCOIS), Ministry of Earth Sciences
3. National Institute of Ocean Technology (NIOT), Ministry of Earth Sciences
4. National Centre for Sustainable Coastal Management (NCSCM)
5. Central Marine Fisheries Research Institute (CMFRI)
6. Suganthi Devadason Marine Research Institute
7. National Maritime Foundation
8. School of Industrial Fisheries, Cochin University of Science and Technology, Cochin
9. Dept. of Aquatic Biology and Fisheries, University of Kerala
10. Indian Institute of Technology, Hyderabad (IIT-H)
11. Centre for Environment Education
12. Institute for Ocean Management, Anna University, Chennai
13. National Environmental Engineering Research Institute (NEERI)
14. School of Environment & Natural Resources, Doon University, Dehradun
15. Department of Environmental Sciences, Central University of Kerala
16. Aquatic Environment and Health Management Division, Central Institute of Fisheries Education
17. School of Environmental Sciences, Mahatma Gandhi University, Kerala
18. Department of Geology, University of Madras, Chennai

4.6 Research on marine plastic pollution

4.6.1 Status of understanding of pollution from marine plastic pollution

Increasing attention has been given to marine plastics research within India over the last five to seven years. The depth of this research however varies considerably across the different themes on which the report is focused. A significant proportion of the existing research relates to themes 1, 2 and 3, namely the marine plastic from waste (40 papers); the distribution, abundance, identification, and fate of marine plastics (31 papers); and the impact of marine plastics on the environment (23 papers).

The interest in marine plastic from waste, particularly recycling, reflects on the key area of interest being to find value in the material and develop innovations to address a problem whereas the interest in the latter two areas perhaps reflects India joining the UNEP Clean Seas Programme and its commitment to undertake a national study on marine litter as part of their participation in the SACEP South Asia Seas Programme (SASP). However, even within these themes, there are significant gaps. For example, with respect to theme 2, whilst research into the survey and monitoring of marine plastics has been published regularly, the development of standardised methodologies or optimised extraction procedures is still nascent. This is not surprising however given that the same is also true more generally with attempts elsewhere to quantify and characterise marine plastics in different environments and species, particularly microplastics, also using a range of methodological approaches.

In addition to the 'hotspot' themes, there is also a developing tranche of work being published under the fifth research theme, the upstream production and use of plastics, with much of this being published after 2018. This coincides well with the ban on some single-use plastic products and the guidance on waste management in the Plastic Waste Management (Amendment) Rules, 2018.

Overall, and given that the legislative landscape within India does not yet address marine plastic pollution specifically, it is perhaps not surprising that the enabling actors have also not prioritised the funding of research across the spectrum of the research themes to date, thus limiting the quantity of work under some of the themes.

4.6.2 Research Themes

The research undertaken in South Africa is allocated to specific themes and subthemes in the table in Appendix 1 11.1 Research Themes and References India.

4.6.3 Research gaps

The research gaps identifies the number of papers or published research found against each research sub-theme. If no research is found this is highlighted. Where research is found but there are less than 9 papers, this is classified as being 'limited research found'. Appendix 1 11.2 Research Gap India.

4.7 The regional, international and global context

4.7.1 Regional organisations/ networks and relevant activities/ initiatives of relevance to India's marine plastics R&I

4.7.1.1 South Asian Seas Programme (SASP)

The SASP is one of 18 Regional Seas Programmes of the UN Environment Programme (UNEP). Under this programme, the South Asian Seas Action Plan was adopted in 1995 and is supported by India, along with four other nations in the region: Bangladesh, the Maldives, Pakistan and Sri Lanka. The South Asia Cooperative Environment Programme (SACEP) currently serves as the Action Plan Secretariat.

The Action Plan specifies that all states have agreed to develop a regional programme for monitoring marine pollution in the coastal waters of the South Asian Seas and the regular exchange of relevant data and information. However, more specifically, it states that activities should aim to assess and evaluate the causes, magnitude and consequences of environmental problems, in particular the assessment of marine pollution from land and sea-based sources.

4.7.1.2 South Asian Association for Regional Cooperation (SAARC)

The South Asian Association for Regional Cooperation (SAARC) was established with the signing of the SAARC Charter in Dhaka on 8 December 1985. SAARC comprises of eight Member States: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

The objectives of the Association as outlined in the SAARC Charter are: to promote the welfare of the peoples of South Asia and to improve their quality of life; to accelerate economic growth, social progress and cultural development in the region and to provide all individuals the opportunity to live in dignity and to realise their full potentials; to promote and strengthen collective self-reliance among the countries of South Asia; to contribute to mutual trust, understanding and appreciation of one another's problems; to promote active collaboration and mutual assistance in the economic, social, cultural, technical and scientific fields; to strengthen cooperation with other developing countries; to strengthen cooperation among themselves in international forums on matters of common interests; and to cooperate with international and regional organisations with similar aims and purposes.

4.7.1.3 South Asia Co-operative Environment Programme

South Asia Co-operative Environment Programme (SACEP) is an inter-governmental organisation, established in 1982 by the governments of South Asia to promote and support protection, management and enhancement of the environment in the region. SACEP member countries are Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

4.7.1.4 Plastic free Rivers and Seas for South Asia Project

On 8 June 2020 - World Oceans Day - SACEP officially signed the Plastic Free Rivers and Seas for South Asia Project, which is to be undertaken in collaboration with the World Bank, with SACEP as the implementing agency. The project has a five-year implementation period, with US$40 million in funding, with the objective of accelerating actions that reduce the flow of plastic pollution into the ocean in all eight countries in the South Asian region, including India.

The project has three components, which are detailed below:

1. Supporting competitive block grant investments to reduce plastic waste
   a. Supporting circular plastic economy solutions by providing grants to eligible beneficiary organisations in South Asia.
   b. Facilitating the exchange of knowledge between eligible beneficiaries and South Asian nations and promoting awareness

2. Leveraging public and private sector engagement and solutions
   a. Supporting the development of legislative measures to improve plastic pollution mitigation measures by developing a multi-year plastic policy support programme and working with leading universities and organisations; developing a database for life cycle analysis, data collection and modelling related to plastics across industry value chains; and supporting communication activities.
   b. Supporting circular use of plastic in the economy through regional public and private collaboration and engagement.

3. Strengthening regional integration institutions
   a. Supporting the construction of SACEP's new headquarters and providing technical assistance and building the capacity of SACEP to deliver the programme and to collect, analyse and interpret pollution data
   b. Support the development of a fund to sustain existing activities and accelerate circular plastic economy solutions.

4.7.1.5 South Asia Water Initiative (SAWI)

SAWI is a multi-donor trust fund supported by the United Kingdom, Australia, and Norway, and administered by the World Bank. It supports a portfolio of activities to increase regional cooperation in managing major Himalayan River systems to deliver sustainable, fair, and inclusive development and climate resilience. SAWI aims to:

- strengthen awareness and knowledge about regional water issues;
- enhance technical and policy capacity;
- support dialogue and participatory decision processes to build trust; and
- scope and inform World Bank investments

In the context of water resources planning and management, the programme promotes poverty alleviation, economic development, gender inclusion, and climate change adaptation. SAWI works in three river basins (Indus, Ganges and Brahmaputra) and one landscape (Sundarbans). Together, those focus areas span seven countries: Afghanistan, Bangladesh, Bhutan, China, India, Nepal and Pakistan. .

SAWI also is involved in regional cross-cutting work that supports non-basin specific activities such as groundwater management and plastic pollution. As part of the focus on the latter, SAWI is currently funding several regional scale projects looking to embed methods and pathways of generating national baselines for plastics pollution, including India.

4.8 Global organisations/networks and relevant activities/initiatives where India plays a role

4.8.1 UN Clean Seas Programme

India hosted World Environment Day in 2018 with the theme of 'Beat Plastic Pollution' and in June 2018 joined the Clean Seas Programme.

The campaign, which is technically rooted in the long-standing work of UNEP and the Global Partnership on Marine Litter, focuses on increasing ambition for policies that will reduce pollution and build circular economies, encouraging innovation in supply chain and waste management, and on inspiring individual behaviour change to send important signals to business and government that this is a priority that we all care about.

The Clean Seas Programme aims to drive an up-stream response against plastic litter through better systems of industrial plastic management; the phasing out of non-recoverable plastics (i.e., microplastics in cosmetics) and the significant reduction of single-use plastics. The primary Indian organisation involved is the Ministry of Environment, Forest and Climate Change.

4.8.2 International Maritime Organization (IMO)

The IMO is the United Nations specialised agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. India has been a Member of the IMO since its inception in 1959. The IMO operates through the development and ratification of a series of international agreements with India having signed and ratified key ones such as MARPOL 73/78, including its annexes of which one relates to the management of garbage form ships.

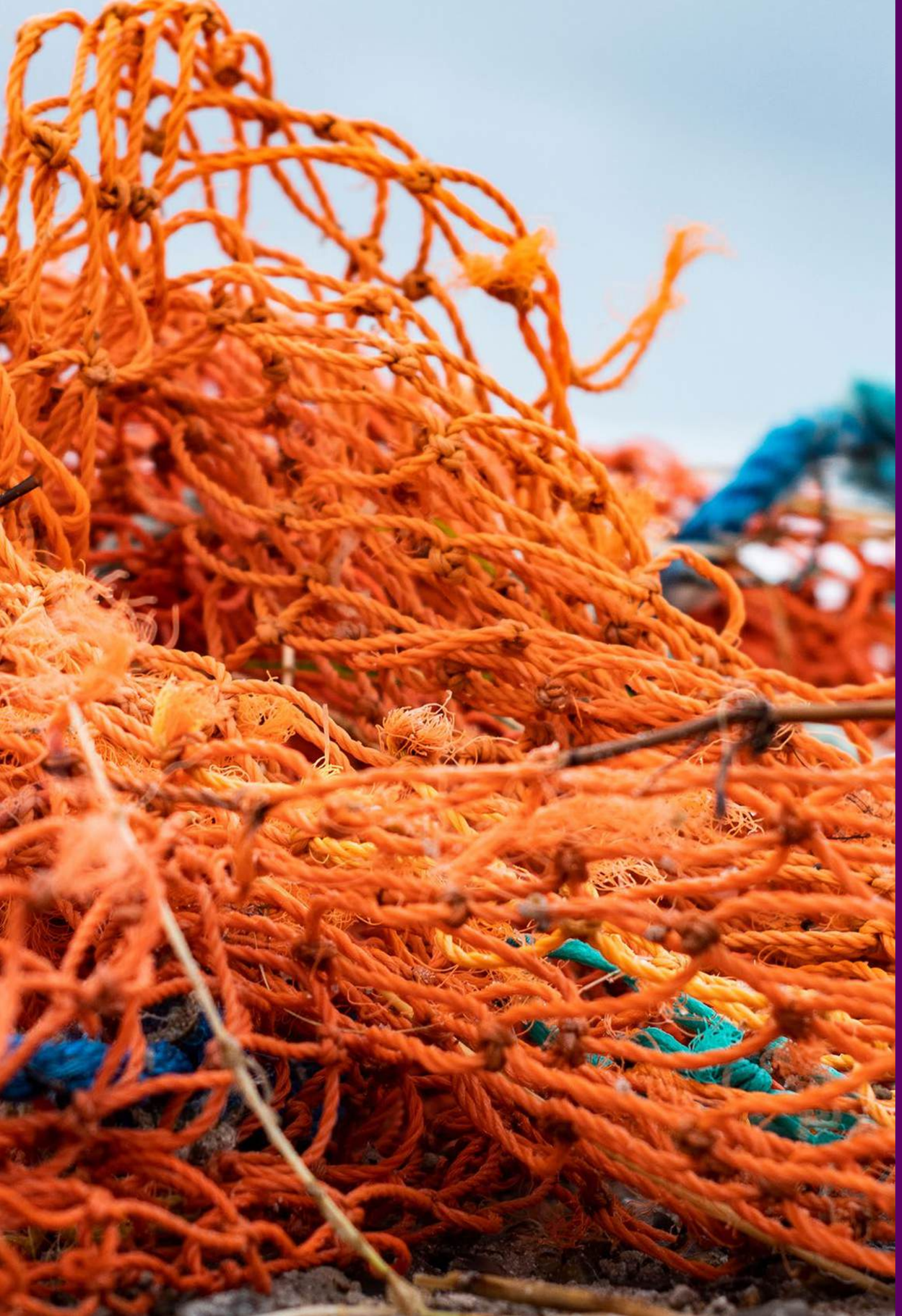
As part of its work on the protection of the marine environment, the IMO has a standing Marine Environmental protection Committee (MEPC) of which India is a member. One of the ongoing but current areas of work of the MEPC is that of marine plastics and in particular marine plastics from shipping. The MEPC meeting to be held in November 2021 is due to discuss the discharge of plastics from fishing vessels, known as Abandoned, Lost and Discarded Fishing Gear (ALDFG).

The primary Indian organisation involved in IMO is the Ministry of Shipping.

4.8.3 The Commonwealth Blue Charter

The Commonwealth Blue Charter is an agreement by all 54 countries of the Commonwealth, of which India is one, to cooperate to solve ocean problems and to meet commitments for sustainable ocean development. The Blue Charter works through a set of Action Groups, each devoted to a particular ocean issue with each Action Group driven by member countries and led by 'Champion' countries. One of these Action Groups is the Clean Ocean Alliance (CCOA), led by the UK and Vanuatu, which focuses on tackling marine plastic pollution.

As part of meeting its commitment to the objectives of CCOA, the UK developed the Commonwealth Litter Programme (CLiP). CLiP is facilitated by an Executive Agency of the UK Department for Environment, Food and Rural Affairs (DEFRA), the Centre for Environment, Fisheries and Aquaculture Science (CEFAS). CEFAS are the UK government's marine and freshwater science experts, working for healthy and productive oceans, seas and rivers and safe and sustainable seafood. Innovative, world-class science is central to their mission and they work to safeguard human and animal health, food security and support marine economies. CLiP began in 2018 and has been working in India since 2019 primarily through the Ministry of Earth Sciences (MoES) and in collaboration with the National Centre for Coastal Research (NCCR) on the development of a national marine litter plan.



4.9 Summary

The issue of marine plastics is an emergent problem with widespread global attention only a relatively recent phenomenon. One of the challenges evident in addressing the issue lies in its transdisciplinary nature as it can be viewed from many different perspectives. This is exacerbated in countries such as India where the scale and complexity of both the issue and its governance are magnified. Nevertheless, common themes can be identified that reflect the situation globally. The applications and demand for synthetic polymers have been growing rapidly, with these 'plastics' providing solutions to a range of problems. This growth has not only outstripped other sectors of the global economy, but it has also developed at a pace considerably faster than any concomitant system of governance aimed at managing it. To date, the problems associated with marine plastics have instead led to a range of responses from a cross section of organisations that can currently be described as sectoral, fragmented, and piecemeal. Effective management has lagged significantly, and India is no different in this respect to other countries.

Recognising the importance of the issue, the Commonwealth Clean Ocean Alliance (CCOA), an action group of the Commonwealth Blue Charter, is working to address the problem through the inception of the Commonwealth Marine Plastics Research and Innovation Framework (CWPRIF); intended to stimulate R&I throughout the Commonwealth and beyond. The subject of MPP provides for a diversity of perspectives and is both transdisciplinary and transboundary in nature. As a result, it is inevitably cross jurisdictional from the perspective of governance.

In mapping the breadth and extent of organisations involved in marine plastics there are a multitude of stakeholders, including private sector, informal sector, and non-government organisations. However, this report focuses only on the key government enablers and research and science actors involved to date. It is anticipated that many of these however will undoubtedly develop research and innovation further as the policy drivers strengthen and as the funding becomes more accessible.

05

Marine Plastics R&I in South Africa

UK CIRCULAR PLASTICS NETWORK

UKRI Innovate UK

5.1 Context in South Africa

South Africa has a vibrant plastic production and manufacturing sector.

Up to half of all plastic raw material consumed in the country is imported, with the rest produced by local polymer producers and then manufactured into packaging (over 50% of total raw material) and other products. The annual plastic consumption per capita was between 40 to 50kg in 2018, with per capita plastic waste generation in the same year of 41kg which is higher than global per capita plastic waste generation of 29kg. Approximately 18% of generated waste is plastic of a total of 55.6 million tonnes generated in 2017c. Consumption and waste generation is concentrated around urban centres and there is a notable lack of reuse and refill schemes resulting in high consumption of single use items consumed on the go. This relatively high consumption of single use products and packaging is then coupled with inadequate waste management, including collection and separation at source, in many municipalities with only 64% of households receiving formal waste collection nationally. The informal waste sector collects up to 80% of recyclable materials (including plastic) due to these materials having a market value. This provides livelihoods to thousands of informal collectors in the absence of mandatory Extended Producer Responsibility and exclusion from the formal waste sector.

A recently published IUCN report titled 'National Guidance for Plastic Pollution Hotspotting and Shaping Action – South Africa', found that of the total plastic waste generated in 2018 (2389 kt) only 352 kt or 14% was recycled, with 28% disposed in sanitary landfills and the remainder in unsanitary landfills and open dumps. This all results in approximately 1.4 million tons of mismanaged waste, with total leakage of plastics into the marine environment at 107 thousand tons per year. The packaging sector is the most significant leakage hotspot, contributing almost 60% of the total plastic leakage, followed by automotive tyres via abrasion resulting in microplastic pollution. The construction and fishing sector is ranked third and fourth with gear loss and leakage from fishing vessels considered minor in the country and does not represent a critical sector hotspot.

Government has recognised the trend of increasing waste generation and mismanagement with a result that policy, such as Extended Producer Responsibility and guidelines to integrate the informal sector, is being implemented to enable the transition to a circular economy. Industry have also started to collaborate on finding solutions upstream via initiatives such as the South African Plastics Pact. NGOs are also very active in this space and have generated much research providing road maps and recommendations for action. There has also been an increase in research on marine plastics, with a focus on upstream and downstream sources and impacts, funded by national government as well as international bodies. However, there is still a need for further research to monitor and track current and future interventions which will also require more regional and international collaboration.

5.2 Marine Plastics R&I strategy and priorities in South Africa

5.2.1 The marine plastics policy and strategic context

Currently there is no specific strategy, roadmap or policy for marine plastics or marine litter in South Africa. As of 2021, there is also no legal definition of marine plastic pollution or marine debris in national legislation which is considered to be a legal deficiency. Environmental law in South Africa, due to the relative infancy of the discipline, is dependent on the influence of international developments and it is expected that some form of policy specific to marine plastics will emerge in future.

The highest law of the land, namely The Constitution of the Republic of South Africa, 1996, makes general provision that everyone has right to an environment that is not harmful to their health or well-being, which includes the prevention of pollution and ecological degradation. Derived from the Constitution are various primary and secondary environmental legislation that pertains to the broader regulation of plastics, namely:

- The National Environment Management Act (NEMA) (Act No. 107 of 1998);
- National Environmental Management Act (107/1998): Amendments to the Environment; Conservation Act Plastic Carrier Bags and Plastic Flat Bags Regulations of 2003;
- National Environmental Management: Waste Act (Act no. 59 of 2008) (Waste Act);
- The National Environmental Management: Integrated Coastal Management Act (NEMICMA);
- The Marine Pollution (Prevention of Pollution from Ships) Act 1986 (Act No. 2 of 1986) read together with its regulations;
- National Water Act (Act No. 36 of 1998).

The most prominent law is the National Environmental Management: Waste Act (Act no. 59 of 2008) (Waste Act) which is under the jurisdiction of the Department of Forestry, Fisheries and the Environment (DFFE). The Act provides the Minister with the power to implement various provisions including Extended Producer Responsibility and plastic carrier bag regulations. Even though the Waste Act covers a large portion of the plastics life cycle, from product design and bans to the management of plastics as a waste, the provisions covering upstream life cycle stages via product restrictions or bans have not been used. Waste management is shared across governmental levels, where the responsibility and mandates are cascaded from national, to provincial and finally to local government. The Waste Act also requires the drafting of the National Waste Management Strategy by DFFE at five yearly intervals, to meet the objectives of the Act and to align future activities to the waste hierarchy.

The latest National Waste Management Strategy (NWMS), published in 2020, refers to marine plastics for the first time and acknowledges the increasing rate of plastic and microplastic pollution in the marine environment. It states that South Africa, due to its extensive coastline, needs to collaborate with the international community to find solutions to reduce future plastic leakage, and to address the existing pollution. It also identifies that plastic pollution consists mostly of single use consumer packaging. Minimising the impact of plastic packaging on the oceans, rivers and wetlands and human settlements through diversion from landfill and increasing reuse, recycling and recovery is an important objective stated in the Strategic Pillar 1: Waste Minimisation.

A shared governmental approach under DFFE is also undertaken with various coastal laws including NEMICMA, where the national, provincial and municipal coastal committees are responsible for implementing coastal management programmes. There is no statutory requirement under NEMICMA to include pollution control measures within these coastal management programmes, but the provincial and municipal governments have the constitutional mandate to do so. The monitoring of the coastal zone for litter and shipping waste is undertaken by the provincial government which also produces the 'State of the Coast' report. An example of a recent 'State of the Coast' report produced by the Western Cape provincial government which assesses coastal themes, places the coastal pollution theme, which covers litter, shipping activity and dumping, as a high concern.

The Marine Pollution Act (Prevention of Pollution from Ships) (Act No. 2 of 1986), read together with its regulations GN.R. 1491 and GN.R. 1490 regulates the management of 'garbage', including operational and plastic waste, from ships at South African ports and in territorial or fishing waters. It also requires that the harbour or terminal provide sufficient reception facilities to receive and manage the waste from ships. It is challenging to monitor compliance to this regulation, specifically GN.R 1490 as ships can dump 'garbage' outside of harbours or terminals to avoid the management fee. The DFFE do conduct random checks on vessels in harbours and terminals with resulting fines for non-compliance for example if ships do not have operational waste on board when arriving.

With the DFFE being the relevant authority for plastic waste management on land via the Waste Act and coastal pollution management and monitoring via NEMICMA, the management of freshwater systems with the accompanying plastic and other pollution is the mandate of the Department of Water and Sanitation (DWS). This highlights the need for improved cross-departmental coordination with regards to coastal discharge.

National government initiatives linked more broadly to plastics are the Phakisa Chemicals and Waste Economy, established by the DFFE and the Department of Planning, Monitoring and Evaluation, and the Good Green Deeds programme. The Phakisa Chemicals and Waste Economy is part of the presidential programme designed to fast track the development of the waste management sector by unlocking economic opportunities and reducing unnecessary negative environmental impacts and is aligned with the National Development Plan. An initiative within this programme, with a focus on plastics within municipal waste, aims to increase plastics recycling rates by investing in material recovery facilities and palletisation (recycling) plants. The Good Green Deeds programme is focussed on consumer behaviour and engages with citizens to ensure they dispose of waste responsibly and that their environment is free of litter and pollution.

An industry led initiative, the South African Plastics Pact was launched in January 2020 and has representative members from industry, government and NGOs. Partners during the initiation phase included the UK based non-profit organisation WRAP, the South African Plastics Recycling Organisation and WWF South Africa. Funding was provided by the UK Foreign and Commonwealth Office, the Commonwealth Litter Programme (CLiP), the UK Department of Environment and Rural Affairs (DEFRA), the UN One Planet Programme and the Nedbank Green Trust. Since the launch GreenCape, a non-profit sector development agency has been the secretariat. This initiative is a very strong driver for R&I to tackle plastic pollution, including marine plastics, given that most of the marine plastic pollution originates from land-based sources. The Pact continues to be funded by member fees and externally from international donors such as the MAVA Foundation. In 2021 the Reuse Innovation Challenge was launched where various individuals and organisations showcased cutting edge innovation to move away from single use disposable packaging.

5.2.2 The research and innovation policy and strategy context to tackle marine plastic pollution

The White Paper on Science, Technology and Innovation a, published by the Department of Science and Innovation (DSI) in 2019 is a review of the National System of Innovation and sets the long-term policy direction for science, technology and innovation towards a prosperous and inclusive society. The policy actions proposed in the White Paper will be implemented according to the decadal plan for science, technology and innovation (STI) for 2019 – 2029. The White Paper focuses on the following:

- Raising the profile of Science, Technology and Innovation (STI) in South Africa by instilling an innovation culture and integrating STI into cross-cutting government planning at the highest levels.
- Strengthening partnerships between business, government, academia and civil society, and creating a more enabling environment for STI.
- Focusing on innovation for social benefit and fundamental economic transformation.
- Expanding and transforming the human resource base of the national system of innovation.
- Increasing investment, both public and private, in STI.

The White Paper does not mention 'marine plastics' as a stand-alone focus. However, it acknowledges that the circular economy is becoming part of the international discourse, links strongly to the Sustainable Development Goals (SDGs) and will be influencing the development pathway for the country.

The most notable are the Council for Scientific and Industrial Research (CSIR) and the National Research Foundation (NRF). These entities provide funding and support to various research institutions, research infrastructure platforms and centres of excellence for marine plastics and more broadly plastics R&I. For example, the Shallow Marine and Coastal Research Infrastructure (SMCRI), featured in section 3.3, is one of 13 large Research Infrastructures developed by the DSI as part of the South African Research Infrastructure Roadmap (SARIR)b. The DSI, in partnership with the CSIR and private sector stakeholders, developed the Waste RDI Roadmap for South Africa to provide strategic direction and to coordinate and manage South Africa's investment in R&I in the waste sector for the period 2015-2025. In addition, the research specific to plastic pollution and marine plastics from the various academic institutions is also funded by other departments such as the DFFE and the Water Research Commission within the Department of Water and Sanitation.

The Technology and Innovation Agency, though not engaged currently with marine plastic R&I, is a government entity which could potentially provide the link between R&I at higher education institutions, science councils, public entities and the private sector for commercialisation.

5.3 Key actors and organisations

This section discusses the enabling agencies (government and non-government) and research and science actors involved, directly or indirectly, in research and innovation in marine plastic pollution in South Africa.

5.3.1 UK Enabling Agencies

5.3.1.1 UK Science and Innovation Network (SIN) in South Africa

The UK-South Africa Newton Fund is the flagship joint partnership between SIN and South Africa, working to promote economic development and social welfare through research and innovation. On the UK side, the Newton Fund is administered by the Department of Business, Energy & Industrial Strategy. On the South African side, the Department of Science and Innovation is the lead agency.

In the field of marine plastics pollution, UK SIN has secured South Africa as a beneficiary of the UK's £6m Commonwealth Litter Programme (CLiP). In future, SIN will be supporting the implementation of the Commonwealth Litter Programme in South Africa headed by DEFRA and CEFAS. SIN also plans to provide a platform for greater UK participation in South Africa's Oceans Economy Blueprint under Operation Phakisa.

5.3.1.2 Centre for Environment, Fisheries, and Aquaculture Science (Cefas)

Cefas established the Commonwealth Litter Programme (CLiP) in 2018. The CLiP programme has and will be supporting five developing countries across the Commonwealth to develop national litter action plans focusing on plastics entering the oceans. South Africa is one of the countries and CLiP began working with local partners in September 2019. The results of this partnership were the following:

- The establishment of two microplastic laboratories and training scientists to detect microplastics in sea water and biota;
- Setting up the STOMP! Awards in collaboration with Durban Green Corridors to find innovative ideas, technologies and outreach projects to address marine plastic pollution;
- Hosted the CLiP Innovation Conference together with Sustainable Seas Trust (SST) in December 2020. The objective was to bring together leaders in Science, Technology, Engineering and Mathematics to share ideas and find solutions to marine plastics in South Africa and the region.

The reports produced during the project duration covers sources and pathways of marine plastic litter, waste characterisation and includes the current status of abandoned and lost fishing gear which was not documented previously in South Africa.

5.3.2 South Africa Enabling Agencies (government and non-government)

5.3.2.1 Department of Science and Innovation (DSI)

The DSI is a national government department seeking to boost socio-economic development in South Africa through research and innovation. To achieve its goals, the Department provides leadership, an enabling environment and resources for science, technology and innovation.

The department has sought to address and improve the stagnation of innovation performance and the exclusivity in the national system of innovation with the launch of the latest 2019 White Paper on Science and Innovation. The policy identifies key areas such as eco-innovation (including green energy), ICT and big data science (4th Industrial revolution) and the need to scale-up support for small and medium enterprises.

Through its programmes and several entities with the department, the DSI is supporting and creating an enabling environment for R&I.

In terms of research and innovation to tackle marine plastic pollution, the DSI, together with public and private partners have developed the country's Waste Research, Development and Innovation (RDI) Roadmap which is an initiative aimed at supporting South Africa's transition to a circular economy. The Waste RDI Roadmap programme for South Africa is administered by the Council for Scientific and Industrial Research (CSIR) and funds much research in the field of plastics and marine plastics.

The DSI is also currently supporting the development a national 'oceans policy' which is under development at DFFE. This development is expected to influence marine plastics research and innovation in the country.

5.3.2.2 Department of Forestry, Fisheries and the Environment (DFFE)

The DFFE aims to transform the approach to environmental protection and balance with socio-economic development as crucial pillars upon which sustainable development rests. The department provides leadership in environmental management, utilisation, conservation and protection of ecological infrastructure through implementation of necessary policies and legislation.

In 2017, the Department together with the Department of Planning, Monitoring and Evaluation launched the Operation Phakisa Chemicals and Waste Economy programme which aimed at engaging on opportunities that lead to a reduction of the chemicals and waste impact on the environment, while growing the overall contribution to GDP of the waste sector and creating jobs.

Through the Oceans and Coasts branch of DFFE work is undertaken on the promotion, management and strategic leadership on oceans and coastal conservation in South Africa. The Oceans and Coasts branch is involved in oceans and coastal research work which includes the annual science report highlighting the state of oceans and coasts around South Africa together with various feasibility studies.

In terms of marine plastics related R&I, the DFFE has funded research together with the DSI on the integration of the informal waste sector into the formal waste management system at the University of the Witwatersrand and the University of the Western Cape. This resulted in the publication of the Integration Guidelines for the Informal waste sector in 2020. The department commissioned a research study on plastic material flows in South Africa in 2017 and the impacts of the plastic carrier bag levy on production and consumption which resulted in the amendment of the plastic carrier bag regulation.

Additionally, the DFFE convened the Plastics Colloquium in 2019 with a follow up in 2020, which brought together various actors from industry, government, civil society and academia to discuss the scope of the plastics pollution problem in the country. While this platform is not necessarily R&I, the DFFE minister uses it to challenge citizens to understand the problem that plastic waste is creating for people and the environment, when not well managed. The event usually covers topics around the end-of-life management of plastic waste–consumer behaviour change, waste management service provision (the state of infrastructure) and the various actors/actions involved.

5.3.2.3 Technology Innovation Agency (TIA)

The TIA is a national public entity under the DSI that serves as the key institutional intervention to bridge the innovation gap between research and development from higher education institutions, science councils, public entities, and the private sector. The mandate of the TIA is derived from the provisions of the Technology Innovation Act (Act 26 of 2008), which establishes the TIA to promote the development and exploitation, in the public interest, of discoveries, inventions, innovations and improvements to improve economic growth and the quality of life of all South Africans.

The TIA provides financial support which includes sourcing investments, providing funding to and thereby driving commercialisation of technology innovation opportunities. This has relevance to future solutions on marine plastic pollution which will need initial funding for commercialisation to reach scale. Concerning non-financial support, the TIA has two programmes namely the Youth Technology Innovation Programme, to assist the youth to participate in the economy and establish techno-enterprises, and the Global Cleantech Innovation programme which promotes clean technology innovation and supporting entrepreneurs in growing their Small, Medium and Micro Enterprises.

Sector funding is available for the waste management sector b which supports technologies that address waste management challenges and climate and environment issues within South Africa. This has specific relevance to plastic waste and marine plastic pollution.

The TIA is funded by the DSI but also engages with the private sector and international entities to secure funding not only for start-ups but also for the commercialisation of market ready technologies.

5.3.2.4 National Advisory Council on Innovation (NACI)

The NACI Council is appointed by the Minister of the DSI to advise the Minister and the Cabinet, on the role and contribution of science, mathematics, innovation and technology, including indigenous technologies.

The membership of NACI is broadly representative of all sectors and is constituted in a manner that ensures a spread of expertise and experience regarding national and provincial interests; scientific and technological disciplines; the needs and opportunities in different socio-economic fields; and research and development in all sectors.

The NACI is instrumental in crafting the high-level framework and focus areas for the Decadal Plan on Science, Technology and Innovation and to evaluate progress of the White Paper on Science and Technology (1996 and 2019). These activities influence future strategy and policy on Science and Innovation in South Africa.

5.3.2.5 WWF South Africa

WWF South Africa is a national office in the global WWF network which was established in 1968. WWF's range of work includes oceans, land, wildlife, freshwater, climate and energy and urban futures. The Circular Plastics Economy programme, which falls under the Urban Futures portfolio of work, was established in 2018 in response to the rising awareness and call to action to address increasing plastic pollution in the marine and other natural environments. The programme applies a holistic systems-based approach in addressing plastic pollution, where each stage of the plastics life cycle is considered for required interventions and action.

The programme aims to accelerate the transition from the inefficient and wasteful linear economy to a circular economy for plastics in South Africa, in which virgin plastic consumption is reduced, the value of plastic is retained in the economy for as long as possible, and no plastic leaks into nature, resulting in multiple environmental and socio-economic benefits.

The Circular Plastics Economy programme is funded by various private donors, international organisations and independent investment funds (e.g., Nedbank Green Trust).

The Marine programmed engages with other NGOs, government, business, coastal communities and seafood consumers to help develop an integrated approach to looking after the marine environment. The Marine

programme is also funded by various private donors, local and international organisations and independent investment funds (e.g., Nedbank Green Trust).

5.3.2.6 IUCN - International Union for Conservation of Nature

IUCN implements the Swedish International Development Cooperation Agency (Sida) funded Marine Plastics and Coastal Communities (MARPLASTICCs) project in South Africa and four other countries. The initiative's goal in South Africa is that the government, industry and society promote, enact and enforce legislation and other effective measures that contain and reduce marine plastic pollution. The project aims to contribute to impact by focusing on four main pathways or "pillars" to impact: Knowledge, Capacity, Policy, and Business.

5.3.2.7 GreenCape

GreenCape is a non-profit organisation that works at the interface of business, government, and academia to identify and remove barriers to economically viable green economy infrastructure solutions. GreenCape catalyses the replication and large-scale uptake of these solutions to enable prosperity in developing countries and their citizens. In South Africa, the organisation focuses primarily on promoting the development of the green economy along with the Western Cape Government and collaborations with other government, industry and academia stakeholders.

Owing to its background and expertise on local collaborations, the organisation currently houses and oversees the implementation of the SA Plastics Pact initiative as a platform to stimulate innovation, dialogue and collaboration to unlock barriers to circularity, to create new business models and generate job opportunities. The SA Plastics Pact Roadmap to 2025 outlines the key activities and outcomes to be achieved as members progress towards attaining the ambitious targets on transforming the way in which SA produces, consumes and dispose of plastic packaging.

In terms of R&I, GreenCape, along with other experts have established the research and development for the green economy (ReDGE) which is a self-reported database amongst stakeholders and produces the market intelligence reports (MIRs) including amongst others, waste and water annual MIRsk. The MIRs highlight insights and opportunities gathered through the engagements with stakeholders in, and research on, the national and Western Cape waste sectors. There is no specific research or initiatives on marine plastics at GreenCape currently.

5.3.2.8 Sustainable Seas Trust (SST)

SST is a Non-Profit Organisation (NPO) that supports and connects communities across Africa through research, education, enterprise development and growing awareness about ocean conservation and plastic pollution. The organisation aims to grow a network of stakeholders in the conservation and waste management sectors to facilitate best practices on conservation of Africa's seas and the management of waste at source before it flows into them. SST houses the African Marine Waste Network (AMWN)a programme, a regional platform focused on mitigating marine pollution in Africa.

5.3.2.9 Wildtrust

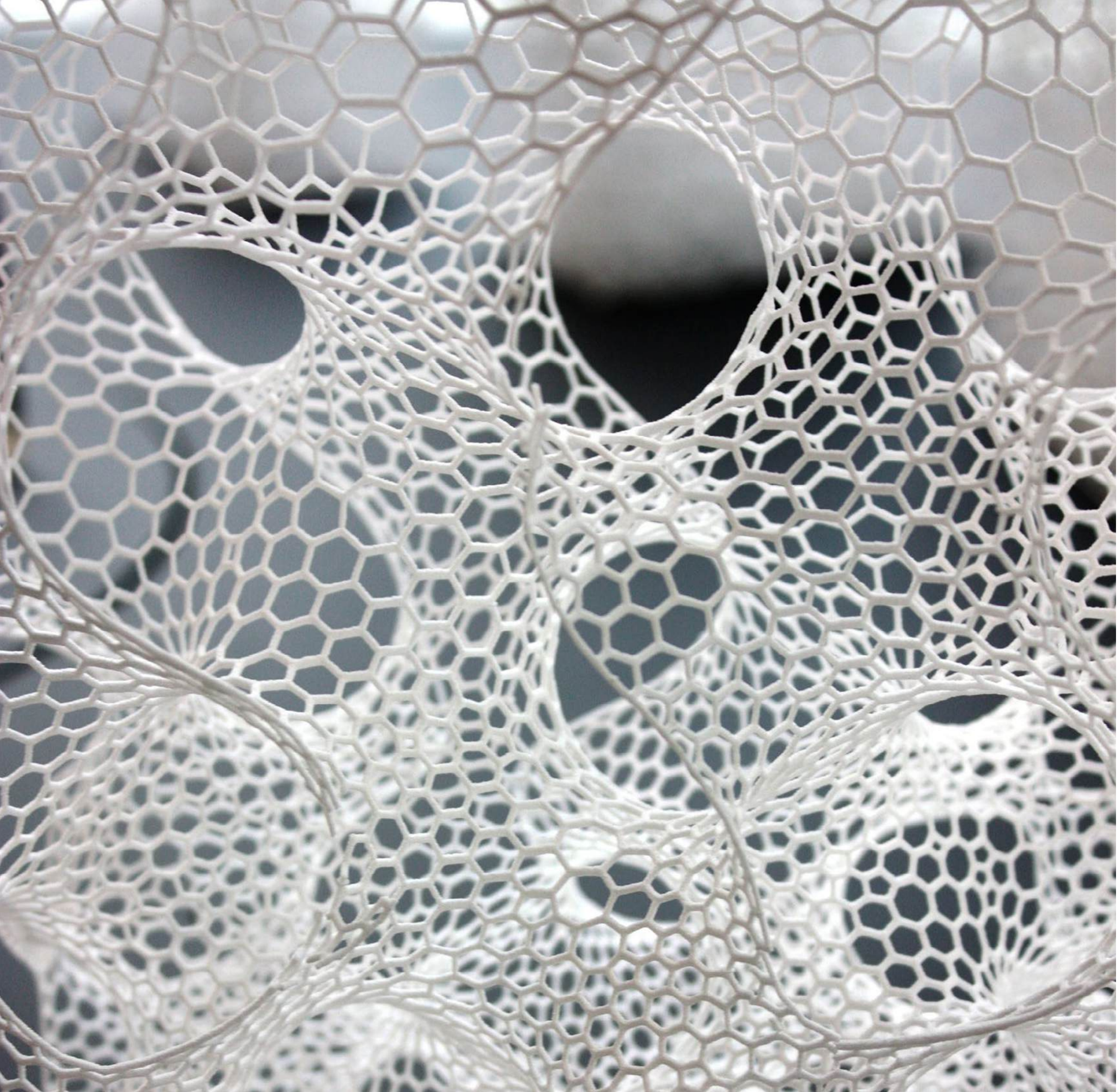
Wildtrust is a non-profit organisation that works for the WILD places. Part of their work involves the safety of threatened species, conserving and restoring the ecosystems in which they can thrive and the upliftment of people, communities, and livelihoods that provide dignity and a future for families. WILDOCEANS, a subsidiary of the Wildtrust was formed with the context of accelerated plans for development in the Southern African marine sector and the sustainable development goals of the Blue Economy.

5.3.2.10 OceanHub Africa (OHA)

OceanHub Africa is non-profit organisation with its focus to accelerate impact-driven start-ups in Africa to protect our oceans. Some of their activities include promoting collaboration between research and civil society to find commercial usage of scientific patents. This is a new organisation that was launched in 2020 with offices in Cape Town. To date they have had two calls for applications and have selected two cohorts for incubation.

5.3.2.11 Dyer Island Conservation Trust (DICT)

The Dyer Island Conservation Trust situated in Gansbaai is a non-profit organisation that has been established for the conservation, rehabilitation and protection of the natural environment. DICT has three plastics related projects that reduces the volume of plastics entering the marine environment.



5.3.3 Research and Science actors

1. Water Research Commission (WRC)
2. The Council for Scientific and Industrial Research (CSIR)
3. National Research Foundation (NRF)
4. The Shallow Marine and Coastal Centre Research Infrastructure (SMCRI)
5. University of Cape Town (UCT)
6. FitzPatrick Institute of African Ornithology
7. Environmental and Process Systems Engineering research group
8. North-West University (NWU)
9. University of the Western Cape (UWC)
10. University of the Witwatersrand (Wits)

5.4 Status of understanding of pollution from marine plastic pollution

This section provides a summary of recent (from year 2000) key research on plastics and marine plastics in South Africa as well as identify research gaps, benchmarked against the research themes in Appendix 1. The focus is on quality research and most visible studies of significant importance undertake by various researchers in the country.

5.4.1 Context to marine plastics research activity in South Africa

The scope of research and information on marine plastics in South Africa is gaining prevalence, particularly in recent years - between 2010 and now. In a 2010 study, the country was allegedly 11th out of the top 20 countries in the world with the most mismanaged plastic waste that ultimately leak into the marine environment (Jambeck et al, 2018).

Seemingly, such estimations have directed interest for most local researchers and key upstream and downstream role players to the subject in a quest to validate or disregard the assumptions.

Research focus has since been undertaken on understanding marine plastics source factors, quantifying leakage, pathways for marine plastics pollution, impact on various ecosystems and possible interventions to address the problem. Moreover, South Africa is among four other African countries with a coastal population of around 12 million, contributing to 2% of mismanaged plastic waste globally. A recent IUCN study, which looked at the leakage rates of four African countries on the Western Indian Ocean seaboard, found the total plastic leakage for Kenya, Mozambique, South Africa and Tanzania at 190 thousand tonnes per annum.

Out of the four countries South Africa has the highest leakage rate and the highest per capita leakage. This quantification of plastic flows and leakage and research on the socio-economic impacts coupled with viable interventions is an area where studies could potentially be focussed on in future, while inland research will be key in providing data and information on related driving forces.

5.5 Research themes

The research undertaken in South Africa is allocated to specific themes and subthemes in the table in Appendix 2 12.1 Research themes and References South Africa.

5.5.1 Research gaps

The research gaps identifies the number of papers or published research found against each research sub-theme. If no research is found this is highlighted. Where research is found but there are less than 9 papers, this is classified as being ‘limited research found’. Appendix 2 12.2 Research Gap in South Africa.

5.6 The Regional, International, Global context for South Africa

5.6.1 Regional organisations/ networks and relevant activities/ initiatives of relevance to South Africa's marine plastics R&I

South Africa is party to two Regional Seas Programme Conventions, the Nairobi Convention for the Protection, Management and Development of Coastal and Marine Environment of the Western Indian Ocean (WIO) region, 1985, and its Strategic Action Programme and the Abidjan Convention for Cooperation in the Protection, Management and Development of the Marine and Coastal Environment of the Atlantic Coast of the West, Central and Southern Africa Region, 1985, and its Protocols. South Africa also participated in the AU's Agenda 2063, which concluded a high-level working session on banning plastics in Africa at the 32nd AU Summit in 2019.

The SST has a regional platform called the African Marine Waste Network (AMWN). The AMWN is an active platform for collaboration, resource and knowledge-sharing within countries and across borders in Africa with a focus on marine plastic pollution mitigation. The mandate of the network is to develop an active consortium of people and organisations within countries and across borders in Africa to develop and implement better waste-management strategies.

However, an end of pipe or waste management approach is taken instead of a life cycle systemic approach to the plastic pollution problem faced in Africa. A strategy plan has been developed which considers the context of African countries with regards to waste management.

The Institute of Waste Management of Southern Africa (IWMSA) is a regional, multi-disciplinary non-profit association that is committed to supporting professional waste management practices in Southern Africa. The association is made up of voluntary members who promote environmentally acceptable, cost effective and appropriate waste management practices. IWMSA is involved in a great deal of activity in the policy, technology and innovation and economic landscape with regards to waste management. Education and training are also a key focus. With regards to marine plastics, the IWMSA does not have a specific focus therein but has an interest group called the 'Waste Minimisation and Recycling Interest Group' (WMRIG) which relates to materials recycling and zero-waste and will host upcoming events on the Circular Economy in South Africa. IWMSA is also a member of the International Solid Waste Association.

The African Circular Economy Network (ACEN) is also a regional initiative with representation in several African countries with members from prominent regional and international organisations and initiatives providing relevant circular economy expertise. This network convenes experts and practitioners for knowledge sharing, updates on regional and international trends and leveraging circular economy opportunities in the African context. The vision of the African Circular Economy Network (ACEN) is to build a restorative African economy that generates well-being and prosperity inclusive of all its people through new forms of economic production and consumption which maintain and regenerate its environmental resources. Funding for this network is drawn from member fees.

5.6.2 Global organisations/network and relevant activities/initiatives where South Africa plays a role.

In the international policy space South Africa is a signatory to various international agreements, treaties and conventions relating to waste and marine pollution. With regards to marine pollution these include:

- the United Nations Convention on the Law of the Sea 1982 (UNCLOS);
- the International Convention for Prevention of Pollution from Ships 1973 (MARPOL) and its Protocols; and
- the Protocol for the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1996 (London Protocol).

These treaties and conventions are affected through a series of national laws, the most relevant of which include NEMICMA; the Marine Pollution (Prevention of Pollution from Ships) Act 1986 and the Waste Act discussed in Section 5.2.1.

At the UN Environment Assembly (UNEA) resolutions have been made on marine litter and microplastics from the first UNEA meeting in 2014. These resolutions called for strengthening the UN Environment Programme's (UNEP) role in taking action on marine litter and microplastics in UNEA-1; establishing the Ad Hoc Open-Ended Expert Group (AHEG) on Marine Litter and Microplastics in UNEA-3; and addressing single-use plastics in UNEA-4. South Africa is part of the member states participating in the UNEA discussions and has participated in some AHEG discussions. The fourth and final AHEG meeting was held in November 2020.

The AHEG-4 resulted in several UN member states, major groups and stakeholders expressing the view that the AHEG should recommend UNEA to start negotiations on a global agreement.

IUCN is an international membership Union with a footprint in South Africa. Under its Global Marine and Polar Programme, IUCN established the 'Close the Plastic Tap' programme which produces analytical research and supports policy development and action in various regions toward addressing plastic pollution. In 2017, funded by Sida, IUCN launched the Marine Plastics and Coastal Communities initiative (MARPLASTICCs), an initiative in Africa and Asia in five countries: Kenya, Mozambique, South Africa, Thailand, and Vietnam. MARPLASTICCs uses an integrated life-cycle approach which, supports a global transition from a linear take-make-dispose model to a circular plastics economy and its specific outcomes in South Africa are highlighted in section 3.2.6, above.

South Africa is also a G20 country and is a member of the G20 Action Plan on Marine Litter. The action plan includes a commitment to "take action to prevent and reduce marine litter of all kinds, including from single-use plastics and micro-plastics". And lastly, the amended Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, includes plastics as a material to be regulated from 1 January 2021. South Africa is also a signatory of this convention and the Waste Act, which amongst other things, gives effect to its international obligations through waste import and export regulations which impose procedural and related controls in relation to the transit, import and export of all wastes.

5.7 Summary

The research and innovation landscape on marine plastic and plastic pollution in South Africa has picked up considerably in the last decade due to increasing international awareness and policy actions. The establishment of the Waste RDI programme at the CSIR in 2012 was a pro-active attempt to provide a structure to fund and capacitate further research on waste, including plastic waste, with the ambition to transition to a circular economy. Since 2000 there has been an increase in international collaborations in R&I and funding, notably from Norway and recently with UK and Swedish government agencies and research institutions. This has strengthened the R&I capacity and output within NGOs and academic institutions in the country and provided much-needed funding, particularly when considering the increasingly constrained public funding environment. Initial research was focused on the prevalence and impacts of plastic in the marine environment but has since moved upstream to freshwater systems and material flow analyses on the sources and pathways of plastics pollution. Research gaps are already being identified with funding now available from the Waste RDI Roadmap programme to investigate the impacts of plastic pollution on ecosystem services and the economy in South Africa. There is also a growing realisation that a holistic, systemic approach to research is required across the life cycle of plastics and not only on waste management. Increasingly, local and international research recommends that R&I and interventions are required at every stage of the plastics life cycle to deliver the outcomes needed for mitigation.

There has also been increasing engagement by government and NGOs in international platforms including UNEA, AHEG and membership to the Commonwealth Clean Oceans Alliance. However, there has been hesitation from government to commit to the various targets within these platforms due to the perceived impact on economic growth and job creation in a developing country context. Even so, the government is paying attention to the waste issue, due to rapidly declining landfill space and the high number of non-compliant landfills in the country resulting in increased leakage of plastic and other waste. There is a recent awareness on marine plastics as stated in the latest NWMS and various policies have been put in place to address plastic pollution. However, there is still fragmentation in policy strategies and positions of the various government departments with different approaches in place for plastics production against waste management. Plastic pollution is predominantly seen as a waste management issue instead of a systemic issue and this is where context specific research of the entire value chain to inform the national policy strategy on plastics and marine plastics is an increasingly important requirement.

06

Marine Plastics R&I in Canada

UK CIRCULAR PLASTICS NETWORK

UKRI Innovate UK

6.1 Context in Canada

Plastics are an integral part of the everyday lives of Canadians.

In Canada, total sales of plastic were estimated to be $35 billion CDN in 2017, with approximately 4,667 kt introduced to the Canadian market in 2016. Plastics are used in a variety of industrial sectors, and demand for plastic products continues to grow. Of the 4,667 kt of plastics that entered the Canadian market in 2016, an estimated 3,268 kt were discarded as waste. Of that plastic waste, an estimated 29 kt (or 1%) were discarded outside of the normal waste stream (i.e., not landfilled, recycled or incinerated) in 2016, through direct release to the environment or through dumps or leaks. An estimated 9% of the remaining plastic waste was recycled, 86% was landfilled, and 4% was incinerated for energy recovery.

In Canada as well as internationally, single-use plastics make up the bulk of macroplastics found stranded on shorelines. The most common litter items collected on Canadian shorelines include cigarette butts, bottle caps, plastic bags, plastic bottles, and straws. Microplastic particles such as fragments and Polystyrene pellets are also found on shorelines. Generally, higher rates of marine plastic pollution accumulation is found in areas with high human and industrial activity.

Statistics:

- Canada has three ocean borders – Atlantic Ocean, Pacific Ocean and Arctic Ocean, with 8 of 10 Canadian provinces and all three Canadian territories directly bordering the 243,000 km of coastline.
- Every year, Canadians throw away over 3 million tonnes of plastic waste. This represents up to $8 billion per year in lost value and wastes valuable resources and energy. Without a change in course, Canadians will throw away an estimated $11 billion each year by 2030.
- About one-third of the plastics used in Canada are for single-use or short-lived products and packaging, with less than 10% of plastic used in Canada recycled.
- The most commonly littered items on our shorelines are single-use or short-lived products, many made of plastics.
- Over the last 25 years, nearly 800,000 volunteers have removed over 1.3 million kilograms of trash from across Canada's shorelines through Ocean Wise and World Wildlife Fund Canada (WWF) for Nature's Great Canadian Shoreline Cleanup program, supported by the Government of Canada.

6.2 Marine Plastics R&I Strategy & Priorities

The Government of Canada's agenda has been focused and leading globally on ocean legislation and policy development and promotion. From a national perspective Canada enacted its Oceans Act in 1997 followed by its Ocean Strategy policy in 2017. From an international perspective Canada has been striving to take leadership on law and policy as it relates to ocean pollution by preparing and leading the 2018 ratification of an Oceans Plastics Charter with the G7 countries and strengthening global momentum to tackle plastic pollution within the United Nations Assembly.

6.2.1 Ocean Acts

Canada's Oceans Act , federal legislation, was brought into force January 31, 1997 making Canada the first country in the world to have a comprehensive oceans management legislation. The Act defines Canadian Maritime Territory Law with the terms of the United Nation's Convention in the Law of the Sea 1982. The Act authorises the Minister of Fisheries and Oceans Canada (DFO) to lead development of a national oceans' management strategy, guided by three principles of sustainable development, integrated management and the precautionary approach. Since enacting the legislation the Government of Canada developed and implemented Canada's Oceans Strategy policy in 2017 and presented and ratified the multilateral Oceans Plastics Charter in 2018.

The Oceans Act has six tenants: Sustainable development, Ecosystem Approach, Precautionary Approach, Integrated Management, Economic Diversification and Collaboration.

6.2.2 Oceans Strategy

Canada's Oceans Strategy is a far-reaching policy framework vision for modern oceans management. The policy presents three key strategy messages: Understanding and protecting the marine environment; Supporting sustainable economic opportunities; and international leadership.

The Oceans Strategy discusses three innovative advancements:

1. Develop, support and promote activities to establish institutional governance mechanisms to enhance coordinated, collaborative oceans management across the federal government and all levels of government.
2. Implement a programme of Integrated Management planning to engage partners in planning and managing ocean activities. It brings together the environmental, economic and social considerations by planning for sustainable us of the oceans in a safe and secure environment.
3. Respond to desire for Canadians to become engaged in oceans management activities by promoting stewardship and public awareness.

6.2.3 Canada-wide Strategy on Zero Plastics Waste

In November 2018, through the Canadian Council of Ministers of the Environment (CCME), the federal, provincial, and territorial governments approved in principle a Canada-wide Strategy on Zero Plastic Waste. Building on the Ocean Plastics Charter, the strategy takes a circular economy approach to plastics and provides a framework for action in Canada.

The CCME agreed to work together to achieve results in key areas of the strategy:

- product design, single-use plastics
- collection systems
- markets
- recycling capacity
- consumer awareness
- aquatic activities
- research and monitoring
- clean-up
- global action

In June 2019, Environment Ministers approved the first phase of the action plan, which identifies the government activities that will support the implementation of the strategy.

6.2.4 Canada's Plastics Science Agenda (CaPSA)

CaPSA, led by Environment and Climate Change Canada, (ECCC) builds on Canadian and international plastics science in research and innovation. Its framework prioritises science identified to address the effects of macro-, micro- and nanoplastic plastic pollution, and to achieve a circular economy for plastics. CaPSA is a reflection of discussions held with a wide range of partners, including science and policy experts from federal, provincial, and territorial governments, academia, Indigenous organisations, and industry. The CaPSA science goals are categorised into five themes covering the life cycle of plastics.

1. Detection, quantification, and characterisation of plastics in the environment – Harmonising / standardising the detection, monitoring, and characterisation of the sources, pathways, concentrations, and fate of plastics in the environment
2. Impacts on wildlife, human health, and the environment – Increasing understanding of the impacts of plastics on wildlife, human health, and the environment
3. Plastic design and alternatives – Decreasing the environmental footprint of plastics by improving their design and enabling value recovery
4. Sustainable use of plastics – Supporting the informed and responsible usage and sustainable management of plastics
5. Waste diversion and recovery – Innovating to enhance the capture and value recovery of existing and future plastics

The CaPSA states, "Currently, efforts are being made to address many of these needs. However, there is significant potential for collaboration and leadership among scientists—including all levels of government, academia and research institutes, non-profit and Indigenous organisations, and industry—to achieve the goals of the framework.

Canada is a global leader in plastics science, with significant work happening across the five key themes of the framework, and with participation from many sectors. Much of this work is fragmented, however, creating a patchwork of information and efforts. Mechanisms for collaboration, knowledge mobilisation, and capacity building must be leveraged to increase coordination and best utilise resources and expertise to address all the priority research areas of the framework.

CaPSA will be critical to enable scientists and funders to consider the priority science needs outlined in this agenda, and how research can contribute to achieving the science goals in a way that is aligned with ongoing initiatives. A targeted multi-faceted approach to plastics science in Canada will address priority knowledge gaps, enhance capacity, capitalise on opportunities for innovation and growth, and provide the required evidence base to support sound decision making, including potential new regulations, policies, and programmes.

6.2.5 Canada's Science Assessment of Plastic Pollution

Canada's Science Assessment of Plastic Pollution is a report led by ECCC and Health Canada (HC) was first published in January 2020 as a draft document to allow for stakeholder review and input. The final report was published in October 2020 coinciding with Prime Minister Justin Trudeau announcement a federal ban of six single-use plastic item, with regulations finalised by the end of 2021. The final report "Summarises the current state of the science on the potential impacts of plastic pollution on the environment and human health and informs future research and decision-making on plastic pollution in Canada."

As the focus of this report is on plastic pollution, it is limited to a review of the occurrence of macroplastics and microplastics resulting from plastic waste entering the environment and does not examine non-environmental sources. Moreover, it does not review the economics of waste management practices or evaluate the efficacy of waste management streams (e.g., recycling)."

6.2.6 Canadian Plastics Innovation Challenges

Through the Innovative Solutions Canada Challenge Stream, the Government of Canada invites small and medium-sized enterprises (SMEs) to propose innovations that address specific government challenges. In Phase 1, successful applicants may receive up to $150,000 (Cdn) to develop a proof of concept. If accepted into Phase 2, SMEs could receive an additional $1 million (Cdn) to develop a working prototype.

6.2.7 Plastics Pollution Policy Initiatives

6.2.7.1 Canadian Microbead Plastics Regulations

The Government of Canada prioritised the review and regulation of microbeads because of potential environmental concerns. Microbeads are defined as plastic microbeads that are ≤ 5 mm in size and are used in many products, including toiletries such as bath and body products, skin cleansers and toothpaste. As a precautionary next step to protect the Canadian environment, the Government of Canada added microbeads to the List of Toxic Substances under Canadian Environmental Protection Act (CEPA) 1999 and later published the Microbeads in Toiletries Regulations on June 14, 2017. The Regulations prohibit the manufacture, import and sale of exfoliating or cleansing toiletries containing plastic microbeads.

6.2.7.2 Canadian Single-Use Plastics Policies

On October 7, 2020, the Government of Canada introduced a comprehensive plan to achieve zero plastic waste. The plan embraces the transition towards a circular economy, increased recycled-content standards and improved targets for recycling rates. Canada intend striving to ban plastic bags, straws, stir sticks, six-pack rings, cutlery, and hard-to-recycle take out containers. Provincial governments, particularly in eastern Canada, have also announced legislation banning single-use plastics.

6.3 Key Actors and Organisations

6.3.1 UK Innovation enablers actors in Canada

The key UK innovation enabler in Canada is the Science and Innovation Network (SIN) which is part of part of Foreign, Commonwealth & Development Office and Department for Science, Innovation and Technology (DSIT). SIN Canada helps UK and Canadian government departments, academics, researchers, NGOs, and other stakeholders forge connections, develop partnerships, and exchange policy best practices among one another.

SIN officers, based at the High Commission in Ottawa and the Consulates General Montreal, Toronto, Calgary, and Vancouver, offer professional and authoritative assistance to British and Canadian stakeholders interested in developing connections with the science and innovation communities between both countries.

6.3.2 Government of Canada

6.3.2.1 Environment and Climate Change Canada (ECCC)

Environment and Climate Change Canada (ECCC) is the Government of Canada's lead on marine plastics strategy and policy development, as the lead author of Canada's Ocean Plastics Charter, Canada's Science Plastic Agenda, Canada's Science Assessment of Plastics Pollution and sponsor of Canadian Plastics Innovation Challenges. ECCC has partnered with Fisheries and Oceans Canada (DFO) in developing the Canadian Marine Plastics priorities and promoting the agenda globally through Global Affairs Canada (GAC).

6.3.2.2 Fisheries and Oceans Canada (DFO)

DFO is responsible for safeguarding Canadian waters and managing Canada's fisheries and oceans resources. DFO ensures healthy and sustainable aquatic ecosystems through habitat protection and sound science, and supports economic growth in the marine and fisheries sectors, and innovation in areas such as aquaculture and biotechnology. DFO is the co-sponsor of the Government of Canada's Ocean Plastics Charter.

6.3.2.3 Global Affairs Canada (GAC)

The GAC is responsible for defining, shaping and advancing Canada's interests and values in a complex global environment. It manages diplomatic relations, promote international trade and provide consular support. GAC leads international development, humanitarian, and peace and security assistance efforts. GAC also contributes to national security and the development of international law. Their key role is in connecting the Canadian government with other organisations around the globe and therefore have less direct influence of marine plastic waste policy and decisions on areas of funding.

6.3.2.4 Innovation, Science and Economic Development (ISED)

ISED is responsible for Canadian economic interests to improve conditions for investment, enhance Canada's innovation performance, increase Canada's share of global trade and build a fair, efficient and competitive marketplace. ISED is the federal institution that leads the Innovation, Science and Economic Development portfolio. Two research and innovation agencies of ISED are the NRC and NSERC.

6.3.3 Agencies

The lead funding department for plastics research in Canada is the Innovation, Science and Economic Development (ISED) and its associated agencies National Research Council of Canada (NRC) and the Natural Science and Engineering Research Council of Canada (NSERC). In addition to the ECCC, DFO and ISED other Government of Canada departments are project funding partners for marine plastics and plastics pollution projects including Natural Resources Canada (NRCan), Heath Canada (HC), Transport Canada (TC), Department of National Defence (DND) and Agriculture and Agri-Food Canada (AAFC). The Canadian Council of Ministers of the Environment (CCME) is an agency that provides a national forum for the federal government, and provincial and territorial governments to discuss environment and climate change priorities and align federal, provincial and territorial legislation and policy to reflect the concerns of Canadian citizens.

6.3.3.1 National Research Council (NRC)

The NRC's Ocean programme supports collaborative research and the development of technologies to better understand the behaviour and fate of micro and nanoplastic particles in waterways, and how they affect marine life. Projects will also include researching options for extracting these plastics for use in other industrial processes, like developing feedstocks. In response to the global ocean plastic crisis, NRC are playing a leading role in addressing plastic waste and pollution. Staff at NRC are employed directly by the Government of Canada to lead and carry out research on behalf of the Government of Canada and have generally no direct affiliation to particular universities, although the NRC facilities are often located on university campuses to facilitate interaction between NRC researchers and academic researchers. The NRC funds a programme called Industry Research Assistance Program (IRAP) which provides advice, connections, and funding to small-to-medium sized businesses to increase their innovation capacity and access to market. There are IRAP officers based across Canada to support businesses within regions of Canada.

6.3.3.2 Natural Science Engineering and Research Council (NSERC)

NSERC funds visionaries, explorers and innovators who are searching for the scientific and technical breakthroughs that will benefit our country. NSERC is Canada's largest supporter of discovery and innovation working with universities, colleges, businesses and not-for-profits to remove barriers, develop opportunities and attract new expertise to make Canada's research community thrive. Staff at NSERC generally do not carry out the research, but programme manage and supply the funds through a competitive process to academics and academic institutions, similarly to UKRI in the UK. See Plastics Science for a Cleaner Future and the Canadian Healthy Oceans Network (CHONe) for current R&I funded programmes.

6.3.3.3 Canadian Council of the Ministries of Environment (CCME)

CCME link the intergovernmental federal, provincial and territorial agency's current priorities on waste to increase waste reduction and resource recovery, contribute to the transition toward a circular economy in Canada, and promote approaches that shift responsibility from taxpayers to producers and users. The CCME has very few direct employees but is used to effectively assimilate and communicate work done by other organisations but at regional and national level. CCME is addressing environmental priorities by implementing the Canada-wide Action Plan on Zero Plastic Waste.

6.4 Research and Science

6.4.1 Canadian Universities

The key Canadian universities, researchers and focus, from the east coast to west coast, leading on Research & Innovation into marine plastic waste are:

- Memorial University, St. John's, NL
- Acadia University, Wolfville, NS
- Dalhousie University, Halifax, NS
- McGill University, Montreal, QC
- University of Waterloo, Waterloo, ON
- Polytechnique Montreal, Montreal, QC
- Queen's University & Royal Military College of Canada, Kingston, ON
- University of Toronto, Toronto, ON
- University of Victoria. Victoria, BC
- University of British Columbia, Vancouver, BC

6.4.2 Canadian Research Institutes

6.4.2.1 Canada's Oceans Supercluster (St. John's, NL)

This organisation represents companies from across Canada with $306 million in total Ocean Supercluster funding ($153 million invested by industry, $153 by the Government of Canada). $250 million in total project value commitments. 100+ new ocean products, processes, and services will be developed and commercialised from projects announced to date.

6.4.2.2 Ocean Frontier Institute (OFI) (Dalhousie University & Memorial University of Newfoundland)

OFI was established in September 2016 through a partnership led by Dalhousie University, Memorial University, and the University of Prince Edward Island. As an international hub for ocean research, OFI brings together experts from both sides of the North Atlantic to explore the vast potential of the ocean.

6.4.2.3 Ocean Networks Canada (University of Victoria, BC)

Focused on monitoring the west and east coasts of Canada and the Arctic to continuously deliver data in real-time for scientific research to help industry, communities, and governments make informed decisions about the future.

6.4.2.4 Ocean Wise Conservation Association (Ocean Wise - Vancouver, BC)

A Public-Private-Partnership focused on tackling three major ocean challenges: overfishing, ocean pollution and climate change.

Ocean Wise Research is home to more than 30 researchers committed to pursuing science in support of ocean conservation. The Ocean Wise Plastics Lab is an Environmental Microplastics Facility which aims to deliver cutting-edge technical insight into the source, transport, fate and effects

related to microplastics in Canada's aquatic environments. The lab employs 12 research staff studying microplastics occurrence in laundry machine outflow, seawater, municipal wastewater and the stomachs and organs of aquatic animals.

6.4.2.5 Coastal Ocean Research Institute (Vancouver Aquarium, Vancouver, BC)

Studies coastal ecosystems establishing independent systematically collected, analysed, and publicly communicate data describing the health of coastal ecosystems and ocean pollution on Canada's West Coast.

6.4.2.6 Institute of Ocean Sciences (Fisheries and Oceans Canada)

A network of nine major scientific facilities across Canada funded and operated by Fisheries and Oceans Canada. The Government of Canada Institutes are home to government scientists, technicians, support staff and ships' crews.

6.5 Status of understanding of pollution from Marine Plastics

6.5.1 Research themes

The research undertaken in Canada is allocated to specific themes and subthemes in the table in Appendix 3 13.1 Research Themes and References Canada

6.5.2 Research Gaps

The research gaps identifies the number of papers or published research found against each research sub-theme. If no research is found this is highlighted. Where research is found but there are less than nine papers, this is classified as being 'limited research found' Appendix 3 13.2 Research Gap in Canada

6.6 Regional & Global Context

6.6.1 Ocean Plastics Charter

Under Canada's G7 presidency in 2018, Canada championed the development of the Ocean Plastics Charter to move toward a more sustainable approach to producing, using, and managing plastics. By signing onto the Charter, governments, businesses, and organisations join in committing to a more resource-efficient and life cycle approach to plastics stewardship, on land and at sea. Through these partnerships, Canada grew the momentum for real action on plastic pollution around the world.

Charter signature Partner countries are invited to implement the objectives and commitments of the Charter within their respective jurisdictions and area of influence. They are also invited to report on their progress in implementing the Charter through their own reporting processes and mechanisms.

6.6.2 The Canada-United Kingdom Partnership on Clean Growth and Climate Change

The partnership was announced in September 2017. The Partnership aims to advance clean innovation promoting cooperation between parties in areas of mutual interest. The Partnership also promotes the participation of both public and private sector bodies in Canada and the UK. The Partnership is overseen by ECCC and the UK Department for Science, Innovation and Technology (DSIT). ECCC collaborates with other federal departments to deliver the Partnership, primarily NRCan and ISED.

6.6.3 The Protection of the Arctic Marine Environment Working Group (PAME)

PAME is one of six Arctic Council working groups. PAME was first established under the 1991 Arctic Environmental Protection Strategy and was continued by the 1996 Ottawa Charter that established the Arctic Council. PAME is the focal point of the Arctic Council's activities related to the protection and sustainable use of the Arctic marine environment and provides a unique forum for collaboration on a wide range of activities in this regard.

6.7 Summary

Canada has a clear desire to take a leading role in reducing marine plastic waste and has put in place a clear action plan to address the issue. Internationally, they used the presidency of the G7 to set out the Ocean Plastics Charter. To support this, Canada has a developed set of policies and these are supported with government documents setting out the relevant scientific needs, in particular Canada's Plastics Science Agenda (CaPSA) and Canada's Science Assessment of Plastic Pollution. Similar documents do not appear to readily available in other countries investigated. All this work has been led by Environment and Climate Change Canada (ECCC), the key government department overseeing the science development.

It should be noted that, unlike the UK, the Canadian Government directly employs scientists in the National Research Council (NRC) and there is a significant group working in the area of plastics waste. Other supporting research programmes have also recently been run.

CaPSA has also been used to introduce the key academics working in the relevant areas linked to the five strategic themes and these are highlighted in the report. Due to its population size, Canada does not have as larger academic community as other Commonwealth countries e.g. UK and India, however a literature search has highlighted work linked to almost all the benchmark themes being used. A key strength of Canadian research is in the monitoring, tracking and identification of plastics in a variety of marine environments from rivers to lakes to oceans. ECCC itself has highlighted where there are research gaps in particular human health effects and environmental effects.

07

Marine Plastics in the United Kingdom

UK CIRCULAR PLASTICS NETWORK

UKRI Innovate UK

7.1 Context in the United Kingdom

An estimated 4.9 million tonnes of plastics is placed on the UK market each year, of which around 3.7 million tonnes become waste.

An estimated 69% of all plastic waste produced is plastic packaging. Non-packaging plastics accounts for an estimated 31% of the total plastic waste. In terms of recycling, plastic packaging, which accounts for more than half of all packaging waste, is recycled at 45% and non-packaging plastic is thought to be recycled at a much lower rate.

The UK Government's recently published 25-year Environment Plan states its ambition to eliminate avoidable plastic waste by the end of 2042 and the supply chain has responded rapidly to the challenges posed by waste plastic with over 80%of supermarkets signing up to the UK Plastics Pact. This first of a kind, voluntary agreement seeks to eliminate unnecessary single-use packaging by 2025; make all plastic packaging recyclable, reusable or compostable; ensure that 70% of plastic packaging is reused, recycled or composted; and 30% recycled contestant across all packaging.

UK marine and maritime interests can be divided into three categories: economic, environmental and governance. These groupings are inter-connected: the marine environment underpins the economy and economic activity is a major determiner of the environmental health. Effective and stable governance is a key enabler for both and for optimising economic benefit and sustainable ecosystem services (which are co-dependent).

7.2 Marine plastics R&I strategy and priorities

7.2.1 Institutional and legislative context

It is estimated that the UK uses approximately five million tonnes of plastic every year, of which almost half is packaging. The UK is reported to be ranked fourth globally for countries generating the most single-use plastic waste per person and is therefore also a major contributor to global plastics pollution.

The UK highly values the marine environment and over the years has been party to the development of numerous international and national frameworks, legislation and agreements to protect, manage and promote sustainable use of the marine environment with regards to natural resources, biodiversity, shipping, pollution, dumping of waste and also leisure activities to name a few. Examples of such governance in place to protect the marine environment from the impacts of anthropogenic activities include OSPAR (ratified by the UK in 1998, implemented and coordinated by DEFRA) and the UK ratified 'United Nations Convention on the Law of the Sea' (UNCLOS) which details the rights and responsibilities of nations regarding their use of the oceans.

In the context of marine plastics pollution, the UK government is 'committed to being a world-leader in tackling plastic pollution. The UK's vision to be a global leader in reducing plastic pollution perhaps comes from a position and need to address its own plastic pollution challenges, a position mirrored by nations across the globe.

Currently less than 10% of everyday plastic packaging gets recycled in the UK. Plastic waste continues to be exported from the UK for recycling 'because at this point in time it has no choice'. The UK does not have capacity to recycle all of the plastics it produces.

Much of the UK's existing waste legislation is EU derived and will be retained in UK law through the European Union Withdrawal Act 2018. Control of some environmental policy reverts to the UK, an example of which is the new EU rules on exporting plastic waste to non-OECD countries, including unsorted plastic waste, which came into force in January 2021. The UK chose not to transpose the new rules but instead opted to adopt a new system of prior informed consent which means that unsorted plastic waste can still be exported to non-OECD countries from the UK if the importer agrees to accept non-hazardous plastic waste. This is one of the first divergences seen so far in the field of environmental regulations since the UK left the EU.

A number of the UK's policies and proposals on waste management and tackling the issues of plastic waste and plastic pollution are UK wide however in addition to the shared UK legislation devolved governments are individually responsible for their waste management which has led to Wales, Scotland and Northern Ireland consulting, planning and implementing some of their own measures to address the issue of plastic waste and the aim of a more circular economy.

Other pending EU legislation includes the 'European Strategy for Plastics in a Circular Economy' which includes a Single Use Plastic Directive which will ban specified items of single use plastic in EU Member States. Member states have until 3 July 2021 to transpose the Directive. The UK is not required to transpose the Directive however Northern Ireland is required to transpose certain articles from the Directive under the provisions agreed as part of the UK/ EU Withdrawal Agreement Northern Ireland Protocol (as amended). To date the Welsh and Scottish governments have both consulted on banning the full range of single use plastic items set out in the Directive.

7.2.2 Legislative framework for plastic waste management

The details below, though not exhaustive provide a summary of some of the national and international agreements, UK obligations, frameworks, strategies and commitments for marine environmental protection, plastic waste management and good environmental status. Although 'plastic waste management' is not directly mentioned in all of the earlier legislative frameworks these have been included to demonstrate the UK's historic governance to ensure accountability and responsibility in protecting the marine environment against pollution and mismanagement of resources. Much of this legislation has facilitated and informed today's marine litter and plastics pollution frameworks.

7.2.3 Legislation to control pollution and dumping of waste at sea from shipping and fishing activities (including discarded fishing gear)

This legislation plays a significant role in restricting the type and quantity of waste dumped at sea. Increased port reception facilities contribute to a reduction in ship-based waste being dumped at sea and carries a requirement for ships to notify the harbour authority with details of the waste they will discharge.

- 1972: London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter & 1996 London Protocol
- 1973: International Convention for the Prevention of Pollution from Ships (MARPOL)
- 1983: Bonn Agreement for Cooperation in Dealing with Pollution of the North Sea by Oil and other Harmful Substances and 1 amendment
- 1984: United Nations Convention on the Law of the Sea (UNCLOS)
- 1992: OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic (1998, 2007 amendments)
- Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2020
- EU Port Reception Facility Directive (EC/2000/59)

7.2.4 Marine litter frameworks, strategies, plans and initiatives

7.2.4.1 Marine Strategy Framework Directive

Marine Strategy Framework Directive (MSFD 2008/56/EC) was adopted on 17 June 2008 (amended in 2017) with the aim of achieving good environmental status (GES) in the marine environment by 2020. Within the framework 11 Descriptors detailed the anthropogenic impacts and pressures on the marine environment. The Framework Directive report published in June 2020 details the increased need for measures to address anthropogenic pressures on the marine environment including plastic litter.

OSPAR Regional Action Plan for Prevention and Management of Marine Litter in the North-East Atlantic 2014. This Regional Action Plan (RAP) sets out the policy context for OSPAR's work on marine litter, describes the various types of actions that OSPAR will work on over the coming years and provides a timetable to guide the achievement of these actions.

Northern Ireland and Scotland published their own Marine Litter Strategies in 2013 and 2014 respectively.

Other UK programmes for waste and litter management through prevention include the Environmental Protection Act 1990 for England, Wales and Scotland and the subsequent codes of practise and strategies such as the Litter Strategy for England 2017, which highlights the extent and economic cost of littering, iterating that littering is a criminal offence providing local councils with the authority to enforce this.

Initiatives led by non-government organisations are wide-spread and continue to be crucial for raising awareness regarding plastics use, plastic pollution and environmental stewardship. Many of these citizen science programmes collect data that can be used to inform research studies and evidence the need for legislative change from government for industry.

The Marine Conservation Society one of the many organisations running initiatives such as the 'The Great British Beach Clean', 'Don't Let Go', 'Stop Ocean Threads', 'Ask Your MP' and the Marine Litter Action Network (MLAN), each encouraging stakeholder collaboration, education and raising awareness of the marine plastics problem.

Networks such as the European Marine Science Educators Association (EMSEA) and MLAN promote collaboration and protection of the marine environment through a diversity of projects and collaborations incorporating holistic approaches including citizen science, behaviour change and education.

On the 26th May 2021 the UK announced its membership of the Ocean Risk and Resilience Action Alliance (ORRAA), the second G7 country to become a full member. ORRAA brings the financial sector, governments and NGOs together and aims to drive $500 million of global investment by 2030 into nature-based solutions to climate change, building resilient coastal communities and enhancing marine ecosystems.

The UK's new £500m Blue Planet Fund will aim to help countries protect and restore critically important marine ecosystems.

7.2.5 Plastic packaging waste management

1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal and 1 amendment (From Jan 2021 Prior Informed Consent procedure is used for the export of certain types of plastic waste. These amended rules apply across the UK).

Plastic and Packaging Waste Directive (94/62/EC) as amended, required EU countries to take measures to reduce the amount of packaging waste and to minimise environmental impacts as a result of the packaging (including plastic). The measures implemented through incentives such as EPR schemes, national programmes and campaigns.

Producer Responsibility Obligations (Packaging Waste) Regulations 2007 (as amended); Producer Responsibility Obligations (Packaging Waste) Regulations (Northern Ireland).

2007 (as amended) and Packaging (Essential Requirements) Regulations 2015 - These regulations minimise packaging and packaging waste through producer obligation to promote or fund the recovery, re-use and recycling of packaging. Eco-responsibility is key for these packaging producer responsibility schemes which adopt a 'polluter pays' type of accountability.

The UK will introduce new legislation in the form of a Plastic Packaging Tax from April 2022 with the policy objective of providing economic incentives to businesses to use recycled material in the manufacture of plastic packaging, creating increased levels of recycling and collection of plastic waste, reducing the quantity of plastic sent to landfill or incineration.

Single use plastic regulations within the UK include Single use carrier bags charge regulations (Wales, 2010; Northern Ireland, 2013; Scotland, 2014; England, 2015) These were introduced with a charge of 5p per carrier bag. In England from May 2021 the charge per bag increased to a minimum of 10p with shops potentially facing a fine if they do not charge. In England there is a requirement for retailers employing more than 250 staff to record and report the number of single use carrier bags they sell.

The EU Circular Economy Action Plan (CEP) adopted in March 2020 announced initiatives promoting the life cycle of products, product design, circular economy, sustainable consumption and waste prevention. The UK, Welsh, Scottish and Northern Ireland governments decided that the 2020 CEP measures would be transposed. In some cases, parts of the UK have already introduced policies which the UK government considers to be sufficient to meet revised EU legislation for a more circular economy.

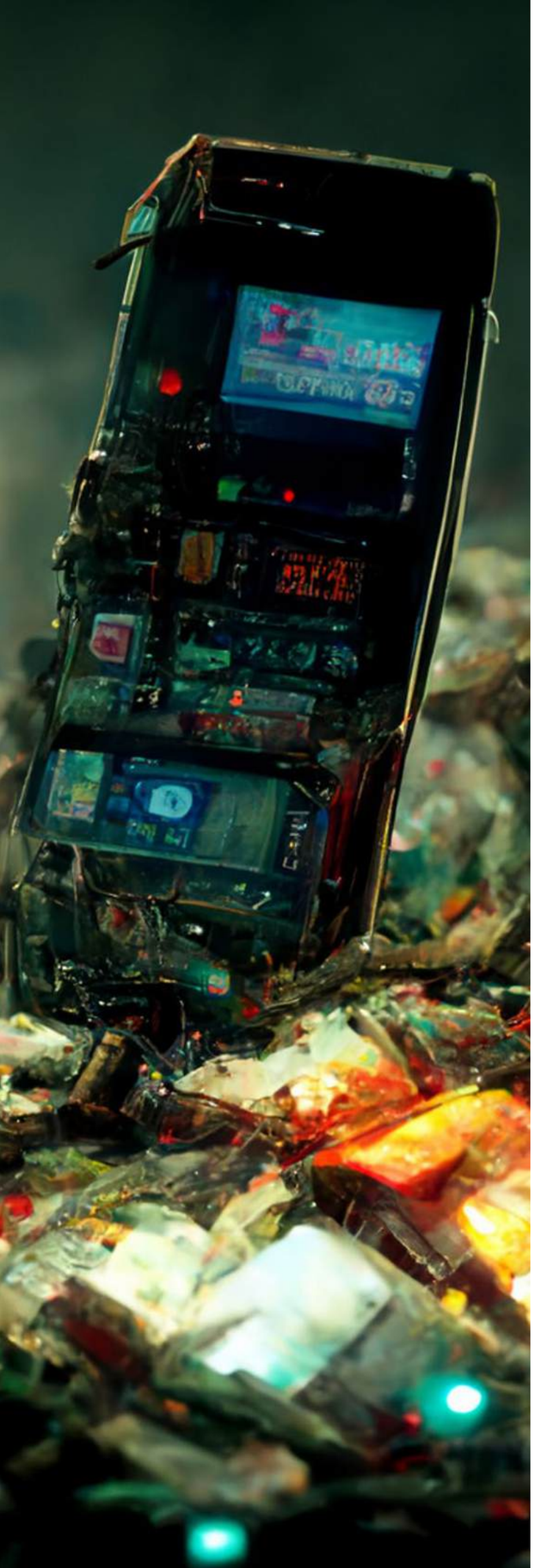
The UK Plastics Pact was developed with the charity WRAP who use their expertise to deliver lasting change through business voluntary agreements, citizen behaviour change, technical support, grants and investments, and policy and insights. WRAP aim to make changes at all points of the value chain to bring about systemic change.

Voluntarily Plastics Pact Members agree to 'eliminate problematic plastics' reducing the total amount of packaging on supermarket shelves, 'stimulate innovation and new business models' and 'help build a stronger recycling system in the UK.' Ensuring that plastic packaging is 'designed so it can be easily recycled' and made into new products and packaging and, with the support of governments, to ensure 'consistent UK recycling' is met.

DEFRA has also co-funded WRAP's support to the South Africa Plastics Pact which was launched in January 2020.

An Extended Producer Responsibility (EPR) is one of the strategic aims of 'Our Waste, Our Resources: A strategy for England (2018)' which to be effective will require the whole supply chain to take responsibility for the adverse environmental impact of plastic pollution.

Deposit and Return Scheme for Scotland 2020 is due to be implemented in July 2022 and will be the first part of the UK to introduce a deposit return scheme (DRS) for drinks containers. As part of Scotland's recycling system the DRS will be available throughout Scotland aiming to make it easier to recycle used bottles, cans and all drinks sold in PET plastic, metal and glass.



7.2.6 Waste and Water framework directives

A number of EU directives adopted by the UK to protect the water environment from domestic and industrial wastewater discharges to sewers include the Urban Wastewater Treatment Directive (UWWTD; 91/271/EEC), set up to manage waste water and treatment of waste water to stop environmental pollution. Some directives are too old to deal adequately with concerns such as the pollution of water bodies by pharmaceutical residues and microplastics in the wastewater system and are under review.

- Environmental Permitting (England and Wales) Regulations 2010
- Waste (England and Wales) Regulations 2011/Waste Regulations (Northern Ireland) 2011/ Waste (Scotland) Regulations 2012 transpose the Waste Framework Directive (2008/98/EC).
- Revised Bathing Waters Directive (BWD; 2006/7/EC) requires monitoring and provision of public information through measures including visual inspections for waste, including tarry residues, glass, plastic or rubber.
- Water Framework Directive (WFD; 2000/60/EEC)/ Water Framework Directive implementation in England and Wales: new and updated standards to protect the water environment (2014) include measures to address pollution through surface water run off reducing litter entering water bodies. Measures to tackle intermittent sewage treatment works discharges.

Departure from the EU has also led to some revisions and amendments by the UK government to within the wastewater framework.

7.2.7 Legislative framework, strategies and commitments for Research and Innovation – established and pending.

The Conservative and Unionist Party Manifesto 2019

'We will continue to lead the world in tackling plastics pollution, both in the UK and internationally, and will introduce a new levy to increase the proportion of recyclable plastics in packaging. We will introduce extended producer responsibility, so that producers pay the full costs of dealing with the waste they produce and boost domestic recycling. We will ban the export of plastic waste to non-OECD countries, consulting with industry, NGOs and local councils on the date by which this should be achieved. '

'We will establish a new £500 million Blue Planet Fund to help protect our oceans from plastic pollution, warming sea temperatures and overfishing, and extend the Blue Belt programme to preserve the maritime environment. We will continue to lead diplomatic efforts to protect 30 per cent of the world's oceans by 2030.'

The UK continues to commission research and innovation to solve the plastics pollution crisis. Some examples are given below.

Research has been commissioned by DEFRA to better understand existing plastic waste recycling capacity in the UK and OECD countries to inform policy options to deliver the manifesto commitment.

In December 2018 the UK government published 'Growing the Bioeconomy: A National Bioeconomy Strategy to 2030'. This detailed a commitment to work with industry and the UK Research and Innovation (UKRI) to assess the implications, benefits and demand regarding standards for bio-based and degradable plastics. Consultation was sought to identify gaps and provide expert advice on:

- The overall sustainability of bio-based and biodegradable plastic products in comparison with those made from other materials including all aspects of a product's life-cycle.

- Existing relevant plastic degradation standards and how, or if, they might be promoted without any adverse effects to the environment and disposal routes.

The design and implementation of standards for biodegradable plastics to ensure that they fully biodegrade in a reasonable timeframe in specified environments.

Plastic Research and Innovation Fund (PRIF) – UK government pledged £20 million to PRIF which is co-ordinated by Innovate UK and EPSRC. Its aim was to explore novel ideas and innovations with the potential to make the plastics sector more circular and address the challenge of persistent plastic pollution.

New Plastics Economy Global Commitment initiative was launched in 2018 at Our Oceans conference developed by the Ellen MacArthur Foundation. The UK government and many of the world's largest packaging producers, retailers, recyclers and NGOs have today signed the commitment to eradicate plastic waste and pollution.

UK Marine Policy Statement from 1 January 2021 - The Marine Policy Statement contributes to the achievement of sustainable development in the UK marine area. It has been prepared and adopted for the purposes of section 44 of the Marine and Coastal Access Act 2009. This has been jointly agreed by the policy authorities the Secretary of State for the Environment, Food and Rural Affairs, Scottish Ministers, Welsh Ministers and DAERA NI.

The Environment Bill 2021-22 includes provisions for deposit return schemes, charges for single use plastics, charges for carrier bags, producer responsibility schemes and separation of recyclable waste streams, of which plastics is one of the main categories.

A Green Future: 25 Year Environment Plan launched in 2018 commits to "significantly reducing and where possible prevent all kinds of marine plastic pollution – in particular material that came originally from land". The 25 Year Environment Plan also sets out its commitment to work with retailers and WRAP to explore introducing plastic-free supermarket aisles in which all the food is sold loose.

Our Waste, Our Resources: A strategy for England (2018) - This strategy compliments other strategies including the 25 Year Environment Plan and will contribute to the delivery of five strategic ambitions.

- All plastic packaging placed on the market being recyclable, reusable or compostable by 2025.
- Eliminating food waste to landfill by 2030.
- To eliminate avoidable plastic waste over the lifetime of the 25 Year Environment Plan.
- To double resource productivity by 2050.
- To eliminate avoidable waste of all kinds by 2050

The Resources and Waste Strategy suggest solutions such as the Deposit Return Scheme (DRS), Extended Producer Responsibility (EPR) for plastic packaging, improved municipal recycling collections and a tax on plastics packaging (hard to recycle or low recycle value).

7.3 Key Actors and Organisations

7.3.1 UK Enabling Agencies

7.3.1.1 Department for Environment Food & Rural Affairs (DEFRA)

DEFRA is the UK government department responsible for safeguarding the UK natural environment, supporting the UK's world-leading food and farming industry, and sustaining a thriving rural economy. "Our broad remit means we play a major role in people's day-to-day life, from the food we eat, and the air we breathe, to the water we drink." One of their key priorities is 'a cleaner, healthier environment, benefiting people and the economy'.

A particular relevant objective is "Continue to drive UK international leadership on marine plastic pollution through domestic, regional and global action, via UK membership of the G7, G20, UN, OSPAR and the Commonwealth Clean Ocean Alliance (contributes to SDG 14)"

Therefore, it has a key role to play in areas relevant to marine Plastics Waste and leads on both the Commonwealth Marine Litter Programme (CLiP), delivered by CEFAS (see below), and the Global Plastics Action Partnership (GPAP), delivered by the World Economic Forum (WEF) both of which are part of the Commonwealth Clean Oceans Alliance (CCOA).

7.3.1.2 Department for Science, Innovation and Technology (DSIT)

From the government website the priorities for 2021 are:

- get businesses ready for Brexit and the opportunities beyond
- lead the world in tackling climate change
- solve the Grand Challenges facing our society
- make the UK the best place in the world to work and do business

To deliver these priorities DSIT is responsible for funding research activities in the UK, including UKRI, with a specific objective to "maximise impact from the creation of UK Research and Innovation (UKRI), working in partnership across the public and private sector to create the best possible environment for research and innovation to flourish". Within DSIT, there are specific staff associated with various countries/regions around the globe.

7.3.1.3 Government Office for Science

The Government Office for science advises "the Prime Minister and members of the Cabinet, to ensure that government policies and decisions are informed by the best scientific evidence and strategic long-term thinking."

A key piece of work of relevance to the framework is the 'Future of the Sea' project. Its purpose was to inform Government's long-term approach to the sea and provide evidence and strategic thinking to inform relevant activities by all sectors. To achieve this, it considers three questions:

- Why does the sea matter to the UK?
- How are the UK's marine interests expected to change?
- What are the implications of these changes?

One of the relevant recommendations in the report is number 8 - "Reduce plastic pollution in the sea, which is projected to treble in a decade without further intervention. The major response is likely to lie in preventing it from entering the sea, introducing new biodegradable plastics, and potentially public awareness campaigns about marine protection – again addressing the out of sight, out of mind challenge."

7.3.1.4 Department for Business and Trade (DBT)

The Department for Business and Trade (DBT) is an international economic department, responsible for:

- bringing together policy, promotion and financial expertise to break down barriers to trade and investment, and help businesses succeed
- delivering a new trade policy framework for the UK as we leave the EU
- promoting British trade and investment across the world
- building the global appetite for British goods and services

Although the department has direct relevance to the framework than DEFRA and DSIT, they are responsible for the Global Expert Missions (GEM) programme. GEMs support the Industrial Strategy's ambition for the UK to be the international partner of choice for science and innovation. Led by Innovate UK KTN, GEMs play an important role in building strategic partnerships, providing deep insight into the opportunities for UK innovation and shaping future bilateral collaboration programmes.

7.3.1.5 Foreign, Commonwealth & Development Office (FCDO)

At a high level on the Government website it states about the Foreign, Commonwealth & Development Office (FCDO) "We pursue our national interests and project the UK as a force for good in the world. We promote the interests of British citizens, safeguard the UK's security, defend our values, reduce poverty and tackle global challenges with our international partners."

Within FDCO, and also part of DSIT, is a key organisation directly relevant to the framework – the science and innovation network.

7.3.1.6 UK Science and Innovation Network

The Science and Innovation Network (SIN) has approximately 100 officers in over 40 countries and territories around the world building partnerships and collaborations on science and innovation. SIN officers work with the local science and innovation community in support of UK policy overseas, leading to mutual benefits to the UK and the host country.

SIN teams develop country-specific action plans and work to the following global objectives:

- Prosperity – enhancing UK growth and exports; connecting innovative UK industries and scientific expertise with international opportunities
- Security – delivering solutions to global challenges such as anti-microbial resistance (AMR), health, energy, the conservation and sustainable use of oceans, and enhancing resilience to natural disasters
- Influence – strengthening the UK's foreign policy influence through science and innovation
- Development – supporting international development goals and matching UK expertise to international need

7.3.1.7 Centre for Environment, Fisheries and Aquaculture Science (CEFAS)

The Centre for Environment, Fisheries and Aquaculture Science (CEFAS) is an executive agency of the Department for Environment, Food and Rural Affairs. It carries out a wide range of research, advisory, consultancy, monitoring and training activities for a large number of customers around the world. Of particular relevance is "We monitor and map the health of seas and oceans, measure water quality, and evaluate pollution from chemicals and marine litter. We provide advice to help achieve national and global environmental commitments, and to ensure clean and resilient marine environments. The collected data is managed for the long-term, openly accessible and analysed to produced scientific based evidence on the status of our seas. Our work is internationally recognised and published in scientific journals."

It is leading the delivery of the Commonwealth Marine Litter Programme (CLiP) which will support five developing countries across the Commonwealth to take action on plastics entering the oceans.

7.3.1.8 UK Research and Innovation (UKRI)

Launched in April 2018, UKRI is a non-departmental public body sponsored by the Department for Science, Innovation and Technology (DSIT). The organisation brings together the seven disciplinary research councils, Research England, which is responsible for supporting research and knowledge exchange at higher education institutions in England, and the UK's innovation agency, Innovate UK. UKRI provides funding to researchers, businesses, universities, NHS bodies, charities, and non-governmental organisations (NGOs). Funding is provided for every stage of research, from fundamental research to applied research that develops new products and services.

UKRI spent nearly £8 billion for the year ending 31 March 2019: £3.28 billion in pioneering ideas. £1.73 billion in research and innovation infrastructure. £1.6 billion in cutting-edge innovation to improve the business environment

For international collaborations it should be noted that researchers based in countries outside the UK can work as co-investigators on some funding opportunities, although the principal investigator for these opportunities must be based in the UK.

Of the 7 research councils, the most relevant for marine plastic waste is -

7.3.1.9 Natural Environment Research Council (NERC)

The Natural Environment Research Council (NERC) advances the frontier of environmental science by commissioning new research, infrastructure and training that delivers valuable scientific breakthroughs. "We do this because understanding our changing planet is vital for our wellbeing and economic prosperity." The delivery plan focuses on eight priority areas to deliver NERC's ambition:

- Environmental solutions: Champion environmental solutions to contribute to clean growth, nurturing a generation of researchers who take a systems approach to complex environmental problems.
- Pushing the frontiers of understanding: Maintain the UK's leading environmental science expertise to be ready for the unknown challenges of the future, challenging researchers to be adventurous and ambitious, exploiting new technologies and approaches.
- Productive environment: Build understanding of economic and environmental system interactions, embed environmental sustainability into economic models, and enable a shift to a circular, resource-efficient economy.

- **Healthy environment**: Promote research to reduce environmental degradation and support healthy life on Earth, increase understanding of the health and wellbeing benefits of a healthy environment, and of the interactions between environmental systems and a healthy economy, society and culture.
- **Resilient environment**: Increase understanding of environmental change and environmental hazards to manage vulnerability, risk, response and recovery, and promote interdisciplinary research to protect lives and livelihoods.
- **Digital environment**: Use cutting-edge technology including machine learning, miniaturisation and battery technology to advance environmental nowcasting. Combine data across disciplines to generate new insight, using high-performance computing to create virtual environments.
- **Global environment**: Bring leadership and UK expertise to understanding the whole Earth system, tackling global challenges, international development and responding to environmental emergencies. Work in partnership and in internationally coordinated efforts to tackle complex environmental challenges.
- **Best environment for research and innovation**: Maintain and enhance the NERC centres of expertise, infrastructure, services and facilities, which benefit the UK environmental science community and global partners. Ensure a pipeline of talent with the skills to resolve future challenges and take a whole-systems approach.

NERC funds the National Oceanography Centre (NOC) which has a specific mission "to make sense of changing seas, upon which future human prosperity and wellbeing depends"

And British Antarctic Survey (BAS) which provide world-leading research infrastructure to enables scientists from the UK, and colleagues from many nations, to work safely and effectively in the polar regions.

7.3.1.10 Innovate UK

As stated on the Innovate UK website "With a strong business focus, we drive growth by working with companies to de-risk, enable and support innovation. We connect businesses to the partners, customers and investors that can help them turn ideas into commercially successful products and services and business growth. We fund business and research collaborations to accelerate innovation and drive business investment into research and development. Our support is available to businesses across all economic sectors, value chains and UK regions."

7.3.2 Relevant NGOs

7.3.2.1 WRAP (Waste and Resources Action Programme)

WRAP was established as a not-for-profit company in 2000 and became a charity in 2014. It works with governments, businesses, and communities to deliver practical solutions to improve resource efficiency around the world.

7.3.2.2 The Ellen MacArthur Foundation

"The Ellen MacArthur Foundation develops and promotes the idea of a circular economy. We work with, and inspire, business, academia, policymakers, and institutions to mobilise systems solutions at scale, globally. Our mission is to accelerate the transition to a circular economy.

Our vision is a new economic system that delivers better outcomes for people and the environment. Business models, products, and materials are designed to increase use and reuse, replicating the balance of the natural world, where nothing becomes waste and everything has value. A circular economy, increasingly built on renewable energy and materials, is distributed, diverse, and inclusive."

7.3.2.3 Sky Ocean Ventures

"Sky Ocean Ventures is accelerating ideas to help us all to kick our plastic habit. We're looking for transformational products and solutions that can change the way millions of people live, enabling us all to use less plastic and recycle more. So far, we are supporting 21 high-potential ideas. We are searching for more. We're funding everything from a disposable bottle made of paper to sachets made of seaweed, to packaging made of wood chips. We hope some of these products will change the way we live, for the better."

7.3.2.4 Surfers Against Sewage

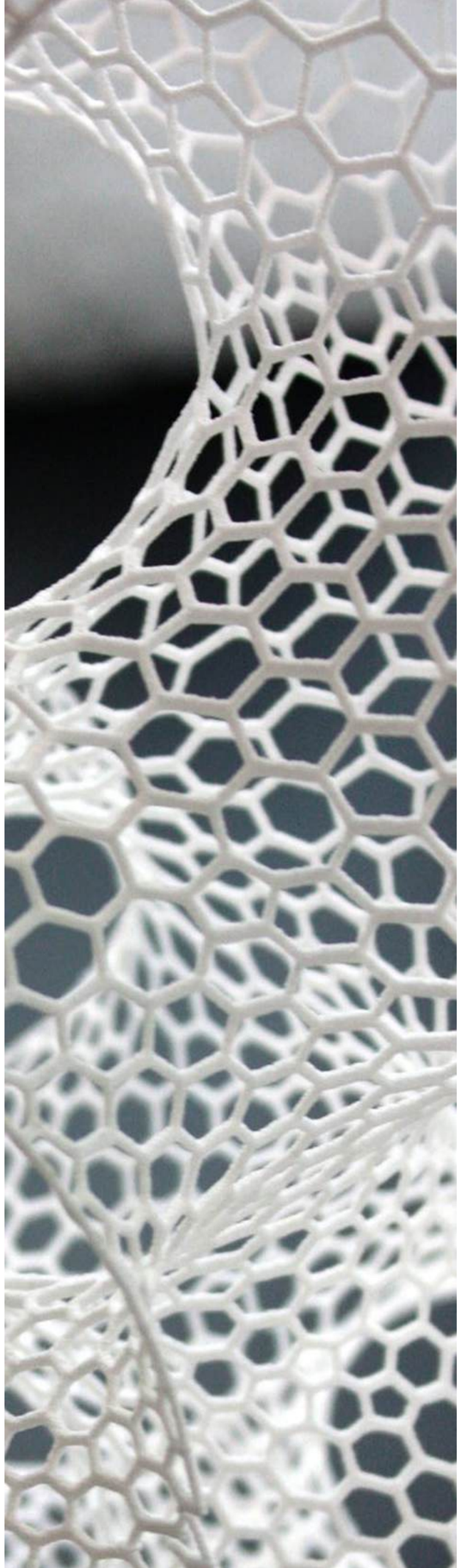
"Surfers Against Sewage is a leading voice in the campaign to eliminate plastic pollution, mobilising and empowering a nationwide network of ocean activists to take action from the beach front to the front benches of Parliament. We work in collaboration with partners to connect grassroot community action and businesses with policy makers to drive progressive government legislation and policy focused on reduction, reuse and refill interventions."

7.3.2.5 Less Plastic

Less plastic is a family-run, non-profit organisation based on the South Devon coast in the UK. Since the Less plastic set up in 2015, it created a whole series of educational infographics and published the world's first book aimed specifically at helping businesses to reduce plastic waste and shared their plastic reduction expertise with hundreds of individuals, schools, businesses and community organisations around the world.

7.3.2.6 WWF

WWF is an international non-governmental organisation founded in 1961 that works in the field of wilderness preservation and the reduction of human impact on the environment. The WWF work for urgent action at the UN and immediate agreement which to stop the leakage of plastics into the oceans



7.4 Research & Science

7.4.1 United Kingdom Universities

The key UK universities, researchers and focus, from England, Scotland, Wales and Northern Ireland, leading on research & innovation into marine plastic waste are:

- University of Plymouth
- Bangor University
- University of Portsmouth
- University of Stirling
- University of East Anglia
- University of Exeter
- University of Surrey
- University of Cambridge
- University of Hull
- University of Bath
- University College London
- Loughborough University
- University of Southampton
- University of Manchester

7.4.2 United Kingdom Research Institutes

ReNew ELP's Wilton Centre, Redcar	ReNew ELP have partnered with Plastic Oceans UK, an organisation focused on developing research into and raising awareness of the damage that plastic is having on our precious oceans, marine life, wildlife and human health through science, sustainability and education programmes.
National Oceanography Centre Southampton, UK	The National Oceanography Centre is an independent self-governing organisation – a charitable company limited by guarantee. The NOC is funded by UK Research and Innovation to work on National Capability programs and manages on its behalf. The NOC conducting research to understand the extend of implication of microplastics pollution on the health of marine ecosystem.
Plastic Ocean UK London, UK	The Plastic Oceans UK have been experts on plastic pollution for a decade, starting with award-winning documentary A Plastic Ocean. It's been named by Sir David Attenborough as "one of the most important films of our time" and has ignited mass consumer awareness. The mission of Plastic Oceans UK is to stop plastic reaching the ocean by engaging the citizens in campaigns and education programs to solve the crisis and change attitudes. The programmes engage multiple audiences on the appropriate use and value of plastics.
Centre for Environment Fisheries and Aquaculture Science Suffolk, UK	CEFAS is government's marine and freshwater science experts. Cefas mission is to help keep the seas, oceans and rivers healthy and productive and the seafood safe and sustainable by providing data and advice to the UK government and our overseas partners. Cefas work with partners across the Commonwealth to share expertise and find solutions to the environmental and socio-economic problems caused by litter in the marine environment.
Plymouth Marine Laboratory Plymouth, UK	PML is interdisciplinary research that benefits society and promotes stewardship of marine ecosystems. Since 2002, and in association with a wide range of national and international partners, PML have provided capabilities as an independent company limited by guarantee with charitable status. The PML mission is to provide scientific evidence for policy and training the next generation of marine scientists. Through the delivery of our science plan, we are also contributing to UN Sustainable Development Goals to promote healthy, productive and resilient oceans and seas. PML is conducting several projects to tackle marine plastic pollution.
Institution of Marine Engineering and Technology London, UK	The IMarEST directly contributes to initiatives aimed at tackling ocean plastics through collaboration with the International Maritime Organization and partnership in international projects to support a much-needed regional focus and capacity building efforts for plastic waste management.
Environmental Research Institution Scotland, UK	The ERI is part of North Highland College UHI. ERI have rapidly evolving research profile and provide a high quality, vibrant research environment. ERI have multi- and inter-disciplinary team focus on promoting excellence research in the region. ERI mission work on research on Plastics and Society by analysis the economic and societal viewpoint(s) relevant to plastic use, disposal and damage caused to the environment and to ecosystems with emphasis on solutions that contribute to the circular economy.
The Marine Conservation Society Ross-on-Wye, UK	The Marine Conservation Society is a UK charity fighting for a cleaner, better protected, healthier ocean. Run several campaigns to reduce plastics waste from getting into the ocean by sharing the awareness and running campaigns to such as Deposit Return Schemes.

7.5 Status of understanding of pollution from Marine Plastics

7.5.1 Research Themes

The research undertaken in the UK is allocated to specific themes and subthemes in the table in Appendix 4 14.1 Research Themes and References United Kingdom.

7.6 Research Gaps

The research gaps identifies the number of papers or published research found against each research sub-theme. If no research is found this is highlighted. Where research is found but there are less than nine papers, this is classified as being 'limited research found.
Appendix 4 14.2 Research Gap in United Kingdom.

7.7 Regional and Global Context for the UK

Marine litter is global problem. Powerful ocean currents sweep across thousands of miles of ocean transporting plastics and other marine debris along with them. The absence of adequate waste management around the world facilitates the accumulation of litter into the environment. This section provides a summary of the regional and global initiatives where the UK plays a role. The focus is on initiatives that would help support marine plastics R&I.

7.7.1 Regional Initiatives of Relevance to Marine Plastics

7.7.1.1 The Marine Strategy Framework Directives

The Marine Strategy Framework Directive (MSFD) was formally adopted in July 2008 and takes an ecosystems-based approach to manage human activity on the coast as sustainably as possible. The MSFD requires all EU Member States to achieve Good Environmental Status (GES) in their marine waters by 2020. In relation to marine litter, GES should mean that Member States, including the UK, manage activities so that they do not cause harm to the environment by 2020. Within the MSFD the UK's marine territory is divided into two discrete areas, the Celtic Sea and the Greater North Sea. The UK is required to produce a marine strategy for both these regions in conjunction with the neighbouring EU countries within the same region. These individual marine strategies must outline how the region will protect and, where needed, enhance the marine ecosystem.

7.7.1.2 European Strategy for Plastics in a Circular Economy

As part of its commitment to a circular economy, the European Commission on 16 January 2018 adopted a European Strategy for Plastics in a Circular Economy. The aim of the strategy is that "all plastic packaging on the EU market will be recyclable by 2030, the consumption of single-use plastics will be reduced and the intentional use of microplastics will be restricted." The UK has banned microbeads in rinse-off personal care products, placed a levy on plastic bags on the high street and has introduced a ban on the supply of plastic straws, drink stirrers and other single-use plastics.

7.7.1.3 OSPAR Regional Action Plan on Marine Litter

The UK is an active participant in OSPAR (the Oslo and Paris Convention for the protection of the marine environment of the North-East Atlantic). This is a collaborative effort with neighbouring countries to address marine litter. The OSPAR objective regarding marine litter is "to substantially reduce marine litter in the OSPAR maritime area to levels where properties and quantities do not cause harm to the marine environment" by 2020. To fulfil this objective OSPAR 2014 agreed a Regional Action Plan (RAP) for Marine Litter for the period 2014-2021. The RAP contains 55 collective and national actions which aim to address both land-based and sea-based sources, as well as education and outreach and removal actions.

7.7.1.4 British-Irish Council

The British-Irish Council (BIC) was established as part of the multi-party agreement reached in Belfast on 10 April 1998. Its membership comprises representatives from the Irish Government; UK Government; Scottish Government; Northern Ireland Executive; Welsh Government; Isle of Man Government; Government of Jersey and Government of Guernsey. It has a Marine Litter Subgroup that comes under the umbrella of the BIC Environment work sector. The 30th British-Irish Council Summit, held in Guernsey, on the 22 June 2018 highlighted a number of marine environment issues. The Ministers stressed that marine litter needed urgent, concerted and collaborative action. They reaffirmed their commitment to "prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution" by 2025 as required by UN Sustainable Development Goal 14: Life Below Water. More specific actions relating to marine was further discussed at the British-Irish Council Marine Litter Symposium, held in Glasgow, on the 22 February 2019. Ministers identified different areas where they could collaborate further, including recycling of end of life fishing gear, reducing the loss of pre-production plastics and improving education for young people and the fishing industry.

7.8 Global Initiatives of Relevance to Marine Plastics and UK Plays a Role

7.8.1 The Commonwealth Blue Charter and the Commonwealth Clean Oceans Alliance

The Commonwealth Blue Charter is an agreement by all 54 countries of the Commonwealth to cooperate to solve ocean problems and to meet commitments for sustainable ocean development. The Blue Charter works through a set of Action Groups, each devoted to a particular ocean issue with each Action Group driven by member countries and led by 'Champion' countries. One of these Action Groups is the Clean Ocean Alliance (CCOA), led by the UK and Vanuatu, which focuses on tackling marine plastic pollution.

7.8.1.1 UN Sustainable Development Goal 14

The United Nations 2030 Agenda for Sustainable Development is a "plan of action for people, planet and prosperity" consisting of 17 Sustainable Development Goals. UN Sustainable Development Goal (SDGs) 14 aims to "Conserve and sustainably use the oceans, seas and marine resources for sustainable development". In September 2015, 193 Member States, including the UK, adopted this Agenda and committed themselves to working "tirelessly for the full implementation of this Agenda by 2030". SDG14 includes the target of:

By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution

7.8.2 UN Clean Seas Campaign and the Global Partnership on Marine Litter

The United Nations Environment Programme (UNEP) #CleanSeas Campaign was launched in February 2017 with the aim of "engaging governments, the general public, civil society and the private sector in the fight against marine plastic litter." The UK Government has signed up to this campaign, which contributes to the goals of the Global Partnership on Marine Litter (GPA) a voluntary open-ended partnership for international agencies, governments, businesses, academia, local authorities and non-governmental organisations hosted by UN Environment.

7.8.3 UN resolution on marine litter and microplastics

In December 2017 the UK Government reported that the UK was one of the 193 UN member states to sign a resolution, Marine Litter and Microplastics (UNEP/EA.3/Res.7) to help reduce the amount of plastic in the world's seas. Under the agreement, an international task force will advise how to combat marine litter. Among other things, the Resolution stresses the importance of long-term elimination of discharge of litter and microplastics to the oceans and of avoiding detriment to marine ecosystems and the human activities dependent on them from marine litter and microplastics.

7.8.4 The IMO "London Protocol"

According to the International Maritime Organization (IMO), 87 States are Parties to this Convention, which was one of the first global conventions to protect the marine environment from human activities and has been in force since 1975. In 1996, the "London Protocol" was agreed to further modernise the Convention and, eventually, replace it. Under the Protocol all dumping is prohibited, except for possibly acceptable wastes on the so-called "reverse list". The Protocol entered into force on 24 March 2006 and there are currently 50 Parties to the Protocol.

7.9 Summary

The UK is reported to be ranked fourth globally for countries generating the most single-use plastic waste per person and currently a major contributor to global plastics pollution.

In the context of marine plastics pollution, the UK is committed to being a world-leader in tackling plastic pollution. The UK also highly values the marine environment and over the years has been party to the development of numerous international and national frameworks, legislation and agreements to protect, manage and promote sustainable use of the marine environment with regards to natural resources, biodiversity, shipping, pollution, dumping of waste and also leisure activities to name a few.

At the international, national and local level there is a raft of activities to combat marine litter. In 2018 the UK Government established the Commonwealth Clean Oceans Alliance (CCOA) to address plastic pollution and to stop single use plastic. The UK and Vanuatu led CCOA to act on the UN's Sustainable Development Goal (SDG) 14 (life below water) and to encourage other Commonwealth countries to sign up to and implement international agreements to protect the ocean. Countries that sign up are encouraged to commit to actions such as the elimination of single use plastic waste, reduction in single use carrier bags and a ban on the manufacture and sale of microbeads in personal care products and rinse-off cosmetics.

CCOA members are also requested to adopt the London Protocol, UN Clean Seas Campaign and the Global Ghost Gear Initiative.

Plastic pollution is also detailed in the Future of the Sea Framework report (May 2018) by the Government Office for Science, which considers the role that science and technology can play in understanding and providing solutions to the long-term issues affecting the sea. Marine plastics is seen as a growing problem, with suggested interventions to prevent plastics entering the marine environment. One of the key priorities for the UK Government, through DEFRA, is 'a cleaner, healthier environment, benefiting people and the economy'. A particular relevant objective is to "Continue to drive UK international leadership on marine plastic pollution through domestic, regional and global action, via UK membership of the G7, G20, UN, The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) and the Commonwealth Clean Ocean Alliance (contributes to SDG 14)." DEFRA, therefore, has a key role to play in areas relevant to marine Plastics Waste and leads on both the Commonwealth Marine Litter Programme (CLiP), delivered by CEFAS and the Global Plastics Action Partnership (GPAP), delivered by the World Economic Forum (WEF) both of which are part of the Commonwealth Clean Oceans Alliance (CCOA).

There are wide-ranging research and innovation activities taking place in the UK focused on marine plastic waste. Focus areas include:

1. Understanding the impacts of marine litter on the environment and society, and to identify the solutions and the pathways necessary to achieve them
2. Plastic use, plastic pollution and plastic alternatives
3. Enzymatic degradation of plastics
4. Understanding the impact of microplastics pollution
5. Mapping the sources of plastic waste, investigating its effects, and generating solutions to reduce waste in the marine environment.

Studies are also required to evaluate the effectiveness of measures to prevent and reduce marine litter and to provide useful guidance to managers and decision makers for litter mitigation. The use of geospatial technologies and remote sensing could be better explored to make the most of limited resources for monitoring and assessment as well as data management and sharing.

Over a 3-year period Research Councils and Innovate UK (UKRI) has invested in plastics R&I initiatives totalling well over £200m. This is a strong indicator of the UK Government's commitment to reducing plastic waste entering the marine environment.

08

Cross-country research themes gaps/synergies

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Table 3: The gaps in Research and Innovation themes and sub-themes in each country.

Theme	Sub theme	UK	CAN	SA	IND
01 Marine plastic from waste	Composition of plastics in solid waste generated				
	Collection and sorting efforts (including port/harbour waste reception facilities)				
	Source differentiation: land leakage, rivers, coastal, sea-based sources				
	Abandoned, lost or otherwise discarded fishing gear (ALDFG)	▲		▲	▲
02 Distribution, abundance, identification and fate of marine plastic	Standardising methodologies – constructing internationally accepted categories and analysis approaches				
	Optimising the extraction procedures and identification methods (e.g. extraction and identification of marine plastics from marine litter, mixed waste)				
	Deposition, accumulation, hotspots, transportation and movement (e.g., numerical models)				
	Building a marine plastics data platform (e.g., fingerprint repository for microplastics, marine plastic debris abundance and distribution)				
	Removal and recyclability of marine plastics			▲	▲
	Degradation and fragmentation (e.g., rates,mechanisms, products)				
03 Impact of marine plastic on the environment	Occurrence of plastics across taxa and trophic levels				
	Monitoring of impact on marine ecosystems (e.g., numerical models)	▲			▲
04 Socio-economic impact of marine plastic	Economic loss (e.g., plastic in fishing gear, threat on tourism)	▲			▲
	Food security	▲		▲	▲
	Human health				
	Plastic as a vector/pathway for pathogens	▲		▲	▲
05 Upstream production – manufacture and use of plastic	Development of new polymers				
	Ban on specific polymers: manufacture, import or use and their impact on marine plastic pollution			▲	
	Limitation in use (i.e., specific polymers for specific application, for example include packaging) and their impact on marine plastic pollution				
06 Governance and regulation of marine plastic at international and regional levels	Outcomes/impacts of relevant policies, regulations	▲			▲
	Changes to (national/international) trade regulations and their impact on marine plastic pollution in the pilot country	▲		▲	▲
	Outcomes/impacts of relevant frameworks in development (expected outcomes), being developed.				

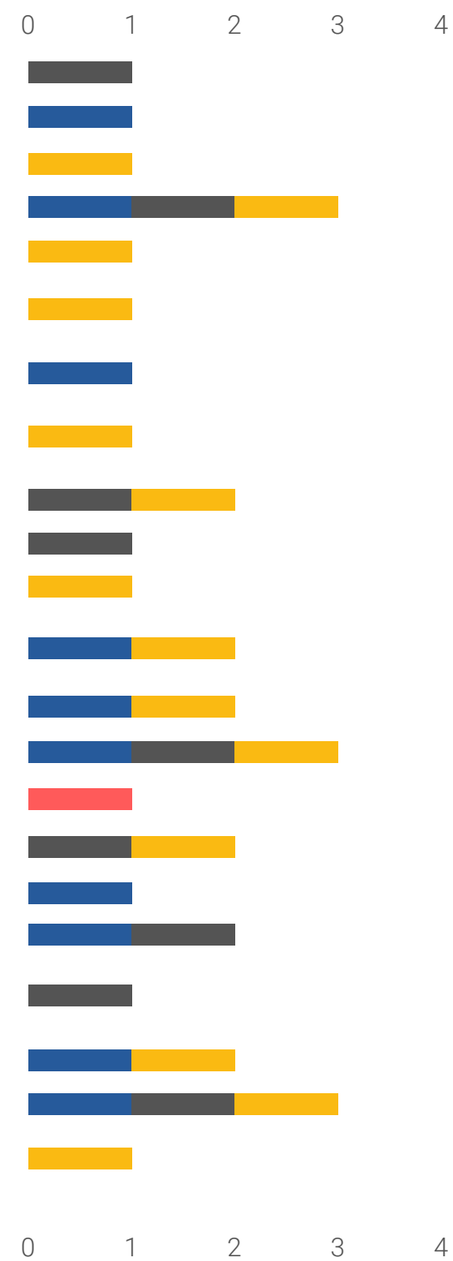
KEY

Little research found in at least 3 of the 4 countries ▲

Little research found in 2 of the 4 countries ▲

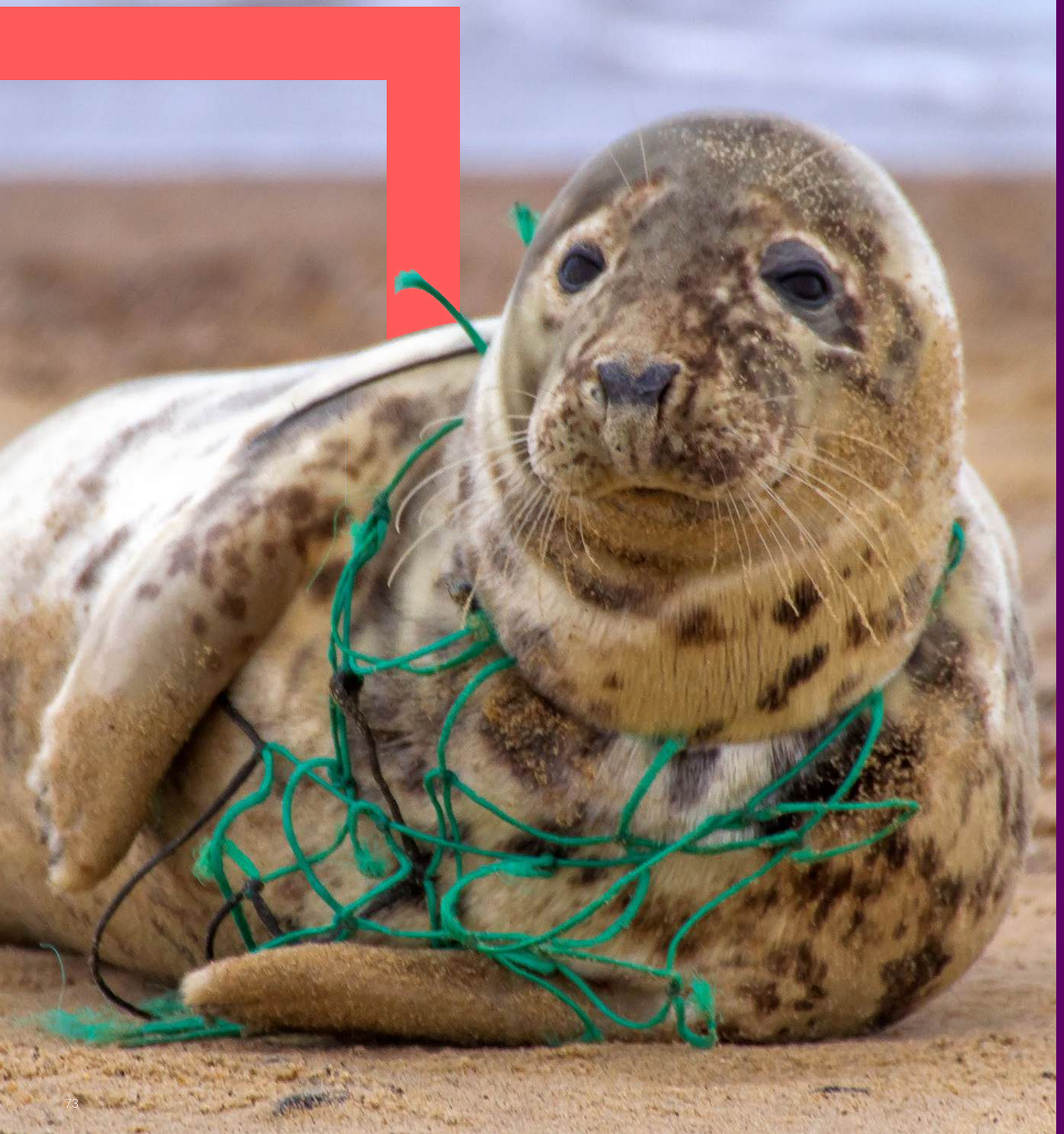
Figure 1: Gaps in Research and Innovation themes and sub-themes in each country.

Theme	
01 Marine plastic from waste	Composition of plastics in solid waste generated
	Collection and sorting efforts (including port/harbour waste reception facilities)
	Source differentiation: land leakage, rivers, coastal, sea-based sources
	Abandoned, lost or otherwise discarded fishing gear (ALDFG)
02 Distribution, abundance, identification and fate of marine plastic	Standardising methodologies – constructing internationally accepted categories and analysis approaches
	Optimising the extraction procedures and identification methods (e.g. extraction and identification of marine plastics from marine litter, mixed waste)
	Deposition, accumulation, hotspots, transportation and movement (e.g., numerical models)
	Building a marine plastics data platform (e.g., fingerprint repository for microplastics, marine plastic debris abundance and distribution)
	Removal and recyclability of marine plastics
	Degradation and fragmentation (e.g., rates,mechanisms, products)
03 Impact of marine plastic on the environment	Occurrence of plastics across taxa and trophic levels
	Monitoring of impact on marine ecosystems (e.g., numerical models)
04 Socio-economic impact of marine plastic	Economic loss (e.g., plastic in fishing gear, threat on tourism)
	Food security
	Human health
	Plastic as a vector/pathway for pathogens
05 Upstream production – manufacture and use of plastic	Development of new polymers
	Ban on specific polymers: manufacture, import or use and their impact on marine plastic pollution
	Limitation in use (i.e., specific polymers for specific application, for example include packaging) and their impact on marine plastic pollution
06 Governance and regulation of marine plastic at international and regional levels	Outcomes/impacts of relevant policies, regulations
	Changes to (national/international) trade regulations and their impact on marine plastic pollution in the pilot country
	Outcomes/impacts of relevant frameworks in development (expected outcomes), being developed.



KEY

UK United Kingdom
CAN Canada
SA South Africa
IND India



09
Conclusions

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This report highlights the significant gaps in marine plastics research, which need to be addressed by the pilot countries (India, South Africa, Canada and United Kingdom), working globally, nationally and at local scale or at potential collaborations between bi/multilateral countries through webinars, explorative workshops, etc.

The variation of research gaps between the pilot countries comes from criteria to identify the gaps by depending on research published after the year 2000 on high impact journals more than 6 'Impact Factor' (IF).

Building on significant research gaps identified through the report in areas such as abandoned, lost or otherwise discarded fishing gear (ALDFG), food security and changes to (national/international) trade regulations and their impact on marine plastic pollution in the pilot countries.

Moreover, this report identified gaps in marine plastics research where the United Kingdom and India can work together to address it, such as monitoring of impact on marine ecosystems (e.g., numerical models), economic loss (e.g., threat on tourism) and Outcomes/impacts of relevant policies and regulations. This can be done though bilateral collaborations between researchers, organisations, NGOs and governments work nationally or internationally to fill the gaps of research needed.

Areas where South Africa and India have significant gaps in research such as removal and recyclability of marine plastics vector/pathway for pathogens, ban on specific polymers: manufacture, import or use and their impact on marine plastic pollution.

The coordination between countries is the priority for successful future collaborations in order to assess and help policy makers to better understand the issues and actions that will be effective to address the impact of marine plastics at a global scale.

10

Recommendations

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1. This report has identified strengths in plastic waste research common across countries that should now be used as best practice to build on commercialisation and implementation.
2. This report has also identified gaps in multi county R&I topics, and these should be closed by focusing on those specific themes.
3. Further support should be given to bilateral collaborations where one country has got a strength in a particular topic and another country has a gap. The coordination between countries is priority for successful future collaborations to assess and help policy makers to better understand the issues and actions that will be effective to address the impact of marine plastics at global scale.
4. Further follow-on work could take an even more holistic approach as 80% of marine plastics waste originates from land.
5. The framework should also assess emerging technologies and identify the unknowns, using the portal to discuss thought leadership and latest thinking. This should be facilitated as needed by the framework governance structure.
6. There should be a knowledge share from those areas with strength. There are a number of themes in common which could be strengthened by working with industry and stakeholders beyond marine scientists – the framework should establish a mechanism to bring the Commonwealth together to showcase areas of interest and mutual benefit.
7. The portal should be used as the mechanism for continuous knowledge exchange, building collaborations and communicating thought leadership.
8. A formal showcase for promoting technologies across the Commonwealth should be held on a regular basis.

11

Appendix 1
India

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11.1 Research Themes and References India

MARINE PLASTIC FROM WASTE

Research sub theme	Scope of work	Publication Date	Reference
Composition of plastics in solid waste generated	Composition of household waste among different socio-economic groups across one Indian city (Dehradun)	2015	Surindra Suthar, Pavitra Singh, Household solid waste generation and composition in different family size and socio-economic groups: A case study, *Sustainable Cities and Society,* Vol. 14, 2015, https://doi.org/10.1016/j.scs.2014.07.004 (last accessed 5th April 2021)
Collection and sorting efforts	Mass flow analysis for plastics across Indian cities	2015	Biplob Nandy, Gaurav Sharma, Saryu Garg, Shweta Kumari, Tess George, Yengkhom Sunanda, Bärbel Sinha, Recovery of consumer waste in India – A mass flow analysis for paper, plastic and glass and the contribution of households and the informal sector, *Resources, Conservation and Recycling, Vol. 101,* https://doi.org/10.1016/j.resconrec.2015.05.012 2015, (last accessed 5th April 2021)
	Assessment of the state of municipal solid waste management in towns and cities across India	2009	Sunil Kumar, J.K. Bhattacharyya, A.N. Vaidya, Tapan Chakrabarti, Sukumar Devotta, A.B. Akolkar, Assessment of the status of municipal solid waste management in metro cities, state capitals, class I cities, and class II towns in India: An insight, *Waste Management,* Vol. 29, Issue 2, 2009, https://doi.org/10.1016/j.wasman.2008.04.011 (last accessed 5th April 2021)
Recycling and trade in plastic waste	Analysis of recycling and associated markets in Delhi	2005	Ankit Agarwal, Ashish Singhmar, Mukul Kulshrestha, Atul K. Mittal, Municipal solid waste recycling and associated markets in Delhi, India, *Resources, Conservation and Recycling,* Volume 44, Issue 1, 2005, https://doi.org/10.1016/j.resconrec.2004.09.007 (last accessed 5th April 2021)
	Country-wide plastics flow analysis	2006	Nitin H. Mutha, Martin Patel, V. Premnath, Plastics materials flow analysis for India, Resources, *Conservation and Recycling,* Vol. 47, Issue 3, 2006, https://doi.org/10.1016/j.resconrec.2005.09.003 (last accessed 5th April 2021)
Source differentiation	Land-based plastic pollution in the Gangetic Delta	2021	Utpal Kumar Raha, B. Ramesh Kumar, Santosh Kumar Sarkar, Policy Framework for Mitigating Land-based Marine Plastic Pollution in the Gangetic Delta Region of Bay of Bengal - A review, *Journal of Cleaner Production,* Volume 278, 2021, https://doi.org/10.1016/j.jclepro.2020.123409 (last accessed 3rd April 2021)
		2020	K. Amrutha, Anish Kumar Warrier, The first report on the source-to-sink characterization of microplastic pollution from a riverine environment in tropical India, *Science of The Total Environment,* Vol. 739, 2020, https://doi.org/10.1016/j.scitotenv.2020.140377
Abandoned, lost or otherwise discarded fishing gear (ALDFG)	Extent of ALDFG in the Ganges, behavioural drivers of disposal and risk to conservation	2021	Sarah E. Nelms, Emily M. Duncan, Surshti Patel, Ruchi Badola, Sunanda Bhola, Surfarsha Chakma, Gawsia Wahidunnessa Chowdhury, Brendan J. Godley, Alifa Bintha Haque, Jeyaraj Antony Johnson, Hina Khatoon, Sumit Kumar, Imogen E. Napper, Md. Nazmul Hasan Niloy, Tanjila Akter, Srishti Badola, Aditi Dev, Sunita Rawat, David Santillo, Subrata Sarker, Ekta Sharma, Heather Koldewey, Riverine plastic pollution from fisheries: Insights from the Ganges River system, *Science of The Total Environment,* Volume 756, 2021, https://doi.org/10.1016/j.scitotenv.2020.143305 (last accessed 6th April 2021)

DISTRIBUTION, ABUNDANCE, IDENTIFICATION AND FATE OF MARINE PLASTIC

Research sub theme	Scope of work	Publication Date	Reference
Survey and monitoring		2017	S. Sruthy, E.V. Ramasamy, Microplastic pollution in Vembanad Lake, Kerala, India: The first report of microplastics in lake and estuarine sediments in India, *Environmental Pollution,* Vol. 222, 2017, https://doi.org/10.1016/j.envpol.2016.12.038 (last accessed 3rd April 2021)
		2021	T.G. Sunitha, V. Monisha, S. Sivanesan, M. Vasanthy, M. Prabhakaran, K. Omine, V. Sivasankar, A. Darchen, Micro-plastic pollution along the Bay of Bengal coastal stretch of Tamil Nadu, South India, *Science of The Total Environment*, Vol. 756, https://doi.org/10.1016/j.scitotenv.2020.144073 2021, (last accessed 5th April 2021)
Deposition, accumulation, hotspots, transportation and movement		2020	S. Veerasingam, M. Ranjani, R. Venkatachalapathy, Andrei Bagaev, Vladimir Mukhanov, Daria Litvinyuk, Liudmila Verzhevskaia, L. Guganathan, P. Vethamony, Microplastics in different environmental compartments in India: Analytical methods, distribution, associated contaminants and research needs, *Trends in Analytical Chemistry*, Vol. 133, 2020, https://doi.org/10.1016/j.trac.2020.116071 (last accessed 5th April 2021)
Degradation and fragmentation		2021	Raghawendra Kumar, Priti Pandit, Dinesh Kumar, Zarna Patel, Labdhi Pandya, Manish Kumar, Chaitanya Joshi, Madhvi Joshi, Landfill microbiome harbour plastic degrading genes: A metagenomic study of solid waste dumping site of Gujarat, India, *Science of The Total Environment*, Vol. 779, 2021, https://doi.org/10.1016/j.scitotenv.2021.146184 (last accessed 3rd April 2021)
		2016	S. Veerasingam, Mahua Saha, V. Suneel, P. Vethamony, Andrea Carmelita Rodrigues, Sourav Bhattacharyya, B.G. Naik, Characteristics, seasonal distribution and surface degradation features of microplastic pellets along the Goa coast, India, *Chemosphere*, Vol. 159, 2016, https://doi.org/10.1016/j.chemosphere.2016.06.056 (last accessed 5th April 2021)

IMPACT OF MARINE PLASTIC ON THE ENVIRONMENT

Research sub theme	Scope of work	Publication Date	Reference
Uptake, egestion, assimilation, accumulation and transfer of ingested plastics by marine organisms		2020	Damaris Benny Daniel, P. Muhamed Ashraf, Saly N. Thomas, Microplastics in the edible and inedible tissues of pelagic fishes sold for human consumption in Kerala, India, *Environmental Pollution,* Vol. 266, Part 2, 2020, https://doi.org/10.1016/j.envpol.2020.115365 (last accessed 5th April 2021)
		2021	Ishrat Vasi Shaikh, Vasi Ahmed Ebrahim Shaikh, A comprehensive review on assessment of plastic debris in aquatic environment and its prevalence in fishes and other aquatic animals in India, *Science of The Total Environment*, Volume 779, 2021, https://doi.org/10.1016/j.scitotenv.2021.146421 (last accessed 3rd April 2021)
Occurrence of plastics across taxa and trophic levels		2020	Nagarajan Vikas Madhav, Kannappan Panchamoorthy Gopinath, Aakriti Krishnan, Neha Rajendran, Abhishek Krishnan, A critical review on various trophic transfer routes of microplastics in the context of the Indian coastal ecosystem, *Watershed Ecology and the Environment,* Volume 2, 2020, https://doi.org/10.1016/j.wsee.2020.08.001(last accessed 5th April 2021)
Effect on particular taxa, communities and ecosystems		2020	Dusmant Maharana, Mahua Saha, Jaffer Yousuf Dar, Chayanika Rathore, R.A. Sreepada, Xiang-Rong Xu, J. Bimali Koongolla, Heng-Xiang Li, Assessment of micro and macroplastics along the west coast of India: Abundance, distribution, polymer type and toxicity, *Chemosphere*, Volume 246, 2020, https://doi.org/10.1016/j.chemosphere.2019.125708 (last accessed 5th April 2021)
		2020	Rojalin Priyadarshini Singh, Sunanda Mishra, Alok Prasad Das, Synthetic microfibers: Pollution toxicity and remediation, *Chemosphere*, Volume 257, 2020, https://doi.org/10.1016/j.chemosphere.2020.127199 (last accessed 6th April 2021)
Effect on marine environment		2020	J.K. Patterson Edward, G. Mathews, K. Diraviya Raj, R.L. Laju, M. Selva Bharath, P. Dinesh Kumar, A. Arasamuthu, Gabriel Grimsditch, Marine debris — An emerging threat to the reef areas of Gulf of Mannar, India, *Marine Pollution Bulletin*, Vol. 151, 2020, https://doi.org/10.1016/j.marpolbul.2019.110793 (last accessed 3rd April 2021)
		2021	M. Ranjani, S. Veerasingam, R. Venkatachalapathy, M. Mugilarasan, Andrei Bagaev, Vladimir Mukhanov, P. Vethamony, Assessment of potential ecological risk of microplastics in the coastal sediments of India: A meta-analysis, *Marine Pollution Bulletin*, Volume 163, 2021, https://doi.org/10.1016/j.marpolbul.2021.111969 (last accessed 5th April 2021)

IMPACT OF MARINE PLASTIC ON THE ENVIRONMENT

Research sub theme	Scope of work	Publication Date	Reference
Marine plastics as a vector/ pathway for pathogens and toxic components		2019	Imran M, Das KR, Naik MM. Co-selection of multi-antibiotic resistance in bacterial pathogens in metal and microplastic contaminated environments: An emerging health threat. *Chemosphere*, Vol. 215, 2019, https://doi.org/10.1016/j.chemosphere.2018.10.114 (last accessed 6th April 2020)
		2021	S. Selvam, K. Jesuraja, S. Venkatramanan, Priyadarsi D. Roy, V. Jeyanthi Kumari, Hazardous microplastic characteristics and its role as a vector of heavy metal in groundwater and surface water of coastal south India, *Journal of Hazardous Materials*, Volume 402, 2021, https://doi.org/10.1016/j.jhazmat.2020.123786 (last accessed 5th April 2021)

SOCIO-ECONOMIC IMPACT OF MARINE PLASTIC

Research sub theme	Scope of work	Publication Date	Reference
Human health		2020	Damaris Benny Daniel, P. Muhamed Ashraf, Saly N. Thomas, Microplastics in the edible and inedible tissues of pelagic fishes sold for human consumption in Kerala, India, *Environmental Pollution,* Volume 266, Part 2, 2020, https://doi.org/10.1016/j.envpol.2020.115365 (last accessed 5th April 2021)
		2021	Mahua Saha, Akshata Naik, Aniket Desai, Mandar Nanajkar, Chayanika Rathore, Manish Kumar, Priyansha Gupta, Microplastics in seafood as an emerging threat to marine environment: A case study in Goa, west coast of India, *Chemosphere*, Volume 270, 2021, https://doi.org/10.1016/j.chemosphere.2020.129359 (last accessed 3rd April 2021)
Plastic as a vector/pathway for pathogens		2019	Imran M, Das KR, Naik MM. Co-selection of multi-antibiotic resistance in bacterial pathogens in metal and microplastic contaminated environments: An emerging health threat. *Chemosphere,* Vol. 215, 2019, https://doi.org/10.1016/j.chemosphere.2018.10.114 (last accessed 6th April 2020)
		2021	S. Selvam, K. Jesuraja, S. Venkatramanan, Priyadarsi D. Roy, V. Jeyanthi Kumari, Hazardous microplastic characteristics and its role as a vector of heavy metal in groundwater and surface water of coastal south India, *Journal of Hazardous Materials,* Volume 402, 2021, https://doi.org/10.1016/j.jhazmat.2020.123786 (last accessed 5th April 2021)

UPSTREAM PRODUCTION - MANUFACTURE AND USE OF PLASTIC

Research sub theme	Scope of work	Publication Date	Reference
Development of new polymers		2020	Chibu O. Umerah, Deepa Kodali, Sydnei Head, Shaik Jeelani, Vijaya K. Rangari, Synthesis of carbon from waste coconut shell and their application as filler in bioplast polymer filaments for 3D printing, *Composites Part B: Engineering*, Volume 202, 2020, https://doi.org/10.1016/j.compositesb.2020.108428 (last accessed 5th April 2021)
		2021	Pawankumar Rai, Srishti Mehrotra, Smriti Priya, Edgard Gnansounou, Sandeep K. Sharma, Recent advances in the sustainable design and applications of biodegradable polymers, *Bioresource Technology,* Volume 325, 2021, https://doi.org/10.1016/j.biortech.2021.124739 (last accessed 5th April 2021)
Ban on specific polymers: manufacture, import or use and their impact on marine plastic pollution		2020	K.E.K. Vimal, K. Mathiyazhagan, Vernika Agarwal, Sunil Luthra, K. Sivakumar, Analysis of barriers that impede the elimination of single-use plastic in developing economy context, *Journal of Cleaner Production,* Vol. 272, 2020, https://doi.org/10.1016/j.jclepro.2020.122629 (last accessed 5th April 2021)
		2021	M. Dhanshyam, Samir K. Srivastava, Effective policy mix for plastic waste mitigation in India using System Dynamics, *Resources, Conservation and Recycling*, Volume 168, 2021, https://doi.org/10.1016/j.resconrec.2021.105455 (last accessed 3rd April 2021)

GOVERNANCE AND REGULATION OF MARINE PLASTIC AT INTERNATIONAL AND REGIONAL LEVELS

Research sub theme	Scope of work	Publication Date	Reference
Outcomes/impacts of relevant policies, regulations		2021	Zinaida Fadeeva, Rene Van Berkel, 'Unlocking circular economy for prevention of marine plastic pollution: An exploration of G20 policy and initiatives', *Journal of Environmental Management,* Volume 277, 2021, https://doi.org/10.1016/j.jenvman.2020.111457 (last accessed 8th April 2021)
		2020	F. Alpizar, F. Carlsson, G. Lanza, B. Carney, R.C. Daniels, M. Jaime, T. Ho, Z. Nie, C. Salazar, B. Tibesigwa, S. Wahdera, A framework for selecting and designing policies to reduce marine plastic pollution in developing countries, *Environmental Science & Policy,* Volume 109, 2020, https://doi.org/10.1016/j.envsci.2020.04.007 (last accessed 8th April 2021)

11.2 Research Gap India

MARINE PLASTIC FROM WASTE

Research sub theme	Comments
Composition of plastics in solid waste generated	Limited research found
Collection and sorting efforts (including port/harbour waste reception facilities)	Limited research found
Source differentiation: land leakage, rivers, coastal, sea-based sources	Limited research found
Abandoned, lost or otherwise discarded fishing gear (ALDFG)	Limited research found

DISTRIBUTION, ABUNDANCE, IDENTIFICATION AND FATE OF MARINE PLASTIC

Research sub theme	Comments
Standardising methodologies - constructing internationally accepted categories and analysis approaches	No research found
Optimising the extraction procedures and identification methods	No research found
Deposition, accumulation, hotspots, transportation and movement (models)	Limited research found
Building a marine plastics data platform	No research found
Removal and recyclability of marine plastics	No research found
Degradation and fragmentation	Limited research found
Occurrence of plastics across taxa and trophic levels	Limited research found
Effect on particular taxa, communities and ecosystems (e.g., toxicity, productivity, food chain)	Limited research found
Effect on marine environment (e.g., physical, chemical, level of absorption)	Limited research found
Marine plastics as a vector/pathway for pathogens and toxic components (e.g., microbes, additives and Persistent Organic Pollutants [POPs])	Limited research found
Monitoring of impact on marine ecosystems (e.g. numerical models)	No research found

SOCIO-ECONOMIC IMPACT OF MARINE PLASTIC

Research sub theme	Comments
Economic loss	Limited research found
Food security	No research found
Plastics as a vector for pathogens	Limited research found

UPSTREAM PRODUCTION - MANUFACTURE AND USE OF PLASTIC

Research sub theme	Comments
Development of new polymers	Limited research found
Limitation in use and their impact on marine plastic pollution	Limited research found

GOVERNANCE & REGULATION OF MARINE PLASTIC AT INTERNATIONAL AND REGIONAL LEVELS

Research sub theme	Comments
Outcomes/impacts of relevant policies, regulations	Limited research found
Changes to trade regulations and their impact on marine plastic pollution in India	Limited research found
Outcomes/impacts of relevant frameworks in development (expected outcomes), being developed	Limited research found

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Appendix 2 South Africa

UK CIRCULAR PLASTICS NETWORK

UKRI Innovate UK

12.1 Research Themes and References South Africa

MARINE PLASTIC FROM WASTE

Research sub theme	Scope of work	Publication Date	Reference
Composition of plastics in solid waste generated	Approach for estimating informally disposed domestic waste in rural versus urban South Africa	2020	Rodseth, C, P Notten and von Blottnitz, H., A revised approach for estimating informally disposed domestic waste quantities in rural versus urban South Africa and implications for waste management; SA *Journal of Science*, 116 (1/2), 2020. https://doi.org/10.17159/sajs.2020/5635
	Insights into the SA waste sector and provision of alternative waste treatment and beneficiation solutions (Waste MIR)	2020	GreenCape Waste Market Intelligence Report. 2020
	Waste classification in SA – analysis of waste generation and disposal	2020	Cefas, Centre for Environment, Fisheries and Aquaculture Science, *South Africa – Waste classification report*, March 2020
	Comparative LCA of five straw material options and their potential environmental impact	2020	Chitaka, T.Y., V. Russo and H. von Blottnitz, In pursuit of environmentally friendly straws: a comparative life cycle assessment of five straw material options in South Africa, *International Journal of Life Cycle Assessment*, 2020. https://doi.org/10.1007/s11367-020-01786-w.
Collection and sorting efforts (including port/Harbour waste reception facilities)	Treatment options for marine plastic waste in South Africa	2020	Williams-Wynn, M.D. and Naidoo, P., A review of the treatment options for marine plastic waste in South Africa. *MarinePollution Bulletin,* 161, p.111785.2020.
Plastic material flows and leakage	Plastic flows and stocks in South Africa	2021	Olatayo, K.I., Mativenga, P.T., and Marnewick, A.L. Comprehensive evaluation of plastic flows and stocks in South Africa. *Resources, Conservation and Recycling.* 2021 Jul 1; 170:105567.
	National guidance for plastic pollution hotspotting and shaping action: Final Report for South Africa	2020	IUCN-EA-QUANTIS, 2020, National Guidance for plastic pollution hotspotting and shaping action, Country report for South Africa (updated April 2021)
Recycling and trade in plastic waste	The value chain and activities of polyethylene terephthalate plastics in the South African waste economy	2020	Hoffman, M. and Schenck, C. The value chain and activities of polyethylene terephthalate plastics in the South African waste economy. Local Economy. 35(5):523-35. 2020.
	PET plastics value chain within the waste economy of South Africa	2020	Hoffman, M.J. and Schenck C.J. The value chain of PET plastics within the waste economy of South Africa. 2020. Local Economy (in press) https://doi.org/10.1177%2F0269094220931697
	South African plastics recycling survey	2020	Plastics SA, South African Recycling Survey 2019: Executive Summary. Published September 2020. https://www.plasticsinfo.co.za/wp-content/uploads/2021/11/Recycling-Survey-2020-Executive-Summary3.pdf (accessed 9 April 2021).
	Waste management and recycling in South Africa	2017	Godfrey, L. and Oelofse, S. Historical review of waste management and recycling in South Africa. Resources. 2017 Dec;6(4):57.

MARINE PLASTIC FROM WASTE

Research sub theme	Scope of work	Publication Date	Reference
Recycling and trade in plastic waste	Key integration point between formal and informal sectors in the waste economy	2021	Barnes, K., Blaauw, D. and Schenck, R., Pretorius, A. Buyback centres in Cape Town: the key integration point between formal and informal sectors in the waste economy of the Western Cape. 2021. *GeoJournal*.:1-5. 202
Source differentiation: land leakage, rivers, coastal, sea-based sources	Product-specific leakage propensity and its inclusion into the life cycle management of plastic product	2021	Chitaka TY, von Blottnitz H. Development of a method for estimating product-specific leakage propensity and its inclusion into the life cycle management of plastic products. *The International Journal of Life Cycle Assessment.* 2021 Apr 6:1-8
	Plastics in municipal drinking water and wastewater treatment plant effluents: challenges and opportunities for South Africa	2020	Iroegbu, A.O., Sadiku, R.E., Ray, S.S. and Hamam, Y., Plastics in municipal drinking water and wastewater treatment plant effluents: challenges and opportunities for South Africa—a review. *Environmental Science and Pollution Research,* 27(12), pp.12953-12966.2020
	Land-based sources and pathways of marine plastics in a South African context.	2020	Verster, C. and Bouwman, H., Land-based sources and pathways of marine plastics in a South African context. *South African Journal of Science,* 116(5-6), pp.1-9. 2020
	Microplastics from urban streams	2020	Dahms, H.T., van Rensburg, G.J. and Greenfield, R., 2020. The microplastic profile of an urban African stream. *Science of The Total Environment*, 731, p.138893
	Microplastic pollution along coastlines	2015	Nel HA, Froneman PW (2015) A quantitative analysis of microplastic pollution along the south-eastern coastline of South Africa. *Mar Pollut Bull* 101:274–279
	Trapping floating microplastics or microfibres in dams	2019	Weideman EA, Perold V, Ryan PG (2019) Little evidence that dams in the Orange–Vaal River system trap floating microplastics or microfibres. *Mar Pollut Bull* 149:110664. https://doi.org/10.1016/j.marpolbul.2019.110664
	Plastic pollution in urban estuaries	2015	Naidoo, T., Glassom, D. and Smit, A.J., Plastic pollution in five urban estuaries of KwaZulu-Natal, South Africa. *Marine pollution bulletin,* 101(1), pp.473-480.2015
	Inclusion of leakage into life cycle management of products involving plastic as a material choice	2020	Chitaka, T.Y., Inclusion of leakage into life cycle management of products involving plastic as a material choice. 2020
	Microplastics in freshwater water environments: a scoping study	2018	Bouwman, H. Minnaar, K. Bezuidenhout, C. and Verster, C. Microplastics in freshwater water environments; a scoping study. Report to the Water Research Commission. North West University. *WRC Report No.*2610/1/18. 2018.

MARINE PLASTIC FROM WASTE

Research sub theme	Scope of work	Publication Date	Reference
Source differentiation: land leakage, rivers, coastal, sea-based sources	Microfibre levels in beach sediments	2017	De Villiers S. Quantification of microfibre levels in South Africa's beach sediments, and evaluation of spatial and temporal variability from 2016 to 2017. *Marine pollution bulletin.* 2018 Oct 1; 135:481-9.
	Challenges and emerging solutions to the land-based plastic waste issue in Africa	2018	Jambeck J, Hardesty BD, Brooks AL, Friend T, Teleki K, Fabres J, Beaudoin Y, Bamba A, Francis J, Ribbink AJ, Baleta T. Challenges and emerging solutions to the landbased plastic waste issue in Africa. *Marine Policy.* 2018 Oct 1; 96:256-63.
Abandoned, lost or otherwise discarded fishing gear (ALDFG)	South African marine fisheries and abandoned, lost and discarded fishing gear	2020	Cefas – Randall, P. South African marine fisheries and abandoned, lost and discarded fishing gear. *Commonwealth Litter Programme – South Africa.* (accessed 20 April 2021)

DISTRIBUTION, ABUNDANCE, IDENTIFICATION AND FATE OF MARINE PLASTIC

Research sub theme	Scope of work	Publication Date	Reference
Standardising methodologies – constructing internationally accepted categories and analysis approaches	Monitoring the abundance of plastic debris in the marine environment	2009	Ryan, Peter & Moore, Charles & Van Franeker, Jan & Moloney, Coleen. Monitoring the abundance of plastic debris in the marine environment. *Philosophical transactions of the Royal Society of London*. Series B, Biological sciences. 364. 2009.10.1098/rstb.2008.0207
	Counting marine debris at sea reveals steep litter gradients	2013	Ryan PG. A simple technique for counting marine debris at sea reveals steep litter gradients between the Straits of Malacca and the Bay of Bengal. *Mar Pollut Bull.* 2013 Apr 15;69(1-2):128-36. doi: 10.1016
Survey and monitoring (e.g., distribution, abundance, type) in different environments (e.g., coastal, water surface, water column, seafloor, sediment, biota)	The transport and fate of marine plastics in South Africa and adjacent oceans	2020	Ryan, P. The transport and fate of marine plastics in South Africa and adjacent oceans. *South African Journal of Science.* 116. 2020. 10.17159/sajs.2020/7677.
	Land-based sources and pathways of marine plastics in a South African context.	2020	Verster, C. & Bouwman, H. Land-based sources and pathways of marine plastics in a South African context. *South African Journal of Science,* 116(5-6), 1-9. 2020. https://dx.doi.org/10.17159/sajs.2020/7700
	The physical oceanography of the transport of floating marine debris,	2020	Van Sebille, E., Aliani, S., Law, K.L., Maximenko, N., Alsina, J.M., Bagaev, A., Bergmann, M., Chapron, B., Chubarenko, I., Cózar, A. and Delandmeter, P., 2020. The physical oceanography of the transport of floating marine debris. Environmental Research Letters, 15(2), p.023003.
	Quantifying temporal trends in anthropogenic litter in a rocky intertidal habitat	2020	Weideman EA, Perold V, Omardien A, Smyth LK, Ryan PG. Quantifying temporal trends in anthropogenic litter in a rocky intertidal habitat. *Marine Pollution Bulletin*. 2020. doi: 10.1016/j.marpolbul.2020.111543.

DISTRIBUTION, ABUNDANCE, IDENTIFICATION AND FATE OF MARINE PLASTIC

Research sub theme	Scope of work	Publication Date	Reference
Optimising the extraction procedures and identification methods (e.g., extraction and identification of marine plastics from marine litter, mixed waste)	Towards Characterising Microplastic Abundance, Typology and Retention in Mangrove-Dominated Estuaries	2020	Naidoo, T., Rajkaran, A. and Govender, J., 2020. Towards characterising microplastic abundance, typology and retention in mangrove-dominated estuaries.
	A trawl survey of seafloor macrolitter on the South African continental shelf	2020	Ryan, P.G., Weideman, E.A., Perold, V., Durholtz, D. and Fairweather, T.P., 2020. A trawl survey of seafloor macrolitter on the South African continental shelf. *Marine pollution bulletin*, 150, p.110741
Deposition, accumulation, hotspots, transportation and movement (e.g., numerical models)	Limited dispersal of river litter onto beaches	2021	Ryan, P.G. and Perold, V., 2021. Limited dispersal of riverine litter onto nearby beaches during rainfall events. *Estuarine, Coastal and Shelf Science*, 251, p.107186.
	Surface Macro-Plastics Dominate the Mass of Particulate Pollution	2020	Ryan, P.G., Weideman, E.A., Perold, V. and Moloney, C.L., 2020. Toward Balancing the Budget: Surface Macro-Plastics Dominate the Mass of Particulate Pollution Stranded on Beaches. *Frontiers in Marine Science,* 7, p.929.
	Rapid increase in Asian bottles in the South Atlantic Ocean indicates major debris inputs from ships	2019	Peter G. Ryan, Ben J. Dilley, Robert A. Ronconi, Maëlle Connan. Rapid increase in Asian bottles in the South Atlantic Ocean indicates major debris inputs from ships. *Proceedings of the National Academy of Sciences*.116 (42) 2019 DOI: 10.1073/pnas.1909816116
	Accumulation and characteristics of plastic debris along five beaches in Cape Town.	2019	Chitaka TY, von Blottnitz H. Accumulation and characteristics of plastic debris along five beaches in Cape Town. *Mar Pollut Bull.* 2019 Jan;138:451-457. doi:
	Consistent patterns of debris on South African beaches indicate that industrial pellets and other mesoplastic items mostly derive from local sources.	2018	Ryan PG, Perold V, Osborne A, Moloney CL. Consistent patterns of debris on South African beaches indicate that industrial pellets and other mesoplastic items mostly derive from local sources. *Environ Pollut*. 2018 Jul; 238:1008-1016. doi:
	Debris size and buoyancy influence the dispersal distance of stranded litter	2016	Fazey FMC, Ryan PG. Debris size and buoyancy influence the dispersal distance of stranded litter. *Mar Pollut Bull.* 2016 Sep 15;110(1):371-377. doi: 10.1016/j.marpolbul.2016.06.039. Epub 2016 Jul 5. PMID: 27389460
	Plastic ingestion by estuarine mullet Mugil cephalus (Mugilidae) in an urban harbour	2015	T Naidoo, AJ Smit & D Glassom (2016) Plastic ingestion by estuarine mullet Mugil cephalus (Mugilidae) in an urban harbour, KwaZulu-Natal, South Africa, *African Journal of Marine Science*, 38:1, 145-149, DOI: 10.2989/1814232X.2016.1159616
	Litter survey detects the South Atlantic 'garbage patch	2014	Ryan PG. Litter survey detects the South Atlantic 'garbage patch'. *Mar Pollut Bull.* 2014 Feb 15;79(1-2):220-4. doi: 10.1016/j.marpolbul.2013.12.010. Epub 2013 Dec 18. PMID: 24360332

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Research sub theme	Scope of work	Publication Date	Reference
Building a marine plastics data platform (e.g., fingerprint repository for microplastics, marine plastic debris abundance and distribution)	Marine and freshwater microplastics research in South Africa	2017	Verster, C., Minnaar, K. and Bouwman, H., 2017. Marine and freshwater microplastic research in South Africa. Integrated environmental assessment and management, 13(3), pp.533-535.

IMPACT OF MARINE PLASTIC ON THE ENVIRONMENT

Research sub theme	Scope of work	Publication Date	Reference
Uptake, egestion, assimilation, accumulation and transfer of ingested plastics by marine organisms	Ingestion of plastic litter by the sandy anemone Bunodactis reynaudi	2020	Weideman EA, Munro C, Perold V, Omardien A, Ryan PG. Ingestion of plastic litter by the sandy anemone *Bunodactis reynaudi*. *Environ Pollut*. 2020 Dec; 267:115543. doi: 10.1016/j.envpol.2020.115543. Epub 2020 Aug 29. PMID: 32892023.
Impacts of plastics debris on biota and implications for human health: A South African perspective		2020	Naidoo, Trishan, Rajkaran, Anusha, & Sershen, (2020). Impacts of plastic debris on biota and implications for human health: A South African perspective. *South African Journal of Science,* 116(5-6), 1-
Decadal changes in plastic litter regurgitated by albatrosses and giant petrels at sub-Antarctic Marion Island		2020	Perold, V., Schoombie, S. and Ryan, P.G., 2020. Decadal changes in plastic litter regurgitated by albatrosses and giant petrels at sub-Antarctic Marion Island. *Marine Pollution Bulletin*, 159, p.111471.
Microplastics in mussels along the coast of Cape Town, South Africa		2020	Sparks C (2020) Microplastics in mussels along the coast of Cape Town, South Africa. *Bull Environ Contam Toxicol* 104:423431. https://doi.org/10.1007/s0 0128-020-02809-w
Entanglement of birds by plastics		2018	Ryan, P.G., 2018. Entanglement of birds in plastics and other synthetic materials. *Marine pollution bulletin,* 135, pp.159-164.
Microplastic ingestion by waterbirds from contaminated wetlands		2018	Reynolds C, Ryan PG (2018) Micro-plastic ingestion by waterbirds from contaminated wetlands in South Africa. *Mar Pollut Bull* 126:330–333
Presence of microplastics in the tube structure of the reef-building polychaete Gunnarea gaima rdi		2018	Nel HA, Froneman PW (2018) Presence of microplastics in the tube structure of the reef- building polychaete Gunnarea gaimardi (Quatrefages 1848). *Afr J Mar Sci* 40(1):87–89. https://doi.org/10.2989/1814232X.2018.1443835

IMPACT OF MARINE PLASTIC ON THE ENVIRONMENT

Research sub theme	Scope of work	Publication Date	Reference
Uptake, egestion, assimilation, accumulation and transfer of ingested plastics by marine organisms	Plastic ingestion by estuarine mullet Mugil cephalus (Mugilidae) in an urban harbour, KwaZulu-Natal, South Africa	2016	Naidoo T, Smit A, Glassom D (2016) Plastic ingestion by estuarine mullet Mugil cephalus (Mugilidae) in an urban harbour, KwaZulu-Natal, South Africa. *Afr J Mar Sci* 2338:1–5. https://doi.org/10.2989/1814232X.2016.1159616.
	How quickly do albatrosses and petrels digest plastic particles?	2015	Peter G. Ryan, How quickly do albatrosses and petrels digest plastic particles?, *Environmental Pollution*, Volume 207,2015, Pages 438-440, ISSN 0269-7491, https://doi.org/10.1016/j.envpol.2015.08.005.
	Trends and interventions in large whale entanglement along the South African coast.	2011	Meÿer MA, Best PB, Anderson-Reade MD, Cliff G, Dudley SFJ, Kirkman SP (2011) Trends and interventions in large whale entanglement along the South African coast. *Afr J Mar Sci* 33(3):429–439
	Seabirds indicate changes in the composition of plastic litter in the Atlantic and south-western Indian Oceans	2008	Ryan PG (2008) Seabirds indicate changes in the composition of plastic litter in the Atlantic and south-western Indian Oceans. *Mar Pollut Bull* 56:1406–1409. https://doi.org/10.1016/j.marpolbul.2008.05.004
	Large sharks and plastic debris in KwaZulu-Natal, South Africa	2002	Cliff, G., Dudley, S.F., Ryan, P.G. and Singleton, N., 2002. Large sharks and plastic debris in KwaZulu-Natal, South Africa. *Marine and Freshwater Research,* 53(2), pp.575-581
Occurrence of plastics across taxa and trophic levels	Regional differences in plastic ingestion among Southern Ocean fur seals and albatrosses	2016	Ryan, P.G., De Bruyn, P.N. and Bester, M.N., 2016. Regional differences in plastic ingestion among Southern Ocean fur seals and albatrosses. *Marine pollution bulletin,* 104(1-2), pp.207-210
Effect on particular taxa, communities and ecosystems (e.g., toxicity, productivity, food chain)	Anthropogenic debris in the nests of kelp gulls in South Africa	2017	Witteveen, M., Brown, M. and Ryan, P.G., 2017. Anthropogenic debris in the nests of kelp gulls in South Africa. *Marine Pollution Bulletin*, 114(2), pp.699-704.
Effect on marine environment (e.g., physical, chemical, level of absorption) and Marine plastics as a vector/pathway for pathogens and toxic components (e.g., microbes, additives and Persistent Organic Pollutants [POPs])	Microplastics in aquatic environment: characterization, ecotoxicological effect, implications for ecosystems and developments in South Africa	2020	Pereao, O., Opeolu, B. and Fatoki, O., 2020. Microplastics in aquatic environment: characterization, ecotoxicological effect, implications for ecosystems and developments in South Africa. *Environmental Science and Pollution Research,* 27(18), pp.22271-22291.
Monitoring of impact on marine ecosystems (e.g., numerical models)	Confidence intervals and sample size for estimating the prevalence of plastic debris in seabird nests	2020	Tavares, D.C., Moura, J.F., Acevedo-Trejos, E., Crawford, R.J., Makhado, A., Lavers, J.L., Witteveen, M., Ryan, P.G. and Merico, A., 2020. Confidence intervals and sample size for estimating the prevalence of plastic debris in seabird nests. *Environmental Pollution*, 263, p.114394

SOCIO-ECONOMIC IMPACT OF MARINE PLASTIC

Research sub theme	Scope of work	Publication Date	Reference
Economic loss (e.g., plastic in fishing gear, threat on tourism)	Impacts of marine plastic on ecosystem services and economy: state of South African research	2020	Arabi, S. and Nahman, A., 2020. Impacts of marine plastic on ecosystem services and economy: State of South African research. *South African Journal of Science,* 116(5-6), pp.1-7.
	How much is a clean beach worth? The impact of litter on beach users in the Cape Peninsula, South Africa	2000	Ballance, A., Ryan, P.G. and Turpie, J.K., 2000. How much is a clean beach worth? The impact of litter on beach users in the Cape Peninsula, South Africa. *South African Journal of Science*, 96(5), pp.210-230.
Food security	Microplastics in food	2019	Wilkinson, Braden 2019. Microplastics - Are they in your food? Conservation Captured. The Two Oceans Aquarium. https://www.facebook.com/TwoOceansAquarium/posts/microplastic-what-is-it-where-does-it-come-from-and-why-is-it-in-our-food-for-pl/10158727709086110/
	Plastics facts	2020	Sadan, Z. and De Kock, L. Plastics: Facts and Futures: Moving beyond pollution management towards a circular plastics economy in South Africa. WWF South Africa, Cape Town, South Africa Braden Wilkinson
Human health	Impacts of plastics debris n biota and implications for human health: A South African perspective	2020	Naidoo, T. and Rajkaran, A., 2020. Impacts of plastic debris on biota and implications for human health: A South African perspective. *South African Journal of Science*, 116(5-6), pp.1-8.
Human behaviour and perceptions of marine plastics pollution	The 'plastic waste era'; social perceptions towards single-use plastic consumption and impacts on the marine environment in Durban, South Africa	2020	Van Rensburg, M.L., S'phumelele, L.N. and Dube, T., 2020. The 'plastic waste era'; social perceptions towards single-use plastic consumption and impacts on the marine environment in Durban, South Africa. *Applied Geography*, 114, p.102132.
	Plastic pollution loads reflective of population demographics	2017	Nel HA, Hean JW, Noundou XS, Froneman PW (2017) Do microplastic loads reflect the population demographics along the southern African coastline. *Mar Pollut Bull* 115(1-2):115–119
Plastic as a vector/pathway for pathogens			Upcoming research from SANOCEANS collaboration (Section 3.3.3): Microplastics in wastewater as a carrier and dispersal route of antibiotic resistance in oceans, https://news.nwu.ac.za/nwu-and-norway-declare-war-microplastics (accessed 6 May 2021)

UPSTREAM PRODUCTION - MANUFACTURE AND USE OF PLASTIC

Research sub theme	Scope of work	Publication Date	Reference
Development of new polymers	South Africa collaborates with Japan to develop innovative alternative materials to plastic, specifically single use plastic products	2019	South Africa, UNIDO and Japan collaborate to combat plastic pollution, https://www.csir.co.za/south-africa-collaborates-japan-combat-plastic-pollution, (accessed 19 April 2021)
	An environmental analysis using Life Cycle Assessment comparing a fossil derived polymer and a bio-based polymer		Environmental analysis of plastic production processes: Comparing petroleum-based polypropylene and polyethylene with biologically-based poly-β-hydroxybutyric acid using life cycle analysis"; Harding, K.G., J.S. Dennis, H. von Blottnitz and S.T.L. Harrison; *Journal of Biotechnology* 130 (1), pp. 57-66, 2007.
Ban on specific polymers: manufacture, import or use and their impact on marine plastic pollution			
Limitation in use (i.e., specific polymers for specific application, for example include packaging) and their impact on marine plastic pollution	Linking value chain green economy initiatives and waste management reform to address 70-80% of plastic in the waste stream	2016	Von Blottnitz, H. 2016. Waste management reform and the green economy: When will they meet? *Greening the South African Economy* pp. 252-267

GOVERNANCE AND REGULATION OF MARINE PLASTIC AT INTERNATIONAL AND REGIONAL LEVELS

Research sub theme	Scope of work	Publication Date	Reference
Outcomes/impacts of relevant policies, regulations	Analysis of the plastic carrier bag (disposable polyethylene shopping bags) levy (tax) instituted in 2003 and its impact on consumption patterns	2012	Dikgang, J., Leiman, A. and Visser, M., 2012. Analysis of the plastic bag levy in South Africa. *Resources, Conservation and Recycling* 66(2012), pp. 59– 65. http://dx.doi.org/10.1016/j.resconrec.2012.06.009
	Integrating the informal waste sector into the waste and recycling economy in the context of mandatory Extended Producer Responsibility	2016	Godfrey, L., Strydom, W. and Phukubye, R., 2016. Integrating the informal sector into the South African waste and recycling economy in the context of Extended Producer Responsibility. *CSIR Policy Brief and Briefing Note Series*.
	A critical study of marine plastic debris and pollution laws in international and South African law	2015	R. Naidoo, Master of Law Thesis, University of Kwa-Zulu Natal, 2015
	A review of the legal, policy and institutional frameworks governing marine plastics in South Africa and an analysis of the overall outcomes together with recommendations.	2020	Climate Carbon and Environmental Legal Consulting, 2020. The legal, policy and institutional frameworks governing marine plastics in South Africa. Bonn, Germany: IUCN Environmental Law Centre. 18pp.
	Extended producer responsibility for packaging waste in South Africa: Current approaches and lessons learned.	2010	Nahman, Anton. Extended producer responsibility for packaging waste in South Africa: Current approaches and lessons learned. *Resources, Conservation and Recycling* 54, no. 3 (2010): 155-162.
	Drawing the short straw: regulating plastic pollution in South Africa	2019	Rumble, O., 2019. Drawing the short straw: regulating plastic pollution in South Africa. *South African Journal of Environmental Law and Policy-latest Issue,* 25(1), pp.104-145.
Changes to (national/international) trade regulations and their impact on marine plastic pollution in the pilot country			
Outcomes/impacts of relevant frameworks in development (expected outcomes), being developed.	Policy effectiveness assessment of selected tools (Extended Producer Responsibility and integration of the informal sector) for addressing marine plastic pollution in South Africa	2020	Climate Legal, 2020. Policy effectiveness assessment of selected tools for addressing marine plastic pollution. Extended Producer Responsibility in South Africa. Bonn, Germany: IUCN Environmental Law Centre. 19pp.
	The legal, policy and institutional frameworks governing marine plastics in South Africa	2020	Climate Carbon and Environmental Legal Consulting (2020). The legal, policy and institutional frameworks governing marine plastics in South Africa. Bonn, Germany: IUCN Environmental Law Centre. 18pp.

12.2 Research Gap South Africa

MARINE PLASTIC FROM WASTE

Research sub theme	Comments
Composition of plastics in solid waste generated	No research found on national statistics/categorisation of plastic waste within solid waste in the country – only some statistics for the Western Cape province are emerging
	No reliable data quantifying the amount of plastic waste recovered and diverted into economy
Abandoned, lost or otherwise discarded fishing gear (ALDFG)	Current research is limited
Removal and recyclability of marine plastics	Beach clean-ups ongoing but no research found on the recycling activity thereafter.

DISTRIBUTION, ABUNDANCE, IDENTIFICATION AND FATE OF MARINE PLASTIC

Research sub theme	Comments
Degradation and fragmentation (e.g., rates, mechanisms, products)	No research found

SOCIO-ECONOMIC IMPACT OF MARINE PLASTIC

Research sub theme	Comments
Economic, health, food security	Limited research, especially health and food security impacts
Plastic as a vector/pathway for pathogens	No published research found

GOVERNANCE AND REGULATION OF MARINE PLASTIC AT INTERNATIONAL AND REGIONAL LEVELS

Research sub theme	Comments
Ban on specific polymers: manufacture, import or use and their impact on marine plastic pollution	No legislation/research
Changes to (national/international) trade regulations and their impact on marine plastic pollution in the pilot country	No published research found

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Appendix 3 Canada

UK CIRCULAR PLASTICS NETWORK

UKRI Innovate UK

13.1 Research Themes and References Canada

MARINE PLASTIC FROM WASTE

Research sub theme	Scope of work	Publication Date	Reference
Composition of plastics in solid waste generated	Managing municipal solid waste is a pressing environmental and political concern for Canadian municipalities who bear the primary responsibility for waste management (WM). This study argues that a history of downloading responsibility for WM to municipalities, regional districts, and industry has fragmented WM governance, posing a challenge for developing new waste infrastructure.	2018	Lougheed, S. C., Metuzals, J., & Hird, M. J. (2018). Modes of governing Canadian waste management: a case study of Metro Vancouver's energy-from-waste controversy. *Journal of Environmental Policy & Planning,* 20(2), 170-182.
Collection and sorting efforts	In this short communication, a case example of EPR implementation in Nova Scotia is provided which highlights the potential economic benefits for municipalities ($14–17 M CAD in estimated savings), for improved solid waste management and for increasing recycling rates.	2020	Diggle, A., & Walker, T. R. (2020). Implementation of harmonized Extended Producer Responsibility strategies to incentivize recovery of single-use plastic packaging waste in Canada. *Waste Management,* 110, 20-23.
Recycling and trade in plastic waste	*Informal and Cooperative Recycling as a Poverty Eradication Strategy*	2012	1Gutberlet, J. (2012). Informal and cooperative recycling as a poverty eradication strategy. *Geography Compass*, 6(1), 19-34. https://doi.org/10.1111/j.1749-8198.2011.00468.x
	This study highlights how the global plastic waste trade – whereby developed countries, such as Canada, export to developing countries despite the absence of transparency or evidence of recycling – has contributed to marine plastic pollution.	2018	Liu, Z., Adams, M., & Walker, T. R. (2018). Are exports of recyclables from developed to developing countries waste pollution transfer or part of the global circular economy?. *Resources, Conservation and Recycling*, 136, 22-23.

MARINE PLASTIC FROM WASTE

Research sub theme	Scope of work	Publication Date	Reference
Source differentiation: land leakage, rivers, coastal, sea-based sources	This article outlines how microplastics are found in each of the five Laurentian Great Lakes, their tributary streams and rivers, and the St. Lawrence River carrying Great Lakes water to the Atlantic Ocean.	2020	Helm, P. A. (2020). Occurrence, sources, transport, and fate of microplastics in the Great Lakes–St. Lawrence River Basin. *Contaminants of the Great Lakes,* 15-47.
	This study quantified and characterized microplastics and other anthropogenic particles from Lake Ontario surface waters and source waters (including stormwater runoff, agricultural runoff, and treated wastewater effluent) to better understand sources to the Great Lakes.	2020	Grbić, J., Helm, P., Athey, S., & Rochman, C. M. (2020). Microplastics entering northwestern Lake Ontario are diverse and linked to urban sources. *Water Research,* 174.
Abandoned, lost or otherwise discarded fishing gear (ALDFG)	These 3 studies are all related to ALDFG and comprise many of the same researchers. This research identified key areas or hotspots of ALDFG in the Bay of Fundy (BoF) in Eastern Canada by conducting interviews with fishers and gathering local knowledge.	2019	Goodman, A. J., Brillant, S., Walker, T. R., Bailey, M., & Callaghan, C. (2019). A Ghostly Issue: Managing abandoned, lost and discarded lobster fishing gear in the Bay of Fundy in Eastern Canada. *Ocean & Coastal Management,* 181.
	The second study also used underwater video to identify ALDFG in the BoF. Management and retrieval options were also identified, and this research is ongoing with funding support from DFO.	2020	Goodman, A. J., Walker, T. R., Brown, C. J., Wilson, B. R., Gazzola, V., & Sameoto, J. A. (2020). Benthic marine debris in the Bay of Fundy, eastern Canada: Spatial distribution and categorization using seafloor video footage. *Marine Pollution Bulletin*, 150.
		Under review	Goodman, A. J., McIntyre, J., Smith, A., Fulton, L., Walker, T. R., Brown, C. J., Wilson, B. R., Gazzola, V., & Sameoto, J. A. (under review). Retrieval of abandoned, lost, and discarded fishing gear in southwest Nova Scotia, Canada: Environmental and economic impacts to the commercial lobster industry. *Marine Pollution Bulletin.*

DISTRIBUTION, ABUNDANCE, IDENTIFICATION AND FATE OF MARINE PLASTIC

Research sub theme	Scope of work	Publication Date	Reference
Standardising methodologies – constructing internationally accepted categories and analysis approaches	An international laboratory intercomparison and development exercise surveys the conformity and quality of results among laboratories for microplastics determination worldwide.	2021	van Mourik, L.M., Crum, S., Martinez-Frances, E., van Bavel, B., Leslie, H.A., de Boer, J., & Cofino, W.P. (2020). Results of WEPAL-QUASIMEME/NORMANs first global interlaboratory study on microplastics reveal urgent need for harmonization. *Science of The Total Environment,* 772. https://doi.org/10.1016/j.scitotenv.2021.145071.
	This study characterized macroplastic litter at sea and coast of Arctic Canada and West Greenland.	2021	Mallory, M. L., Baak, J., Gjerdrum, C., Mallory, O. E., Manley, B., Swan, C., & Provencher, J. F. (2021). Anthropogenic litter in marine waters and coastlines of Arctic Canada and West Greenland. *Science of The Total Environment,* 783. https://doi.org/10.1016/j.scitotenv.2021.146971
Survey and monitoring (e.g., distribution, abundance, type) in different environments (e.g., coastal, water surface, water column, seafloor, sediment, biota)	This study assessed monthly accumulation rates and types of man-made marine debris washed ashore at a recreational beach in Point Pleasant Park, Halifax Harbour, between April and September 2005. Items were generated by recreational use of the park (52%), sewage disposal (14%) and from shipping and fishing activities (7%).	2006	Walker, T. R., Grant, J., & Archambault, M. C. (2006). Accumulation of marine debris on an intertidal beach in an urban park (Halifax Harbour, Nova Scotia). *Water Quality Research Journal,* 41(3), 256-262.
	Microplastics and Nanoplastics in Aquatic Environments: Aggregation, Deposition, and Enhanced Contaminant Transport.	2018	Alimi, O.S., Farner Budarz, J., Hernandez, L.M., & Tufenkj, N. (2018). Microplastics and nanoplastics in aquatic environments: Aggregation, deposition, and enhanced contaminant transport. *Environmental Science & Technology,* 52(4), 1704–1724. doi: 10.1021/acs.est.7b05559.
	This article follows plastics throughout their life cycle, defining their impact on biota.	2021	Lavoie, J., Boulay, A. M., & Bulle, C. (2021) Aquatic micro-and nano-plastics in life cycle assessment: Development of an effect factor for the quantification of their physical impact on biota. *Journal of Industrial Ecology.* https://doi.org/10.1111/jiec.13140.

DISTRIBUTION, ABUNDANCE, IDENTIFICATION AND FATE OF MARINE PLASTIC

Research sub theme	Scope of work	Publication Date	Reference
Optimizing the extraction procedures and identification methods (e.g. extraction and identification of marine plastics from marine litter, mixed waste)	*Long-Term Field Measurement of Sorption of Organic Contaminants to Five Types of Plastic Pellets: Implications for Plastic Marine Debris.*	2013	Rochman, C.M., Hoh, E., Hentschel, B.T., & Kaye, S. (2013). Long-term field measurement of sorption of organic contaminants to five types of plastic pellets: Implications for Plastic Marine Debris. *Environmental Science & Technology*, 47(3), 1646-1654. doi: 10.1021/es303700s.
	This study, based on a comprehensive assessment of microplastics in San Francisco Bay water, sediment, fish, bivalves, stormwater, and wastewater effluent, develops and recommends best practices for collecting, analyzing, and reporting microplastics in environmental media.	2021	Miller, E., Sedlak, M., Lin, D., Box, C., Holleman, C., Rochman, C. M., & Sutton, R. (2021). Recommended best practices for collecting, analyzing, and reporting microplastics in environmental media: Lessons learned from comprehensive monitoring of San Francisco Bay. *Journal of Hazardous Materials,* 409.
Deposition, accumulation, hotspots, transportation and movement (e.g., numerical models)	This study finds that pervasive distribution of polyester fibres in the Arctic Ocean is driven by Atlantic inputs.	2021	Ross, P.S., Chastain, S., Vassilenko, E., Etemadifar, A., Zimmermann, S., Quesnel, S., Eert, J., Solomon, E., Patankar, S., Posacka, A.M., & Williams, B. (2021). Pervasive distribution of polyester fibres in the Arctic Ocean is driven by Atlantic inputs. *Nature Communications,* 12. https://www.nature.com/articles/s41467-020-20347-1
	This study reviews the retention of microplastics in a major secondary wastewater treatment plant in Vancouver, Canada.	2018	Gies, E.A., LeNoble, J.L., Noël, M., Etemadifar, A., Bishay, F., Hall, E.R., & Ross, P.S. (2018). Retention of microplastics in a major secondary wastewater treatment plant in Vancouver, Canada. *Marine Pollution Bulletin*, 133, 553-561. doi: 10.1016/j.marpolbul.2018.06.006.
Building a marine plastics data platform	This article investigates how scientists researching plastic pollution are attempting to create a new model – or models – of pollution that accounts for the unpredictable and complex materialities of 21st-century pollutants	2015	Liboiron, M. (2015). Redefining pollution and action: The matter of plastics. *Journal of Material Culture,* 21(1), 87-110. https://doi.org/10.1177/1359183515622966.
Removal and recyclability of marine plastics	This ongoing research's pilot study has identified ALDFG in the Bay of Fundy and retrieved tons of ALDFG along with polypropylene rope. This rope is being recycled into plastic furniture and diesel fuel.	Under review	Goodman, A. J., McIntyre, J., Smith, A., Fulton, L., Walker, T. R., Brown, C. J., Wilson, B. R., Gazzola, V., & Sameoto, J. A. (under review). Retrieval of Abandoned, Lost, and Discarded Fishing Gear in Southwest Nova Scotia, Canada: Environmental and Economic Impacts to the Commercial Lobster Industry. *Marine Pollution Bulletin.*

IMPACT OF MARINE PLASTIC ON THE ENVIRONMENT

Research sub theme	Scope of work	Publication Date	Reference
Uptake, egestion, assimilation, accumulation and transfer of ingested plastics by marine organisms	A Canadian national synthesis and ways forward through understanding the role seabirds play in spreading microplastics.	2014	Provencher, J.F., Bond, A.L., & Mallory, M.L. (2014). Marine birds and plastic debris in Canada: a national synthesis and a way forward. *Environmental Reviews*, 23(1). https://doi.org/10.1139/er-2014-0039.
Occurrence of plastics across taxa and trophic levels & Effect on particular taxa, communities and ecosystems	This research finds that ingested plastic transfers hazardous chemicals to fish and induces hepatic stress.	2013	Rochman, C., Hoh, E., Kurobe, T., & Teh, S.J. (2013). Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. *Scientific Reports,* 3. https://doi.org/10.1038/srep03263.
Effect on marine environment (e.g., physical, chemical, level of absorption)	*The ecological impacts of marine debris: unraveling the demonstrated evidence from what is perceived.*	2016	Rochman, C.M., Browne, M.A., Underwood, A. J., van Franeker, J.A., Thompson, R.C., Amaral-Zettler, L.A. (2016). The ecological impacts of marine debris: unraveling the demonstrated evidence from what is perceived. *Ecology,* 97(2), 302-312. https://doi.org/10.1890/14-2070.1.
Marine plastics as a vector/ pathway for pathogens and toxic components	This study develops a characterization of microplastics and anthropogenic fibers in surface waters of the North Saskatchewan River, Alberta, Canada.	2021	Bujaczek, T., Kolter, S. Locky, D., & Ross, M.S. (2021). Characterization of microplastics and anthropogenic fibers in surface waters of the North Saskatchewan River, Alberta, Canada. *FACETS,* 6(1), 26-43.

SOCIO-ECONOMIC IMPACT OF MARINE PLASTIC

Research sub theme	Scope of work	Publication Date	Reference
Economic loss (e.g., plastic in fishing gear, threat on tourism); Food security	An index to assess the health and benefits of the global ocean	2012	Halpern, B., Longo, C., Hardy, D., McLeod, K.L.,Samhouri, J.F., Katona, S.K. … & Zeller, D. (2012). An index to assess the health and benefits of the global ocean. *Nature*, 488, 615–620. https://doi.org/10.1038/nature11397
Human Health	The article investigates microplastics in seafood and the implications for human health.	2018	Smith, M., Love, D.C., Rochman, C.M., Neff, R.A. (2018). Microplastics in seafood and the implications for human health. *Current Environmental Health Report,* 5, 375–386. https://doi.org/10.1007/s40572-018-0206-z.
	This study highlights the potential impact of ingested microplastics on human health through an analysis of viscera and gills of 110 individual marine fish from 11 commercial fish species for the presence of plastic debris.	2019	Karbalaei, S., Golieskardi, A., Hamzah, H. B., Abdulwahid, S., Hanachi, P., Walker, T. R., & Karami, A. (2019). Abundanceasder54 and characteristics of microplastics in commercial marine fish from Malaysia. *Marine Pollution Bulletin,* 148, 5-15.

SOCIO-ECONOMIC IMPACT OF MARINE PLASTIC

Research sub theme	Scope of work	Publication Date	Reference
Plastic as a vector/pathway for pathogens	This study highlights the urgent need to determine whether certain microbes are capable of plastic biodegradation or are pathogens of humans or other organisms.	2021	Wright, R. J., Langille, M. G., & Walker, T. R. (2021). Food or just a free ride? A meta-analysis reveals the global diversity of the Plastisphere. *The ISME Journal,* 15(3), 789-806.

UPSTREAM PRODUCTION - MANUFACTURE AND USE OF PLASTIC

Research sub theme	Scope of work	Publication Date	Reference
Ban on specific polymers: manufacture, import or use and their impact on marine plastic pollution	This review oversees international policies that reduce marine plastic pollution by regulating plastic bags and microbeads	2017	Xanthos, D., & Walker, T. R. (2017). International policies to reduce plastic marine pollution from single-use plastics (plastic bags and microbeads): A review. *Marine Pollution Bulletin,* 118(1-2), 17-26.
	This study presents new multi-jurisdictional legislative interventions to reduce single-use plastics (SUPs), including microbeads, since 2017. It incorporates emergence of new non-legislative interventions to mitigate other types of SUPs at individual and private-sector levels that complement or influence legislative interventions.	2018	Schnurr, R. E., Alboiu, V., Chaudhary, M., Corbett, R. A., Quanz, M. E., Sankar, K., ... & Walker, T. R. (2018). Reducing marine pollution from single-use plastics (SUPs): A review. *Marine Pollution Bulletin,* 137, 157-171.
	This study provides a framework to reduce marine plastic pollution in Canada, including the first study to document the microbead ban in Canada and proposed further study to assess the efficacy of the ban.	2019	Pettipas, S., Bernier, M., & Walker, T. R. (2016). A Canadian policy framework to mitigate plastic marine pollution. *Marine Policy,* 68, 117-122.
Limitation in use and their impact on marine plastic pollution	Scientific Evidence Supports a Ban on Microbeads	2015	Rochman, C.M., Kross, S.M., Armstrong, J.B., Bogan, M.T., Darling, E.S., Green, S.J., Smyth, A.R., & Veríssimo, D. (2015). Scientific Evidence Supports a Ban on Microbeads. *Environmental Science & Technology,* 49(18), 10759-10761. doi: 10.1021/acs.est.5b03909.

GOVERNANCE AND REGULATION OF MARINE PLASTIC AT INTERNATIONAL AND REGIONAL LEVELS

Research sub theme	Scope of work	Publication Date	Reference
Outcomes/impacts of relevant policies, regulations	This review summarises plastic pollution policies of Arctic countries in relation to seabirds.	2021	Linnebjerg, J. F., Baak, J. E., Barry, T., Gavrilo, M. V., Mallory, M. L., Merkel, F. R., ... & Provencher, J. F. (2021). Review of plastic pollution policies of Arctic countries in relation to seabirds. *FACETS,* 6(1), 1-25.
	This paper reviews existing single-use plastic bag reduction policies in the Southern African Development Community (SADC).	2021	Bezerra, J. C., Walker, T. R., Clayton, C. A., & Adam, I. (2021). Single-Use Plastic Bag Policies in the Southern African Development Community. *Environmental Challenges*, 3, 100029.
	This paper examines current policies in 13 English-speaking Caribbean countries, exploring tools used and process of implementation.	2021	Clayton, C. A., Walker, T. R., Bezerra, J. C., & Adam, I. (2021). Policy responses to reduce single-use plastic marine pollution in the Caribbean. *Marine Pollution Bulletin,* 111833.
	This paper reviews SUP reduction policies, specifically in West Africa.	2020	Adam, I., Walker, T. R., Bezerra, J. C., & Clayton, A. (2020). Policies to reduce single-use plastic marine pollution in West Africa. *Marine Policy,* 116, 103928.
	This article compares legislative tools used internationally to the proposed Nigerian Bill and limitations identified.	2020	Nwafor, N., & Walker, T. R. (2020). Plastic bags prohibition bill: A developing story of crass legalism aiming to reduce plastic marine pollution in Nigeria. *Marine Policy*, 120, 104160.

GOVERNANCE AND REGULATION OF MARINE PLASTIC AT INTERNATIONAL AND REGIONAL LEVELS

Research sub theme	Scope of work	Publication Date	Reference
Changes to (national/ international) trade regulations and their impact on marine plastic pollution in the pilot country	*Waste, Landfills, and an Environmental Ethic of Vulnerability*	2013	Hird, M. (2013). Waste, landfills, and an environmental ethic of vulnerability. *Ethics and the Environment,* 18(1), 105-124. doi:10.2979/ethicsenviro.18.1.105.
	This study analyzed the global plastic waste trade (GPWT) between China and trading countries through their trajectories, characteristics and driving forces of reductions of GHG emissions between 1992 and 2017. Results indicated an increasing trend of reductions of GHG emissions in GPWT between China and trading countries over 25 years.	2021	Liu, Z., Liu, W., Walker, T. R., Adams, M., & Zhao, J. (2021). How does the global plastic waste trade contribute to environmental benefits: Implication for reductions of greenhouse gas emissions?. *Journal of Environmental Management*, 287, 112283.
Outcomes/impacts of relevant frameworks in development (expected outcomes), being developed.	This study examines the impact of broad management strategies, at different levels of effort to estimate plastic emissions to 2030 for 173 countries.	2020	Borrelle, S.B., Ringma, J., Law, K.L., Monnahan, C.C., Lebreton, L., Mcgivern, A., … & Rochman, C.M. (2020). Predicted growth in plastic waste exceeds efforts to mitigate plastic pollution. *Science,* 369(6510), 1515-1518. doi: 10.1126/science.aba3656
Additional resources	https://www.canada.ca/en/environment-climate-change/services/environmental-funding/programs/increasing-knowledge-plastic-pollution-initiative.html https://www.canada.ca/en/environment-climate-change/news/2020/11/the-government-of-canada-invests-in-research-on-plastic-pollution-in-our-environment.html https://www.newswire.ca/news-releases/the-government-of-canada-invests-in-research-on-plastic-pollution-in-our-environment-892278856.html https://www.sciencedirect.com/science/article/pii/S0048969720328989 https://www.canada.ca/en/environment-climate-change/services/evaluating-existing-substances/science-assessment-plastic-pollution.html#toc46		

13.2 Research Gap Canada

OCCURRENCE

Research sub theme	Comments
Developing standardized methods for sampling, quantifying, characterizing, and evaluating the effects of macroplastics and microplastics	N/A

HUMAN HEALTH EFFECTS

Research sub theme	Comments
Furthering the understanding of human exposure to microplastics	N/A
Furthering the understanding of the effects of microplastics on human health	N/A

ENVIRONMENTAL EFFECTS

Research sub theme	Comments
Furthering the understanding of the ecotoxicological effects of microplastics	N/A
Expanding and developing consistent monitoring efforts to include poorly characterized environmental compartments such as soil	N/A

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Appendix 4 United Kingdom

UK CIRCULAR PLASTICS NETWORK

UKRI Innovate UK

14.1 Research Themes and References United Kingdom

MARINE PLASTIC FROM WASTE

Research sub theme	Scope of work	Publication Date	Reference
Collection and sorting efforts (including port/Harbour waste reception facilities)	Here the study represent unique data set collected systematically once a month, every month over a six year period for nine beaches along the North Coast of Cornwall, U.K. to investigate the key drivers of beach litter in the Bude, Padstow and Porthcothan areas.	2017	Watts, A. J. R., Porter, A., Hembrow, N., Sharpe, J., Galloway, T. S., & Lewis, C. (2017). Through the sands of time: Beach litter trends from nine cleaned north cornish beaches. *Environmental Pollution,* 228, 416–424. https://doi.org/https://doi.org/10.1016/j.envpol.2017.05.016
Composition of plastics in solid waste generated	Review paper draws together the findings of municipal solid waste (MSW) compositional surveys undertaken in the United Kingdom.	2007	Burnley, S. J. (2007). A review of municipal solid waste composition in the United Kingdom. *Waste Management,* 27(10), 1274–1285. https://doi.org/https://doi.org/10.1016/j.wasman.2006.06.018
	The research designed to obtain and analyse representative samples of all the components of the MSW stream across Wales	2007	Burnley, S J, Ellis, J. C., Flowerdew, R., Poll, A. J., & Prosser, H. (2007). Assessing the composition of municipal solid waste in Wales. *Resources, Conservation and Recycling,* 49(3), 264–283. https://doi.org/https://doi.org/10.1016/j.resconrec.2006.03.015
Recycling and trade in plastic waste	The study is look for a simple and low-energy method to turn waste into H2 using novel Solar-driven reforming of plastics.	2018	Uekert, T., Kuehnel, M. F., Wakerley, D. W., & Reisner, E. (2018). Plastic waste as a feedstock for solar-driven H2 generation. *Energy & Environmental Science,* 11(10), 2853–2857. https://doi.org/10.1039/C8EE01408F
	The current paper examines the life cycles of single-use black food packaging and black plastic WEEE in the context of current international regulations and directives and best practices for sorting, disposal and recycling.	2018	Turner, A. (2018). Black plastics: Linear and circular economies, hazardous additives and marine pollution. *Environment International,* 117, 308–318. https://doi.org/https://doi.org/10.1016/j.envint.2018.04.036

MARINE PLASTIC FROM WASTE

Research sub theme	Scope of work	Publication Date	Reference
Source differentiation: land leakage, rivers, coastal, sea-based sources	This study examined the release of fibres from polyester, polyester-cotton blend and acrylic fabrics.	2016	Napper, I. E., & Thompson, R. C. (2016). Release of synthetic microplastic plastic fibres from domestic washing machines: Effects of fabric type and washing conditions. *Marine Pollution Bulletin,* 112(1–2), 39–45. https://doi.org/10.1016/j.marpolbul.2016.09.025
	This study characterises, quantifies and investigates the cosmetics as source of plastic microbeads.	2015	Napper, I. E., Bakir, A., Rowland, S. J., & Thompson, R. C. (2015). Characterisation, quantity and sorptive properties of microplastics extracted from cosmetics. *Marine Pollution Bulletin,* 99, 178–185. https://doi.org/10.1016/j.marpolbul.2015.07.029
	The study here investigates how turbidity currents transport microplastics from the river to the sea floor, and their role in differential burial of microplastic fragments and fibres.	2020	Pohl, F., Eggenhuisen, J. T., Kane, I. A., & Clare, M. A. (2020). Transport and Burial of Microplastics in Deep-Marine Sediments by Turbidity Currents. *Environmental Science and Technology*, 54(7), 4180–4189. https://doi.org/10.1021/acs.est.9b07527
	Investigate the plastic pollution in seven localities in the upper Thames estuary. as source of marine pollution	2014	Morritt, D., Stefanoudis, P. V, Pearce, D., Crimmen, O. a, & Clark, P. F. (2014). Plastic in the Thames: a river runs through it. *Marine Pollution Bulletin,* 78(1–2), 196–200. https://doi.org/10.1016/j.marpolbul.2013.10.035

DISTRIBUTION, ABUNDANCE, IDENTIFICATION AND FATE OF MARINE PLASTIC (DS)

Research sub theme	Scope of work	Publication Date	Reference
Standardising methodologies – constructing internationally accepted categories and analysis approaches	Evaluation of sampling technique of marine microplastics by using 100, 333 and 500 µm nets.	2020	Lindeque, P. K., Cole, M., Coppock, R. L., Lewis, C. N., Miller, R. Z., Watts, A. J. R., Wilson-McNeal, A., Wright, S. L., & Galloway, T. S. (2020). Are we underestimating microplastic abundance in the marine environment? A comparison of microplastic capture with nets of different mesh-size. *Environmental Pollution,* 265, 114721. https://doi.org/https://doi.org/10.1016/j.envpol.2020.114721
	Guidelines for Harmonising Ocean Surface Microplastic Monitoring Methods including "rationale for various sample collection methods, sample handling and processing, analytical procedures, reporting requirements, and other matters necessary or desirable for harmonisation"	2020	Michida, Y., Chavanich, S., Chiba, S., Cordova, M. R., Cózar, C. A., Galgani, F., Hagmann, P., Hinata, H., Isobe, A., Kershaw, P., Kozlovskii, N., Li, D., Lusher, A. L., Marti, E., Mason, S. A., Mu, J. L., Saito, H., Shim, W. J., Syakti, A. D., … Wang, J. (2019). Guidelines for Harmonizing Ocean Surface Microplastic. Guidelines for Harmonizing Ocean Surface *Microplastic Monitoring Methods*, June, 71.
Survey and monitoring in different environments sediment, biota	Analysis and data collected over a decade (2005–2014 inclusive) by Marine Conservation Society (MCS) volunteers during beach litter surveys carried along the British coastline, with the aim of increasing knowledge on the composition, spatial distribution and temporal trends of coastal debris.	2016	Nelms, S. E., Coombes, C., Foster, L. C., Galloway, T. S., Godley, B. J., Lindeque, P. K., & Witt, M. J. (2017). Marine anthropogenic litter on British beaches: A 10-year nationwide assessment using citizen science data. Science of The Total Environment, 579, 1399–1409. https://doi.org/https://doi.org/10.1016/j.scitotenv.2016.11.137
		2020	Nelms, Sarah E, Eyles, L., Godley, B. J., Richardson, P. B., Selley, H., Solandt, J.-L., & Witt, M. J. (2020). Investigating the distribution and regional occurrence of anthropogenic litter in English marine protected areas using 25 years of citizen-science beach clean data. *Environmental Pollution,* 263, 114365. https://doi.org/https://doi.org/10.1016/j.envpol.2020.114365
Microplastic burial and its impact on fauna-mediated sedimentary processes was quantified at three coastal sites, and the potential contribution of burrowing faunal		2021	Coppock RL, Lindeque PK, Cole M, Galloway TS, Näkki P, Birgani H, Richards S, Queirós AM. Benthic fauna contribute to microplastic sequestration in coastal sediments. J Hazard Mater. 2021 Mar 4;415:125583. doi: 10.1016/j.jhazmat.2021.125583. Epub ahead of print. PMID: 33773248.

DISTRIBUTION, ABUNDANCE, IDENTIFICATION AND FATE OF MARINE PLASTIC (DS)

Research sub theme	Scope of work	Publication Date	Reference
Survey and monitoring in different environments sediment, biota	The influence of wind on the patterns of micro- and macro-plastic debris within the Tamar Estuary, UK.	2010	Browne, M. A., Galloway, T. S., & Thompson, R. C. (2010). Spatial Patterns of Plastic Debris along Estuarine Shorelines. *Environmental Science & Technology,* 44(9), 3404–3409. https://doi.org/10.1021/es903784e
	Review to investigate the biological interactions of microplastics on the movement, impact, and fate of microplastics in the oceans.	2016	Clark, J. R., Cole, M., Lindeque, P. K., Fileman, E., Blackford, J., Lewis, C., Lenton, T. M., & Galloway, T. S. (2016). Marine microplastic debris: a targeted plan for understanding and quantifying interactions with marine life. *Frontiers in Ecology and the Environment,* 14(6), 317–324. https://doi.org/https://doi.org/10.1002/fee.1297
Optimising the extraction procedures and identification methods (e.g. extraction and identification of marine plastics from marine litter, mixed waste)	Identification method allows detection and automated quantification of small microplastic particles (20–1000 µm).	2017	Erni-Cassola, G., Gibson, M. I., Thompson, R. C., & Christie-Oleza, J. A. (2017). Lost, but Found with Nile Red: A Novel Method for Detecting and Quantifying Small Microplastics (1 mm to 20 µm) in Environmental Samples. Environmental *Science and Technology,* 51(23), 13641–13648. https://doi.org/10.1021/acs.est.7b04512
	New portable method to separate microplastics from sediments of differing types, using the principle of density floatation.	2017	Coppock, R. L., Cole, M., Lindeque, P. K., Queirós, A. M., & Galloway, T. S. (2017). A small-scale, portable method for extracting microplastics from marine sediments. *Environmental Pollution,* 230, 829–837. https://doi.org/https://doi.org/10.1016/j.envpol.2017.07.01
	Investigate the efficacy of using acid, alkaline and enzymatic digestion techniques in mineralizing biological material from marine surface trawls to reveal any microplastics present.	2014	Cole, M., Webb, H., Lindeque, P. et al. Isolation of microplastics in biota-rich seawater samples and marine organisms. *Sci Rep* 4, 4528 (2014). https://doi.org/10.1038/srep04528
Building a marine plastics data platform (e.g., fingerprint repository for microplastics, marine plastic debris abundance and distribution)	Review the transport and effects of plastics across terrestrial, freshwater and marine environments. We focus on hydrological catchments as well-defined landscape units that provide an integrating scale at which plastic pollution can be investigated and managed.	2019	Windsor, F. M., Durance, I., Horton, A. A., Thompson, R. C., Tyler, C. R., & Ormerod, S. J. (2019). A catchment-scale perspective of plastic pollution. *Global Change Biology,* 25(4), 1207–1221. https://doi.org/https://doi.org/10.1111/gcb.14572
	The study presents a new time series, from 1957 to 2016 and covering over 6.5 million nautical miles, based on records of when plastics have become entangled on a towed marine sampler.	2019	Ostle, C., Thompson, R. C., Broughton, D., Gregory, L., Wootton, M., & Johns, D. G. (2019). The rise in ocean plastics evidenced from a 60-year time series. *Nature Communications,* 10(1), 8–13. https://doi.org/10.1038/s41467-019-09506-1

DISTRIBUTION, ABUNDANCE, IDENTIFICATION AND FATE OF MARINE PLASTIC (DS)

Research sub theme	Scope of work	Publication Date	Reference
Deposition, accumulation, hotspots, transportation and movement (e.g., numerical models)	Improved the understanding of microplastic dist ribution in estuarine and beach sediment along the south-west coast of England.	2020	Nel, H. A., Sambrook Smith, G. H., Harmer, R., Sykes, R., Schneidewind, U., Lynch, I., & Krause, S. (2020). Citizen science reveals microplastic hotspots within tidal estuaries and the remote Scilly Islands, United Kingdom. *Marine Pollution Bulletin*, 161, 111776. https://doi.org/https://doi.org/10.1016/j.marpolbul.2020.111776
Removal and recyclability of marine plastics	The study investigates the removal of oceanic plastic using satellite-tracked model observations to observe microplastic from surface.	2016	Sherman, P., & Van Sebille, E. (2016). Modeling marine surface microplastic transport to assess optimal removal locations. *Environmental Research Letters*, 11(1). https://doi.org/10.1088/1748-9326/11/1/014006

IMPACT OF MARINE PLASTIC ON THE ENVIRONMENT

Research sub theme	Scope of work	Publication Date	Reference
Uptake, egestion, assimilation, accumulation and transfer of ingested plastics by marine organisms	Identify thirteen zooplankton taxa had the capacity to ingest 1.7–30.6 µm polystyrene beads,	2013	Cole, M., Lindeque, P., Fileman, E., Halsband, C., Goodhead, R., Moger, J., & Galloway, T. S. (2013). Microplastic ingestion by zooplankton. *Environmental Science and Technology,* 47(12), 6646–6655. https://doi.org/10.1021/es400663f
	Exposure to 20.6 µm polystyrene microplastics and examine the uptake and the egestion through the faecal pellets.	2016	Cole, M., K. Lindeque, P., Fileman, E., Clark, J., Lewis, C., Halsband, C., & S. Galloway, T. (2016). Microplastics Alter the Properties and Sinking Rates of Zooplankton Faecal Pellets. *Environmental Science & Technology,* 50(6), 3239–3246. https://doi.org/10.1021/acs.est.5b05905
	Exposure studies incorporating algal prey and microplastics of varying sizes and shapes	2019	Coppock, R. L., Galloway, T. S., Cole, M., Fileman, E. S., Queirós, A. M., & Lindeque, P. K. (2019). Microplastics alter feeding selectivity and faecal density in the copepod, Calanus helgolandicus. *Science of The Total Environment*, 687, 780–789. https://doi.org/https://doi.org/10.1016/j.scitotenv.2019.06.009
	The study assesses the occurrence of microplastic ingestion in wild fish larvae. Fish larvae and water samples were taken across three sites in the western English Channel	2017	Steer, M., Cole, M., Thompson, R. C., & Lindeque, P. K. (2017). Microplastic ingestion in fish larvae in the western English Channel. *Environmental Pollution*, 226, 250–259. https://doi.org/https://doi.org/10.1016/j.envpol.2017.03.062
	This study present pulse exposures of 14C-radiolabeled nano-polystyrene to a commercially important mollusk,	2018	Al-Sid-Cheikh, M., Rowland, S. J., Stevenson, K., Rouleau, C., Henry, T. B., & Thompson, R. C. (2018). Uptake, Whole-Body Distribution, and Depuration of Nanoplastics by the Scallop Pecten maximus at Environmentally Realistic Concentrations. *Environmental Science & Technology,* 52(24), 14480–14486. https://doi.org/10.1021/acs.est.8b05266
	The mussel, Mytilus edulis, was used to investigate ingestion, translocation, and accumulation of marine debris.	2008	Browne, M. A., Dissanayake, A., Galloway, T. S., Lowe, D. M., & Thompson, R. C. (2008). Ingested Microscopic Plastic Translocates to the Circulatory System of the Mussel, Mytilus edulis (L.). *Environmental Science & Technology,* 42(13), 5026–5031. https://doi.org/10.1021/es800249a

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Research sub theme	Scope of work	Publication Date	Reference
Uptake, egestion, assimilation, accumulation and transfer of ingested plastics by marine organisms	The uptake of microplastics by shore crab (Carcinus maenas) through inspiration across the gills as well as ingestion of pre-exposed food common mussel Mytilus edulis	2014	Watts, A. J. R., Lewis, C., Goodhead, R. M., Beckett, S. J., Moger, J., Tyler, C. R., & Galloway, T. S. (2014). Uptake and retention of microplastics by the shore crab Carcinus maenas. *Environmental Science & Technology,* 48(15), 8823–8830. https://doi.org/10.1021/es501090e
Occurrence of plastics across taxa and trophic levels	The occurrence of microplastics examined on 504 Fish and found in the gastrointestinal tracts of 36.5%.	2012	A.L. Lusher, M McHugh, R. C. T. (2013). Occurrence of microplastics in the gastrointestinal tract of pelagic and demersal fish from the English Channel. *Marine Pollution Bulletin*, 67(1–2), 94–99. https://doi.org/10.1016/j.marpolbul.2012.11.028
	Synthetic particles being isolated from species occupying different trophic levels suggest the possibility of multiple ingestion pathways.	2019	Duncan, E. M., Broderick, A. C., Fuller, W. J., Galloway, T. S., Godfrey, M. H., Hamann, M., Limpus, C. J., Lindeque, P. K., Mayes, A. G., Omeyer, L. C. M., Santillo, D., Snape, R. T. E., & Godley, B. J. (2019). Microplastic ingestion ubiquitous in marine turtles. *Global Change Biology*, 25(2), 744– 752. https://doi.org/https://doi.org/10.1111/gcb.14519
	Investigate the direct and indirect trophic transfer of marine letter, in mammals.	2018	Nelms, Sarah E., Galloway, T. S., Godley, B. J., Jarvis, D. S., & Lindeque, P. K. (2018). Investigating microplastic trophic transfer in marine top predators. *Environmental Pollution,* 1–9. https://doi.org/10.1016/j.envpol.2018.02.016
Effect on particular taxa, communities and ecosystems (e.g., toxicity, productivity, food chain)	Investigating how microplastics of a variety of shapes, in combination with the algal-derived info chemicals dimethyl sulfide (DMS) and dimethylsulfoniopropionate (DMSP), affect the ingestion rate of microplastics in three species of zooplankton	2020	L. R. Botterell, Z., Beaumont, N., Cole, M., E. Hopkins, F., Steinke, M., C. Thompson, R., & K. Lindeque, P. (2020). Bioavailability of Microplastics to Marine Zooplankton: Effect of Shape and Infochemicals. *Environmental Science & Technology,* 54(19), 12024–12033. https://doi.org/10.1021/acs.est.0c02715
	The ecological impacts on the biodiversity and ecosystem functioning of bivalve-dominated habitats by expose exposed intact sediment cores containing European flat oysters or blue mussels in seawater.	2017	Green, D. S., Boots, B., O'Connor, N. E., & Thompson, R. (2016). Microplastics affect the ecological functioning of an important biogenic habitat. *Environmental Science &Technology,*(51), 68–77. https://doi.org/10.1021/acs.est.6b04496
	Examine the toxicity impact of microscopic unplasticised polyvinylchloride (UPVC) on marine worms.	2013	Wright, S. L., Rowe, D., Thompson, R. C., & Galloway, T. S. (2013). Microplastic ingestion decreases energy reserves in marine worms. *Current Biology,* 23(23), R1031–R1033. https://doi.org/https://doi.org/10.1016/j.cub.2013.10.068

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Research sub theme	Scope of work	Publication Date	Reference
Effect on particular taxa, communities and ecosystems (e.g., toxicity, productivity, food chain)	The toxicity impact of smoked cigarette filter toxicants and microfibres on the polychaete worm Hediste diversicolor (ragworm), a widespread inhabitant of coastal sediments.	2015	Wright, S. L., Rowe, D., Reid, M. J., Thomas, K. V., & Galloway, T. S. (2015). Bioaccumulation and biological effects of cigarette litter in marine worms. *Scientific Reports*, 5, 1–10. https://doi.org/10.1038/srep14119
	Exposure to fibrous and particulate microplastics to Coldwater copepod and examine their toxicity and the impact on feeding and lipid accumulation.	2019	Cole, M., Coppock, R., K. Lindeque, P., Altin, D., Reed, S., W. Pond, D., Sørensen, L., S. Galloway, T., & M. Booth, A. (2019). Effects of Nylon Microplastic on Feeding, Lipid Accumulation, and Moulting in a Coldwater Copepod. *Environmental Science & Technology*, 53(12), 7075–7082. https://doi.org/10.1021/acs.est.9b01853
	The impact of polystyrene microplastic on the feeding capacity of Calanus helgolandicus	2015	Cole, M., Lindeque, P., Fileman, E., Halsband, C., & Galloway, T. S. (2015). The Impact of Polystyrene Microplastics on Feeding, Function and Fecundity in the Marine Copepod Calanus helgolandicus. *Environmental Science & Technology,* 49(2), 1130–1137. https://doi.org/10.1021/es504525u
	The study investigated the fate of polypropylene rope microfibers (1–5 mm in length) ingested by the crab Carcinus maenas and the consequences for the crab's energy budget.	2015	Watts, A. J. R., Urbina, M. A., Corr, S., Lewis, C., & Galloway, T. S. (2015). Ingestion of Plastic Microfibers by the Crab Carcinus maenas and Its Effect on Food Consumption and Energy Balance. *Environmental Science & Technology,* 49(24), 14597–14604. https://doi.org/10.1021/acs.est.5b04026
	Examine the uptake and the impact of polysyrene microplastics on Pacific oyster larval feeding and growth.	2015	Cole, M., & Galloway, T. S. (2015). Ingestion of Nanoplastics and Microplastics by Pacific Oyster Larvae. *Environmental Science & Technology,* 49(24), 14625–14632. https://doi.org/10.1021/acs.est.5b04099
	Examine the acute exposure to polystyrene microspheres with different surface coatings.	2016	Watts, A. J. R., Urbina, M. A., Goodhead, R., Moger, J., Lewis, C., & Galloway, T. S. (2016). Effect of Microplastic on the Gills of the Shore Crab Carcinus maenas. *Environmental Science & Technology,* 50(10), 5364–5369. https://doi.org/10.1021/acs.est.6b01187
Marine plastics as a vector/ pathway for pathogens and toxic components (e.g., microbes, additives and Persistent Organic Pollutants [POPs])	The impact of bioavailability and toxicity of microplastic as a complex, dynamic mixture of polymers and additives, to which organic material and contaminants can successively bind	2017	Galloway, T. S., Cole, M., & Lewis, C. (2017). Interactions of microplastic debris throughout the marine ecosystem. *Nature Ecology & Evolution,* 1(5), 116. https://doi.org/10.1038/s41559-017-0116

IMPACT OF MARINE PLASTIC ON THE ENVIRONMENT

Research sub theme	Scope of work	Publication Date	Reference
Marine plastics as a vector/ pathway for pathogens and toxic components (e.g., microbes, additives and Persistent Organic Pollutants [POPs])	This study simulates marine avian gastric conditions in vitro to examine the bio-accessibility of authigenic metals (Fe, Mn) and trace metals (Co, Pb) that have been acquired by polyethylene microplastic pellets from their environment.	2020	Holmes, L. A., Thompson, R. C., & Turner, A. (2020). In vitro avian bioaccessibility of metals adsorbed to microplastic pellets. *Environmental Pollution*, 261, 114107. https://doi.org/https://doi.org/10.1016/j.envpol.2020.114107
	Adsorbed Pb was determined in <5 mm, neutrally-coloured polyethylene pellets that contained no detectable Pb added during manufacture by digestion in dilute aqua regia, while the bio-accessibility of this association was evaluated.	2020	Turner, A., Holmes, L., Thompson, R. C., & Fisher, A. S. (2020). Metals and marine microplastics: Adsorption from the environment versus addition during manufacture, exemplified with lead. *Water Research,* 173, 115577. https://doi.org/https://doi.org/10.1016/j.watres.2020.115577.
	The sorption of two co-contaminants with different physicochemistries, to microplastics. and assess whether co-contaminant bioavailability was increased after microplastic settlement.	2017	Sleight, V. A., Bakir, A., Thompson, R. C., & Henry, T. B. (2017). Assessment of microplastic-sorbed contaminant bioavailability through analysis of biomarker gene expression in larval zebrafish. *Marine Pollution Bulletin,* 116(1), 291–297. https://doi.org/https://doi.org/10.1016/j.marpolbul.2016.12.055
	Modelling the transfer of sorbed organic contaminants dichlorodiphenyltrichloroethane (DDT), phenanthrene (Phe) and bis-2-ethylhexyl phthalate (DEHP) from microscopic particles of polyvinylchloride (PVC) and polyethylene (PE) to a benthic invertebrate, a fish and a seabird	2016	Bakir, A., O'Connor, I. A., Rowland, S. J., Hendriks, A. J., & Thompson, R. C. (2016). Relative importance of microplastics as a pathway for the transfer of hydrophobic organic chemicals to marine life. *Environmental Pollution*, 219, 56–65. https://doi.org/https://doi.org/10.1016/j.envpol.2016.09.046
	The potential for polyvinylchloride (PVC) and polyethylene (PE) to sorb and desorb 14C-DDT, 14C-phenanthrene (Phe), 14C-perfluorooctanoic acid (PFOA) and 14C-di-2-ethylhexyl phthalate (DEHP).	2014	Bakir, A., Rowland, S. J., & Thompson, R. C. (2014). Enhanced desorption of persistent organic pollutants from microplastics under simulated physiological conditions. *Environmental Pollution*, 185, 16–23. https://doi.org/10.1016/j.envpol.2013.10.007

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Research sub theme	Scope of work	Publication Date	Reference
Marine plastics as a vector/ pathway for pathogens and toxic components (e.g., microbes, additives and Persistent Organic Pollutants [POPs])	Examine whether phenanthrene and 4,4'-DDT, in a mixture, compete for sorption sites onto PVC with no added additives and Ultra-High Molecular Weight polyethylene.	2012	Bakir, A., Rowland, S. J., & Thompson, R. C. (2012). Competitive sorption of persistent organic pollutants onto microplastics in the marine environment. *Marine Pollution Bulletin,* 64(12), 2782–2789. https://doi.org/10.1016/j.marpolbul.2012.09.010
	Examine the adsorption of trace metals to both virgin and beached pellets under estuarine conditions in order to better understand the role of plastic materials on the transport and behaviour of metals from river to ocean.	2014	Holmes, L. A., Turner, A., & Thompson, R. C. (2014). Interactions between trace metals and plastic production pellets under estuarine conditions. *Marine Chemistry,* 167, 25–32. https://doi.org/https://doi.org/10.1016/j.marchem.2014.06.001
	Examine the uptake and subsequent release of phenanthrene by three plastics.	2007	Teuten, E. L., Rowland, S. J., Galloway, T. S., & Thompson, R. C. (2007). Potential for Plastics to Transport Hydrophobic Contaminants. *Environmental Science & Technology,* 41(22), 7759–7764. https://doi.org/10.1021/es071737s
	Examine the pathway to transfer attached pollutants and additive chemicals from the microplastics to lugworms (Arenicola marina)	2013	Browne, Mark Anthony, Niven, S. J., Galloway, T. S., Rowland, S. J., & Thompson, R. C. (2013). Microplastic Moves Pollutants and Additives to Worms, Reducing Functions Linked to Health and Biodiversity. *Current Biology,* 23(23), 2388–2392. https://doi.org/https://doi.org/10.1016/j.cub.2013.10.012
	The study discusses microplastic-associated bacterial communities and microplastic uptake pathways into bivalves and discuss whether they represent a human and animal health threat.	2021	Bowley, J., Baker-Austin, C., Porter, A., Hartnell, R., & Lewis, C. (2021). Oceanic Hitchhikers – Assessing Pathogen Risks from Marine Microplastic. *Trends in Microbiology,* 29(2), 107–116. https://doi.org/10.1016/j.tim.2020.06.011
	This study highlights the metabolic potential that exists in the biofilms that colonise plastics-the Plastisphere-to effectively biodegrade plastic additives and flags the inherent importance of microbes in reducing plastic toxicity in the environment.	2020	Wright RJ, Bosch R, Gibson MI, Christie-Oleza JA. Plasticizer Degradation by Marine Bacterial Isolates: A Proteogenomic and Metabolomic Characterization. *Environ Sci Technol.* 2020 Feb 18;54(4):2244-2256. doi: 10.1021/acs.est.9b05228. Epub 2020 Jan 14. PMID: 31894974; PMCID: PMC7031849.

IMPACT OF MARINE PLASTIC ON THE ENVIRONMENT

Research sub theme	Scope of work	Publication Date	Reference
Effect on marine environment (e.g., physical, chemical, level of absorption)	Review paper to investigate the impact of marine debris on entanglement and ingestion, impacting 46,000 individuals and 663 species.	2012	Secretariat of the Convention on Biological Diversity and the Scientific and Technical Advisory Panel—GEF (2012). *Impacts of Marine Debris on Biodiversity: Current Status and Potential Solutions, Montreal, Technical Series No.* 67, 61 pages.
	The interaction between the marine snows and microplastics of different shapes, sizes, and polymers which results in changing in sinks rate of marine snow and increase the uptake by benthic organisms.	2018	Porter, A., Lyons, B. P., Galloway, T. S., & Lewis, C. (2018). Role of Marine Snows in Microplastic Fate and Bioavailability. *Environmental Science & Technology*, 52(12), 7111–7119. https://doi.org/10.1021/acs.est.8b01000
	Microplastic burial and its impact on fauna-mediated sedimentary processes was quantified at three coastal sites, and the potential contribution of burrowing faunal communities.	2021	Coppock, R. L., Lindeque, P. K., Cole, M., Galloway, T. S., Näkki, P., Birgani, H., Richards, S., & Queirós, A. M. (2021). Benthic fauna contribute to microplastic sequestration in coastal sediments. *Journal of Hazardous Materials*, 415(April). https://doi.org/10.1016/j.jhazmat.2021.125583

SOCIO-ECONOMIC IMPACT OF MARINE PLASTIC (LP)

Research sub theme	Scope of work	Publication Date	Reference
Human health	The study determined the potential exposure of humans to household dust fibres during a meal to compare with amounts of MPs present in edible mussels.	2018	Catarino, A. I., Macchia, V., Sanderson, W. G., Thompson, R. C., & Henry, T. B. (2018). Low levels of microplastics (MP) in wild mussels indicate that MP ingestion by humans is minimal compared to exposure via household fibres fallout during a meal. *Environmental Pollution*, 237, 675–684. https://doi.org/https://doi.org/10.1016/j.envpol.2018.02.069
	Concluding paper to the Theme Issue on Plastics, the Environment and Human Health, by synthesize current understanding of the benefits and concerns surrounding the use of plastics.	2009	Thompson, R. C., Moore, C. J., vom Saal, F. S., & Swan, S. H. (2009). Plastics, the environment and human health: current consensus and future trends. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 364(1526), 2153–2166. https://doi.org/10.1098/rstb.2009.0053
	The impact of fibrous microplastics (MPs) in the atmospheric fallouts indoor and outdoor environments on the human health.	2018	Gasperi, J., Wright, S. L., Dris, R., Collard, F., Mandin, C., Guerrouache, M., Langlois, V., Kelly, F. J., & Tassin, B. (2018). Microplastics in air: Are we breathing it in? *Current Opinion in Environmental Science & Health,* 1, 1–5. https://doi.org/10.1016/j.coesh.2017.10.002

SOCIO-ECONOMIC IMPACT OF MARINE PLASTIC (LP)

Research sub theme	Scope of work	Publication Date	Reference
Human health	The current review article draws upon cross-disciplinary scientific literature to discuss and evaluate the potential human health impacts of microplastics and outlines urgent areas for future research.	2017	Wright, S. L., & Kelly, F. J. (2017). Plastic and Human Health: A Micro Issue? *Environmental Science & Technology,* 51(12), 6634–6647. https://doi.org/10.1021/acs.est.7b00423
	Book chapter to discuss some of the most widely encountered plastics in everyday use are identified and their potential hazards listed. Different routes of exposure to human populations, both of plastic additives, microplastics and nano-plastics from food items and from discarded debris are discussed.	2019	Stark, M. (2019). Letter to the Editor Regarding "are We Speaking the Same Language? Recommendations for a Definition and Categorization Framework for Plastic Debris." *In Environmental Science and Technology* (Vol. 53, Issue 9). https://doi.org/10.1021/acs.est.9b01360
Human behaviour and perceptions of marine plastics pollution	This research examined 176 British schoolchildren's (aged 8–13 years) baseline marine litter understanding and self-reported actions and tested the impact of an educational intervention.	2015	Hartley, B. L., Thompson, R. C., & Pahl, S. (2015). Marine litter education boosts children's understanding and self-reported actions. *Marine Pollution Bulletin*, 90(1), 209–217. https://doi.org/https://doi.org/10.1016/j.marpolbul.2014.10.049
	Explores people's knowledge and understandings of microplastics; the role of media in framing perceptions and socio-cultural dimensions to popular solutions to reduce single-use plastics.	2020	Henderson, L., & Green, C. (2020). Making sense of microplastics? Public understandings of plastic pollution. *Marine Pollution Bulletin,* 152, 110908. https://doi.org/https://doi.org/10.1016/j.marpolbul.2020.110908
	Using psychological principles can motivate and implement change by connecting symptoms and sources.	2017	Pahl, S., Wyles, K. J., & Thompson, R. C. (2017). Channelling passion for the ocean towards plastic pollution. *Nature Human Behaviour*, 1(10), 697– 699. https://doi.org/10.1038/s41562-017-0204-4

UPSTREAM PRODUCTION - MANUFACTURE AND USE OF PLASTIC (LdK)

Research sub theme	Scope of work	Publication Date	Reference
Ban on specific polymers: manufacture, import or use and their impact on marine plastic pollution	Policy to ban of Plastic microbeads in cosmetic products.	2017	https://www.legislation.gov.uk/ukia/2017/178/pdfs/ukia_20170178_en.pdf legislation.gov. (2017). Source of intervention : Domestic Signed by the responsible Minister Thérèse Coffey Date : 27 November Summary : Analysis & Evidence Policy Option 1. November, 1–15. Napper, I. E., & Thompson, R. C. (2019). Environmental Deterioration of Biodegradable, Oxo-biodegradable, Compostable, and Conventional Plastic Carrier Bags in the Sea, Soil, and Open-Air Over a 3-Year Period. *Environmental Science & Technology,* acs.est.8b06984. https://doi.org/10.1021/acs.est.8b06984
Limitation in use (i.e., specific polymers for specific application, for example include packaging) and their impact on marine plastic pollution	This study examined biodegradable, oxo-biodegradable, compostable, and high-density polyethylene (i.e., a conventional plastic carrier bag) materials over a 3 year period.	2019	Napper, I. E., & Thompson, R. C. (2019). Environmental Deterioration of Biodegradable, Oxo-biodegradable, Compostable, and Conventional Plastic Carrier Bags in the Sea, Soil, and Open-Air Over a 3-Year Period. *Environmental Science & Technology,* acs.est.8b06984. https://doi.org/10.1021/acs.est.8b06984

GOVERNANCE AND REGULATION OF MARINE PLASTIC AT INTERNATIONAL AND REGIONAL LEVELS (LdK)

Research sub theme	Scope of work	Publication Date	Reference
Outcomes/impacts of relevant policies, regulations	Retailers of any size (large, medium, small, micro and airport retailers) must charge a minimum of 10 pence for single-use carrier bags in England from 21 May 2021.	2021	Thomas, B., Cole, G., Walker, H., & Reeve, S. (2018). 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. May. https://randd.defra.gov.uk/ProjectDetails?ProjectId=20086
Outcomes/impacts of relevant frameworks in development (expected outcomes), being developed.	The Basel Convention has been recently amended to require that, from 1 January 2021, a Prior Informed Consent procedure is used for the shipment of certain types of plastic waste.	2020	Gago, J., Galgani, F., Maes, T., & Thompson, R. C. (2016). Microplastics in Seawater: Recommendations from the Marine Strategy Framework Directive Implementation Process In *Frontiers in Marine Science* (Vol. 3, p. 219). https://www.frontiersin.org/article/10.3389/fmars.2016.00219

14.2 Research Gap United Kingdom

MARINE PLASTIC FROM WASTE

Research sub theme	Comments
Plastic material flows and leakage	No research found
Collection and sorting efforts (including port/harbour waste reception facilities)	Current research is limited
Abandoned, lost or otherwise discarded fishing gear (ALDFG)	Limited Research found in the area

DISTRIBUTION, ABUNDANCE, IDENTIFICATION AND FATE OF MARINE PLASTIC

Research sub theme	Comments
Deposition, accumulation, hotspots, transportation and movement (e.g., numerical models)	Current research is limited

IMPACT OF MARINE PLASTIC ON THE ENVIRONMENT

Research sub theme	Comments
Monitoring of impact on marine ecosystems (e.g., numerical models)	No research found

SOCIO-ECONOMIC IMPACT OF MARINE PLASTIC (LP)

Research sub theme	Comments
Economic loss (e.g., plastic in fishing gear, threat on tourism)	No research found
Food security	No research found

UPSTREAM PRODUCTION - MANUFACTURE & USE OF PLASTIC

Research sub theme	Comments
Development of new polymers	Limited published research papers found in the sub-theme
Ban on specific polymers: manufacture, import or use and their impact on marine plastic pollution	No research found

GOVERNANCE AND REGULATION OF MARINE PLASTIC AT INTERNATIONAL AND REGIONAL LEVELS (LdK)

Research sub theme	Comments
Outcomes/impacts of relevant policies, regulations	No research found
Changes to (national/international) trade regulations and their impact on marine plastic pollution in the UK	No research found

Discover More

Find out more about the plastics by visiting the UK Circular Plastics Network (UKCPN) website:
ukcpn.co.uk
Join UKCPN at the following programme page:
iuk.ktn-uk.org/programme/ukcpn

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