Marine plastic litter on Small Island Developing States (SIDS)

Impacts and measures

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Floating marine litter with snorkeling divers on Bali, Indian Ocean. Photo Credit: Annelie Pompe

MARINE PLASTIC LITTER ON SMALL ISLAND DEVELOPING STATES (SIDS): IMPACTS AND MEASURES

SWEDISH INSTITUTE FOR THE MARINE ENVIRONMENT, REPORT NO. 2017:4

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SWEDEN

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PREFACE

This report, which was commissioned and financed by the Swedish Agency for Marine and Water Management (SwAM), is devoted to current and potential future measures to mitigate the impacts of marine plastic litter on the ocean environment. It is meant to be used as a background report for Swedish actors at the high-level UN Ocean Conference that will convene at the UN Headquarters in New York in June 2017. This Conference aims to support the implementation of Sustainable Development Goal 14: ´Conserve and sustainably use the oceans, seas and marine resources for sustainable development´ and is intended to be the game changer that will reverse the decline in the health of our oceans for the benefit of people, the planet, and prosperity.

This report also aims to serve as a motivator for further actions against marine plastic litter in all coastal regions around the world, especially in Small Island Developing States. It describes both the impacts of marine litter and measures that can prevent the input of plastics into the ocean and reduce the amount of litter that already is in the marine environment. A review of measures suggested in selected Regional Action Plans on Marine Litter is complemented by a presentation of potential other initiatives from corporations and other organisations. Special attention is paid to the impact of marine litter on Small Island Developing States that among others consider their specific structural disadvantages in relation to waste handling. A set of recommendations for decision-makers in governments, agencies, and commercial enterprises concludes the report.

The authors are grateful for constructive discussions with Ulrika Siira and Johanna Eriksson (SwAM), Dr. Carola Betzold (University of Göttingen), Weslynne Ashton (Illinois Institute of Technology), Prof. Göran Björk (University of Gothenburg), David Lymer (SIDA), and Tina Johansen Lilja (Swedish Institute for the Marine Environment). We are also grateful for the comments from a number of anonymous reviewers as well as from colleagues. However, the authors are solely responsible for the content and the conclusions of the report.

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GOTHENBURG, 15 MAY 2017

EXECUTIVE SUMMARY

PURPOSE OF THIS REPORT

Plastic waste that ends up in the oceans as marine litter is a tangible and urgent environmental pressure reaching even the most remote parts of the global oceans. It impacts marine life from plankton to whales and turtles to albatrosses. Public awareness on how the modern lifestyle and the use of plastics in all sectors of society has influenced the marine ecosystems in the last decades is growing, and an emerging discourse about countermeasures of all types can be seen in policies enacted by authorities in national, regional, and international policy arenas. Different coastal areas have launched Regional Action Plans (RAP) on marine litter that provide structured measures that need to be taken and general advice adapted to the respective region. However, the scale of the problem is not only global in dimension, it also cuts across all sectors in society, and until the use of materials in society becomes sustainable, plastic waste will continues to flow into the seas. This report focuses on how marine plastic litter affects Small Island Developing States (SIDS) because these are considered to be more directly vulnerable to environmental changes, including marine litter, than other countries.

This report was commissioned by the Swedish Agency for Marine and Water management and written by analysts at the Swedish Institute for the Marine Environment (affiliated with the University of Gothenburg, Lund University, and Chalmers University of Technology). In this report, it is documented how marine plastic litter reaches even the most remote parts of the oceans, such as some of the small island states, and how SIDS are especially vulnerable to environmental impacts such as climate change and marine litter. The origin and composition of marine plastic litter and its environmental and economic impacts are described. Finally, measures are discussed that can be launched to mitigate the problem, both from state agencies and private corporations. Here, measures from existing RAPs on marine litter are reviewed and examples of private initiatives are mentioned. Further, the corresponding legal framework is given and side effects of marine litter measures on the Sustainable Development Goals of the UN are debated.

THE SPECIAL VULNERABILITY OF SIDS TO MARINE LITTER

SIDS are a set of island nations located in the Caribbean Sea, the Pacific Ocean, and the so-called AIMS region (Atlantic, Indian Ocean, and South China Sea). They are characterised by their small size, isolated location, exposedness, and limited resources. Not all SIDS are islands, and Belize, Papua New Guinea, Guyana, and Suriname are considered SIDS based on the same structural disadvantages. SIDS also tend to have a high biodiversity and are often home to endemic species found only in a single place on Earth. In addition, SIDS are home to an exceptional cultural diversity and heritage. SIDS are exposed to concentrations of plastic litter that often are disproportionate to their own consumption and populations due to a combination of being located near the so-called ocean gyres, which are known to accumulate marine litter, and due to often sub-performing waste collection and treatment systems. SIDS are also especially vulnerable to impacts of marine plastic litter because such litter might lead to lower revenues from the tourism and fishing industries that their economies largely depend on. Finally, their remote locations constitute a significant challenge in organising inter-island logistics, and their limited resources lead to bigger challenges regarding the management of plastic litter compared to their mainland counterparts. In places where people lack food, clean water, shelter, etc., these basic human needs are of immediate priority. In the long term marine litter might become a vital human problem and should be combated, but not at the expense of other development goals. However, several measures for marine litter mitigation foster other goals as well, so positive synergies can occur here.

ORIGINS AND COMPOSITION OF MARINE PLASTIC LITTER

Marine debris and marine litter are used synonymously in this report and are defined as "any persistent, manufactured or processed solid material that is discarded, disposed of, or abandoned in the marine or coastal environment".[1] Because plastic, a persistent and potentially hazardous pollutant, is commonly reported to make up most marine debris, the focus of this report is on plastic litter.

Marine plastic litter that is washed ashore on SIDS originates from both distant countries overseas and the SIDS themselves. At sea, plastic materials degrade slowly and do not readily mineralise; instead, they break down in into ever-smaller fragments over time, which persist in the marine environment. Buoyant plastic litter is globally distributed by ocean currents and is found washed ashore on beach lines around the globe where it negatively impacts ecological and human systems both in the open water and on the coast. Plastics end up in the marine environment through leaks from the global value chains that run from the oil industry through various other industries to local retailers and consumers. The plastic materials are lost from production to disposal through transport, production, use, waste collection, and waste treatment. In the environment, the very same qualities of lightness and resistance that make them attractive to producers and consumers turn them into a nuisance for other species.

A smaller but significant stream of plastic litter follows from the difficulties of many SIDS to establish and maintain efficient waste management systems. Like most if not all countries in the world, SIDS face the challenge of an increasing generation of waste due to the combined result of economic growth, increased population, growing urbanisation, and changes in consumption patterns. "As the urban population of Small Island Developing States (SIDS) continues to grow significantly, the need for extensive waste management systems has like-wise increased. Given SIDS' limited land areas, and landfills acting as the primary method of waste, their capacity to manage waste leaves them at risk to potential environmental damage and public health risks."[2]

IMPACT OF MACRO- AND MICROPLASTIC LITTER ON ECOLOGICAL, SOCIAL, AND ECONOMIC VALUES

Marine litter has been shown to have negative environmental, social, and economic consequences. It impacts the environment and organisms therein in various ways, including through entanglement, ingestion of litter, transfer of chemicals, by smothering, or by otherwise altering habitats. The extent of the economic impact that plastic litter can have on countries around the world is not currently well known. However, the dependence of SIDS on their natural resources through tourism and fisheries, in combination with their exposed coastlines, make them economically vulnerable to plastic litter. Although the effect that marine litter might have

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1 UNEP, 2009. Marine Litter: A Global Challenge. Nairobi: UNEP. 232 pp.

2 UN-DESA (2016). SIDS ACTION PLATFORM, 18 SAMOA pathway priority areas. Management of Chemicals and Waste, including Hazardous Waste. From: A/CONF.223/10. Retrieved 2017-03-16, from http://www.sids2014.org/partnerships/?area=11

on revenues from tourism is likely to be region-dependent, several studies in other tourism-rich areas show that it might have a considerable effect.

MITIGATION AND REMEDIATION STRATEGIES

Mitigation and remediation are the main approaches against environmental problems. For problems related to plastics in general, this means the reduction, reuse, and recycling of plastics in many applications. For marine plastic litter in particular, mitigation implies improved control and management of plastics, which limits leakages into the oceans, whereas remediation is the removal of marine plastic litter from the environment. For plastic litter that reaches SIDS, both remediation and mitigation, especially through waste management and recycling, become necessary.

LEGAL AND POLITICAL FRAMEWORKS

The legal framework for preventing and managing marine litter is present on all levels of governance, from international to national and local rules and regulations, and it can be found within many areas of law and with different types of legal effects. Global agreements that aim at the protection of ecosystems and marine species and biodiversity are highly related to the issue of marine litter. Apart from binding agreements, there are a number of declarations and recommendations relevant to marine litter on SIDS. One of them is the SAMOA Pathway, a declaration made at the third International Conference on Small Island Developing States in 2014, which calls for measures to manage waste, including marine plastic litter. Multilateral agreements require party states to take actions, but because these requirements are often generally formulated, their achievements depend on the choices and participation of all parties.

POLICY MEASURES PROPOSED BY REGIONAL ACTION PLANS

There exist 18 Regional Seas programmes under the United Nations Environmental Program (UNEP). The aim of this programme is to protect the marine environment through a shared approach across state borders where neighbouring countries work together for the protection of the oceans and seas. Some of the Regional Seas programmes have written strategies to guide actions and efforts against marine litter. Supported by UNEP, the member governments of the respective region agreed on a political agenda for the management of marine litter, the RAPs. The contents of different action plans show strong similarities, commonly including measures of legislation, best practise, best techniques, education/awareness, and voluntary agreements. The analyses conducted here show that most measures suggested by RAPs are aimed at downstream processes (i.e. when the material has already escaped controlled material flows), while fewer measures address the problem upstream. Therefore, additional projects and measures are necessary to solve such a global problem.

VOLUNTARY AND COMMERCIAL INITIATIVES

Plastic litter is a problem that comes from numerous sources and affects many parts of society. While the important role of government agencies in solving the problem is evident, marine litter is not only a matter of management or government, but also of governance. Governance takes place in networks, is typically multilateral, and requires collaboration. Single actors cannot address the issue of plastic marine litter, and what is needed is an array of actions, from the local to the global level, that tackle the issue in a coordinated manner. Most of the measures suggested in RAPs and the current work against marine litter involve not only government managers, but also businesses, NGOs, and voluntary initiatives.

RECOMMENDATION: IMPORTANT AREAS FOR FUTURE COOPERATION

To conclude, there is much work to be done on SIDS to solve the problem of marine litter. Competence and enthusiasm for the issue on SIDS as well as elsewhere is growing, but there is still a long way to go. The issue cannot be solved nationally or even regionally alone, and solutions will require international cooperation. Four recommendations for cooperation are highlighted here, and these might be especially valuable for SIDS and other developing countries:

1. Prevent litter from entering the ocean and thus reaching SIDS: Support cooperation in regional and international agreements
2. Plastic material that reaches SIDS should not be released into the environment: Technical cooperation and support for local waste management
3. If waste reaches the environment, collect it where appropriate: Support beach clean-up campaigns and other remediation measures
4. When waste has been collected, ensure that is has a value: Develop recycling markets and opportunities

LIST OF ACRONYMS

AIMS	Atlantic, Indian Ocean, Mediterranean, and South China Sea
AIS	Alien Invasive Species
ALDFG	Abandoned, Lost, or otherwise Discarded Fishing Gear
AOSIS	Alliance of Small Island States
GATT	General Agreement on Tariffs and Trade
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
ICC	International Coastal Clean-up
ISO	International Organisation for Standardisation
LDC	Least Developed Country
MARPOL	International Convention for the Prevention of Pollution from Ships
MSI	Mauritius Strategy of Implementation
PE	Polyethylene
PET	Polyethylene Terephthalate
PP	Polypropylene
PS	Polystyrene
PUR	Polyurethane
PVC	Polyvinyl Chloride
RAP	Regional Action Plan
SAMOA	SIDS Accelerated Modalities of Action
SIDS	Small Island Developing States
UN	United Nations
UN-CED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UN-DESA	United Nations Department of Economic and Social Affairs
UN-EP	United Nations Environmental Programme
UN-OHRLLS	Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and SIDS

CONTENTS

INTRODUCTION

Marine litter, and especially the plastic waste ending up in our oceans, has become one of the most urgent and imminent, and definitely one of the most apparent, threats to the health of the oceans. The general public and the professional world have become more and more aware of the danger marine litter can pose, and momentum to tackle the problem is growing rapidly. Pictures of stranded whales and the plastic extracted from their stomachs or of turtles and seals helplessly entangled in old fishing nets are only the visible tip of the iceberg that experts continue to gain proof of. There is a wide consensus on the need to stem the leaks at their sources in society, to work towards sustainable material design, and to emphasize the concept of use, reuse, and recycle. It is critical not to lose focus on these overarching aims. Although the emerging broad international engagement from the grassroots to the highest political levels is encouraging, a sense of urgency can definitely be seen as plastic waste continues to leak into the marine environment and its impacts on even the most remote ocean environments worsens. This report focuses on SIDS and how they are affected by marine plastic litter because SIDS are particularly exposed and vulnerable to such litter. The detailed nature of the problem and what can be done to reverse it are the central issues of this report.

SMALL ISLAND DEVELOPING STATES (SIDS)

SIDS are a set of island nations (see Box 1 and Figure 1) characterised by their small size, isolated location, exposedness, and limited resources. These islands tend to have high biodiversity and are often home to endemic species found only in a single place on Earth. SIDS are also home to an exceptional cultural diversity and heritage.

Many SIDS are confronted with similar constraints to their sustainable development efforts:[3]

- A narrow resource base, depriving them of the benefits of economies of scale
- Small domestic markets and heavy dependence on a few remote external markets
- High costs for energy, infrastructure, transportation, communication, and servicing
- Low and irregular international traffic volumes
- Low resilience to natural disasters and fragile natural environments
- Growing populations and high volatility of economic growth
- Limited business opportunities for the private sector

"SIDS are […] the globe's barometers of [environmental] changes"[4]. Most of these islands are located within the trade wind belts and on the outer rim of ocean gyres, where ocean currents flow circularly. This makes them particularly exposed to marine plastic litter. With an ecologic

3 UN-OHRLLS (2011). Small island developing states. Small Islands Big(ger) Stakes. Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and SIDS. Retrieved 2017-03-01, from www.unohrlls.org/custom-content/uploads/2013/08/SIDS-Small-Islands-Bigger-Stakes.pdf

4 Kelman, I., & West, J. J. (2009). Climate change and small island developing states: a critical review. Ecological and Environmental Anthropology, 5(1), 1-16. Page 3

and economic resilience that is comparatively low[5,6] and a vulnerability to impacts from changes in the marine environment and climate changes that is comparatively high[7], SIDS are especially sensitive to present and future damage from marine plastic litter.

Box 1: Defining SIDS

"Small Island Developing States (SIDS) were recognized as a distinct group of developing countries facing specific social, economic and environmental vulnerabilities at the United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit, held in Rio de Janeiro, Brazil (3-14 June 1992). This recognition was made specifically in the context of Agenda 21 (Chapter 17 G). The United Nations recognizes the 38 UN Member States belonging to the Alliance of Small Island States (AOSIS), an ad hoc negotiating body established by SIDS at the United Nations. AOSIS also includes other island entities that are non-UN Member States or are not self-governing or non-independent territories that are members of UN regional commissions. It should be noted that Bahrain is not a member of AOSIS.

UN Members: Antigua and Barbuda, Bahamas, Bahrain, Barbados, Belize, Cabo Verde, Comoros *, Cuba, Dominica, Dominican Republic, Federated States of Micronesia, Fiji, Grenada, Guinea-Bissau *, Guyana, Haiti *, Jamaica, Kiribati *, Maldives, Marshall Islands, Mauritius, Nauru, Palau, Papua New Guinea, Samoa, São Tomé and Príncipe *, Seychelles, Singapore, Solomon Islands *, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Timor-Leste *, Tonga, Trinidad and Tobago, Tuvalu *, Vanuatu *

Non-UN members: American Samoa, Anguilla, Aruba, Bermuda, British Virgin Islands, Cayman Islands, Commonwealth of Northern Marianas, Cook Islands, Curacao, French Polynesia, Guadeloupe, Guam, Martinique, Montserrat, New Caledonia, Niue, Puerto Rico, Sint Maarten, Turks and Caicos Islands, US Virgin Islands

* Also least developed countries"

UN Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States[8]

SIDSs are located in the Caribbean Sea, the Pacific Ocean, and the so-called AIMS region (Atlantic, Indian Ocean, and South China Sea) (See Figure 1). Each of these regions has regional bodies to which the respective SIDS may belong for purposes of regional cooperation.

5 Briguglio, L. (1995). Small island developing states and their economic vulnerabilities. World development, 23(9), 1615-1632.

6 Pelling, M., & Uitto, J. I. (2001). Small island developing states: natural disaster vulnerability and global change. Global Environmental Change Part B: Environmental Hazards, 3(2), 49-62.

7 UN-OHRLLS (2015). Small island developing states in numbers, climate change edition 2015. http://unohrlls.org/custom-content/uploads/2015/11/SIDS-IN-NUMBERS-CLIMATE-CHANGE-EDITION_2015.pdf

8 UN-OHRLLS (2017). About the Small Island Developing States. Retrieved 2017-03-20, from http://unohrlls.org/about-sids/

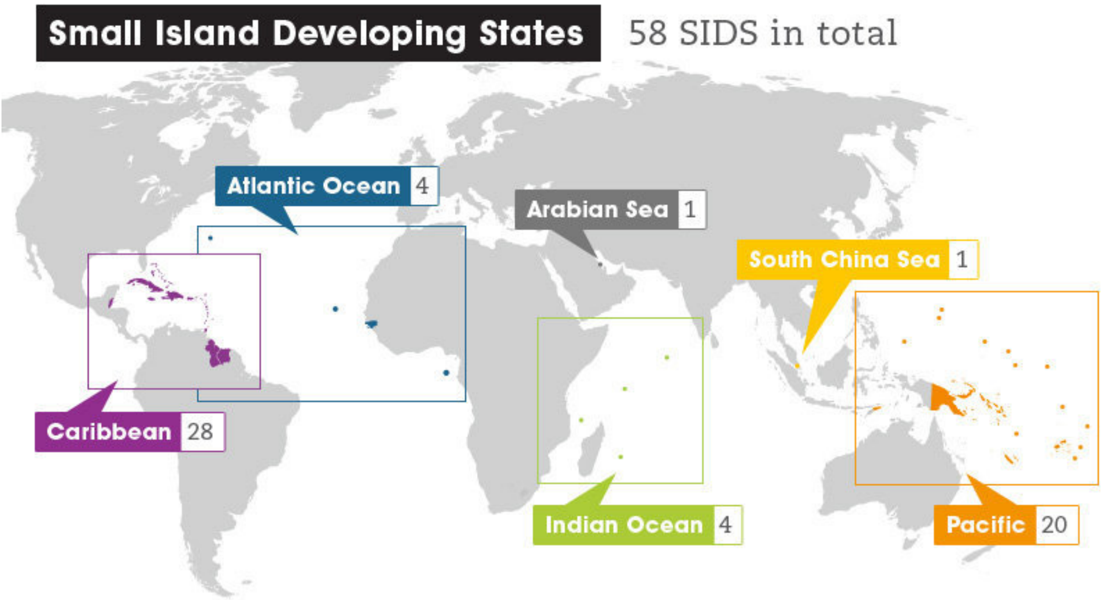

Figure 1: SIDS as listed by UNESCO and UN-OHRLLS.[9]

Box 2: Key UN documents on SIDS

Several official documents from UN conferences and follow-up meetings on SIDS address the situation of small islands and define strategies for their development. The most important ones are the so-called Barbados Programme of Action,[10] the Mauritius Strategy of Implementation,[11] the SAMOA Pathway,[12] and some paragraphs in the outcome document of the UN Earth Summit 2012.[13]

AIMS AND SCOPE OF THE REPORT

The objective of this report is to describe the impact of marine plastic litter on SIDS. It is also to suggest measures to mitigate and possibly remedy these impacts, and such measures are featured as potential grounds for future international cooperation projects. The report does

9 Grimes, S. (2014). Ocean science for development in SIDS: Facts and figures. Small island states´ big development issues. Published 28/08/14 on SciDevNet. Retrieved 2017-04-17 from http://www.scidev.net/global/water/feature/ocean-science-development-sids-facts-figures.html

10 UN-GA (1994). Report of the Global Conference on the Sustainable Development of SIDS. A/CONF.167/9. United Nations General Assembly.

11 UN (2005). Mauritius Declaration. A/CONF.207/L.6. International Meeting to Review the Implementation of the Programme for Action for the Sustainable Development of Small Island Developing States. Page 7

12 UN-DESA (2016). SIDS ACTION PLATFORM, 18 SAMOA pathway priority areas. Management of Chemicals and Waste, including Hazardous Waste. From: A/CONF.223/10. Retrieved 2017-03-16, from http://www.sids2014.org/partnerships/?area=11

13 Brundtland Commission. (1987). Our common future: Report of the World Commission on Environment and Development. UN Documents Gathering a Body of Global Agreements. Paragraph 178. & UN-GA (2012). The Future We Want. A/RES/66/288. Resolution of the United Nations General Assembly. Page 46.

not address Least Developed Countries (LDCs) directly, but many characteristics and challenges of SIDS also apply to LDCs. Thus, information and recommendations given in this report are relevant for other developing countries as well.

This report studies the literature, for example, UN documents and research articles on marine litter, to create an up-to-date overview on the topic. In addition, oceanographic modelling serves as a means to show the distribution of plastic particles by ocean currents. The purpose of this interdisciplinary approach is to provide a material flow system approach to marine litter that combines the insights of marine biology, oceanography, waste management studies, environmental law, ecotoxicology, and industrial ecology. From a material flow perspective (see Figure 2), marine litter originates from leakages in the material flows systems that govern production, distribution, consumption, and disposal. For example, these leakages are caused by faulty handling of plastic pellets, mismanagement of waste and recycling, littering, accidents, and natural catastrophes.

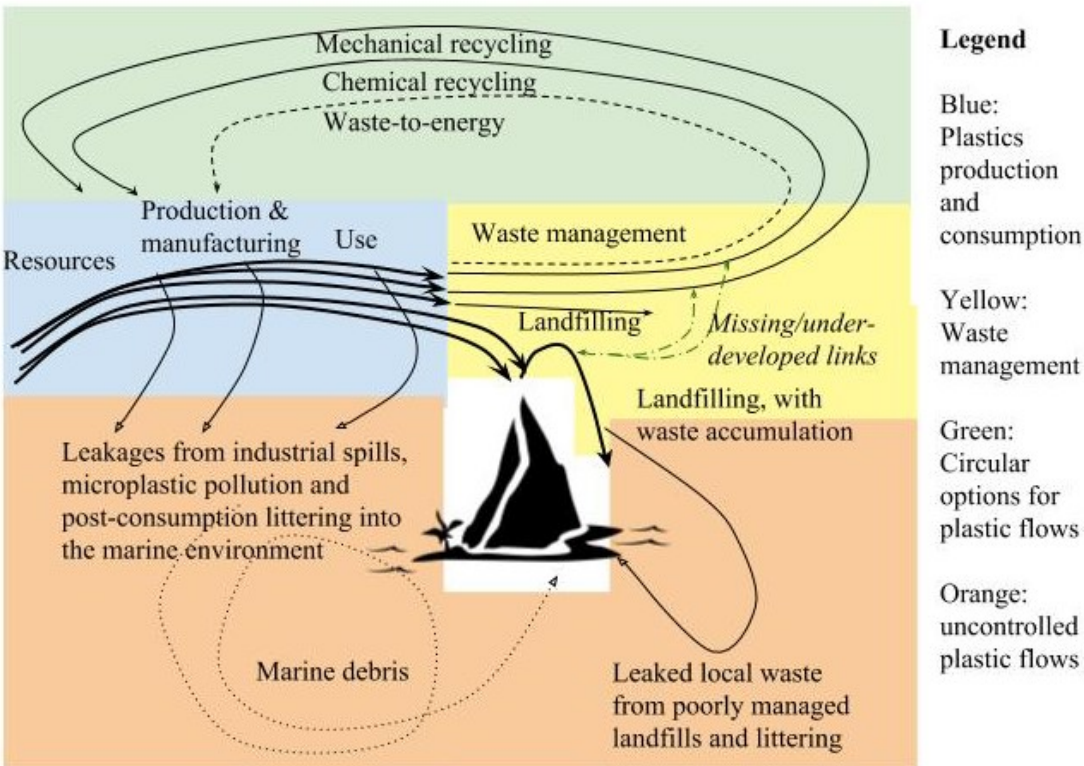

Figure 2: Marine litter in the plastic material flow system.

The focus of this report is on marine plastic litter, which amounts to 80% of the total marine litter.[14] This report addresses the fact that plastic litter originates both from distant countries overseas and from the SIDS themselves. It also addresses the fact that plastic materials at sea degrade slowly and do not readily mineralise; instead, they fragment into ever-smaller pieces over time, and these persist in the marine environment. In particular, the report stresses that

14 Derraik, J. G. (2002). The pollution of the marine environment by plastic debris: a review. Marine pollution bulletin, 44(9), 842-852.

once plastic litter enters the marine environment, it is globally distributed by ocean currents and washed ashore on beach lines around the globe where it negatively impacts ecological and human systems alike – both in the open water and on the coast. In addition, the report describes how marine plastic litter exposes SIDS to environmental, social, and economic threats[15,16,17].

Box 3: Definition of marine litter or debris

> "Marine debris is [...] defined as any persistent, manufactured or processed solid material that is discarded, disposed of, or abandoned in the marine or coastal environment. Three-quarters of all marine debris is plastic, a persistent and potentially hazardous pollutant".[18]

The first part of the report describes plastic as a material and details the origins, composition, and distribution of marine litter. In particular, it uses field observations and oceanographic modelling to explain how plastic litter reaches the coasts of SIDS.

The second part describes the impact of macro- and microplastic litter on ecological, social, and economic assets. Furthermore, the generally higher vulnerability of SIDS compared to other states is depicted, and from this their specific exposure to marine litter is deduced.

The third and final part discusses strategies for the mitigation and remediation of the plastic litter issue in regard to their applicability for SIDS. It presents relevant legal and political frameworks and analyses the policy measures proposed by Regional Action Plans for different areas. In addition, relevant voluntary and commercial initiatives that aim at the reuse of marine litter as a resource are discussed.

15 Leggett, C., Scherer, N., Curry, M., Bailey, R., & Haab, T. (2014). Assessing the economic benefits of reductions in marine debris: a pilot study of beach recreation in Orange County, California. NOAA Mar Debris Progr Ind Econ Inc, 45.

16 UNEP (2014) Valuing Plastics: The Business Case for Measuring, Managing and Disclosing Plastic Use in the Consumer Goods Industry.

17 Mouat, J., Lozano, R. L., & Bateson, H. (2010). Economic impacts of marine litter. Kommunenes Internasjonale Miljøorganisasjon (KIMO).

18 CBD (2016). Marine Debris: Understanding, Preventing and Mitigating the Significant Adverse Impacts on Marine and Coastal Biodiversity. Technical Series No.83. Secretariat of the Convention on Biological Diversity, Montreal, 78 pages.

1 PART 1: ORIGINS AND COMPOSITION OF MARINE PLASTIC LITTER

The production of plastic has grown from fewer than 2 million tons in 1950 to 322 million tons in 2015.[19] In these few decades, plastics have displaced materials such as wood, metal, and glass, and there is no indication that this trend will be reversed in the near future. The presence of litter lying on beaches, hanging on reefs, or floating around islands are unwelcome expressions of the omnipresence of plastic in contemporary society. Plastics end up in the marine environment through leaks from the global value chains that run from the oil industry through various other industries to local retailers and consumers. There, the very same qualities of lightness and resistance that make them attractive to producers and consumers turn them into a nuisance.

Figure 3: Marine plastic litter on a beach on the Seychelles. Photo credit: Eric Maeder

1.1 PLASTICS AND POLYMERS

Plastic is a colloquial term for a wide range of synthetic and natural organic materials. These materials are called "plastic" because they can be reshaped when heat and pressure are applied. Most industrial plastics are made from synthetic polymers through polymerization or polycondensation, and various additives are added to a polymer to modify its material quality[20]. A polymer is made up of repeated monomers, which are relatively simple molecules that together form long polymer chains.

19 PlasticsEurope (n.d.). Global plastic production from 1950 to 2015 (in million tons)*. In Statista - The Statistics Portal. Retrieved March 23, 2017, from https://www.statista.com/statistics/282732/global-production-of-plastics-since-1950/

20 Rosato, D. V., & Rosato, M. G. (2012). Concise encyclopedia of plastics. Springer Science & Business Media.

In Figure 4, the structures of a few polymers are shown. There are thousands of different types of plastics, but a more limited range shows up in marine plastic litter. Studies[21,22,23,24] have identified polyethylene (PE), polypropylene (PP), and polyterephthalate (PET) together with various types of foamed plastics (expanded polystyrene (PS), synthetic rubber, etc.). Also, nylon, which is used for ropes and fishing nets, is commonly found. These four materials are among the six material groups—also including polyurethane (PUR) and polyvinylchloride (PVC)—that make up 80% of all plastics production.[25] The plastics that show up in beached marine litter are typically those used in litter-prone applications (e.g. packaging) and hard to contain applications (e.g. nurdles and fishing gear) and are buoyant (e.g. PE and PP). Heavier plastic items (e.g. PVC) tend to sediment near the location where they are lost.

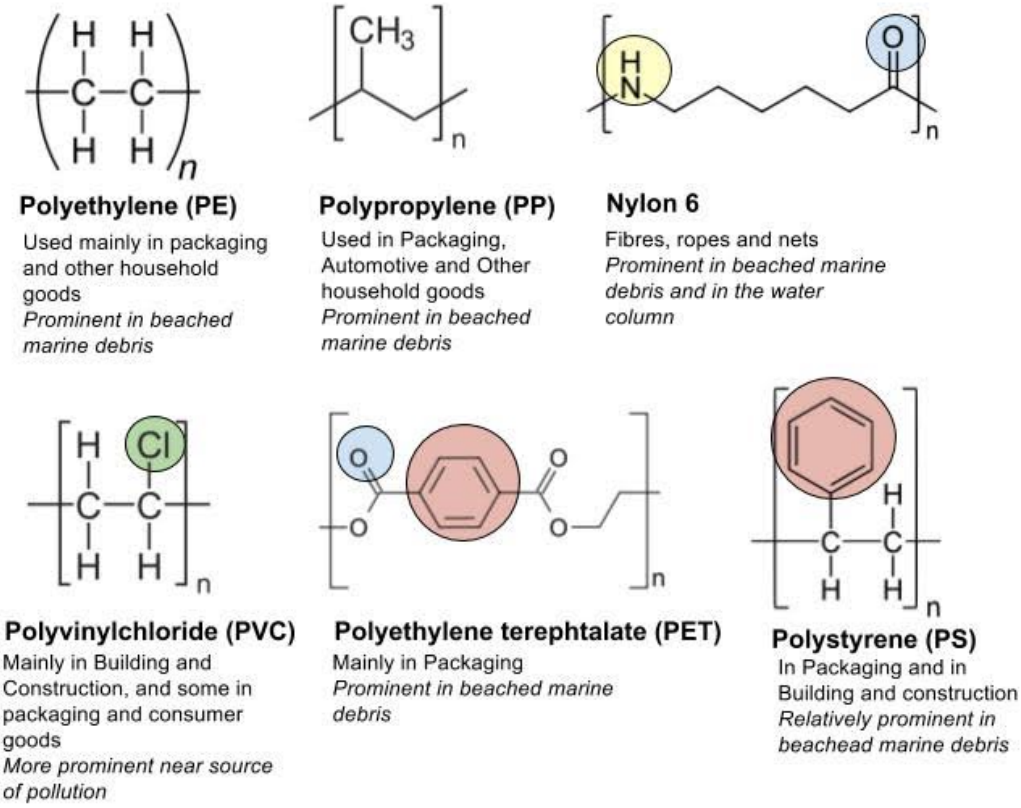

Figure 4: Chemical structures, main application areas, and prominence in marine plastic litter for the six major groups of plastics. (Green circle = chlorine compound, brown circle = aromatic hydrocarbon, blue circle = oxygen compound, yellow circle = amine compound.)

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21 Iñiguez, M. E., Conesa, J. A., & Fullana, A. (2016). Marine debris occurrence and treatment: A review. Renewable and Sustainable Energy Reviews, 64, 394-402.

22; Iñiguez, M. E., Conesa, J. A., & Fullana, A. (2017). Pollutant content in marine debris and characterization by thermal decomposition. Marine Pollution Bulletin, 117(1), 359-365.

23 Jung, R. T., Sung, H. G., Chun, T. B., & Keel, S. I. (2010). Practical engineering approaches and infrastructure to address the problem of marine debris in Korea. *Marine pollution bulletin*, *60*(9), 1523-1532.

24 Li, W. C., Tse, H. F., & Fok, L. (2016). Plastic waste in the marine environment: A review of sources, occurrence and effects. Science of The Total Environment, 566, 333-349.

25 PlasticsEurope (2016). Plastics – the Facts 2016. An analysis of European plastics production, demand and waste data. Retrieved 2017-03-02, from http://www.plasticseurope.org/Document/plastics---the-facts-2016-15787.aspx?FolID=2

Plastic polymers are very unalike each other and can thus not be treated as one material. Each polymer has different properties, and these properties can be further modified with additives such as colour pigments, flame-retardants, plasticisers, and fillers. Some of the additives and plastics create additional environmental and public health-related concerns:

- PVC and polystyrene release monomers that are toxic and that are linked to cancer and reproductive problems.[26,27]
- Bisphenol A, which is used for the production of polycarbonates (e.g. for CDs and DVDs) and epoxy resins (used e.g. for lining pipes), is an endocrine oestrogen-like disruptor.
- Phthalates are a group of industrial chemicals used as plasticisers, which make plastics such as PVC more flexible or resilient. Their use is extremely widespread, and they are found in items including toys, food packaging, hoses, raincoats, shower curtains, and vinyl flooring. Phthalates have been associated with cancer and endocrine disruption.
- Brominated flame retardants are deemed necessary in plastics for safety reasons. Common examples of these are polybrominated diphenyl esters and tetrabromobisphenol A. They are added to a variety of consumer products, including textiles and thermoplastics used in electronics. Some are suspected of causing neurobehavioural effects and endocrine disruption.

For recycling purposes, it is important to handle plastics in a material-specific manner in order to maintain their respective material qualities. Due to their diverse properties, plastics cannot be treated as one material and different product chains need to be considered for recycling to be effective. The most efficient method is the recycling of pure fractions of one polymer at a time.[28] Where material-specific recycling is not possible, the remaining alternatives are mixed material "down-cycling", chemical recycling, or waste-to-energy incineration.

CHARACTERISTICS OF MARINE PLASTIC LITTER

The material properties, densities, and purposes of plastic items affect their distribution and fate in the environment. Materials with low density (e.g. PE and PP) will typically float and are thus more common on beaches and in surface waters, whereas higher density materials (PVC, PET, PUR, and PS) are more often found in sediment and on the ocean floor. However, high-density polymers can also end up on beaches due to the material properties of the plastic item, e.g. the expanded form of PS used for buoys, insulation, and Styrofoam cups. Conversely, low-density materials can sink to the bottom as a consequence of biofouling, which is the growth

26 Marcilla, A., Garcıa, S., & Garcıa-Quesada, J. C. (2004). Study of the migration of PVC plasticizers. Journal of analytical and applied pyrolysis, 71(2), 457-463.

27 Garrigos, M. C., Marin, M. L., Canto, A., & Sanchez, A. 2004). Determination of residual styrene monomer in polystyrene granules by gas chromatography–mass spectrometry. Journal of Chromatography A, 1061(2), 211-216.

28 Ellen MacArthur Foundation (2017). The New Plastics Economy, Catalysing action. Page 40. Retrieved 2017-03-02, from https://newplasticseconomy.org/report-2017

of algae, barnacles, and microorganisms on the surface, and from degradation.[29] Thus the properties of plastic litter might change once it is in the environment.

There are also specific problems with plastic beach litter that complicates its waste management. Litter collected on beaches is often entangled in sea grass and covered with sand so that the material needs to be washed prior to the actual recycling or else the material quality will be poor. The saltiness from the sea causes problems for both recycling and for waste-to-energy solutions. The salt causes corrosion in incinerators, and there is a risk for the formation of chlorinated hydrocarbons—the worst in this group of compounds being dioxin[30]. Furthermore, owing to long-term exposure to sunlight and seawater, the polymer material in plastic litter is in itself already somewhat degraded and fragmented, resulting in poorer material quality compared with post-consumer plastics collected for recycling, which is why plastics from marine litter are often mixed with better quality plastics for recycling. This is, however, mainly a problem for mechanical recycling (e.g. re-melting of PE), but not for chemical recycling (e.g. de- and re-polymerisation of nylon).

Not only is plastic litter made up of different polymeric materials, it also comes in different sizes, from bigger macroscopic items down to microscopic and nanoparticles. This has implications for the ecological impact of the litter. Beach litter varies in composition depending on location, proximity to local sources, and environmental conditions and ranges from recognizable items to smaller pieces. Common items include packaging foils, plastic bags, food containers, drinking bottles, oil canisters, Styrofoam, pieces of ropes and nets, gloves, shoes, fish crates and floats, and sanitary items. Smaller objects commonly include bottle caps, lighters, cigarette butts, sewage plant bioreactor pieces, and shotgun cartridges.[31] Microplastics are defined as particles smaller than 5 mm in size.[32] These come either as primary microplastics, i.e. microbeads (pre-production nurdles manufactured in this size range), or as secondary microplastics, i.e. particles formed as the result of the weathering and breakdown of larger plastic litter (Figure 5).

29 Fazey, F. M., & Ryan, P. G. (2016). Biofouling on buoyant marine plastics: An experimental study into the effect of size on surface longevity. Environmental Pollution, 210, 354-360. & Holmström, A. (1975). Plastic films on the bottom of the Skagerack.

30 Cañete Vela, I. (2017). Closing the Loop for Plastic Debris. Environmental Analysis of Beach Clean-Up and Waste Treatments. ESA report 2017:4, Environmental Systems Analysis, Chalmers University of Technology, Göteborg, Sweden.

31 OSPAR Commission (2007). Monitoring of marine litter in the OSPAR region. OSPAR Pilot Project on Monitoring Marine Beach Litter. Biodiversity series.

32 GESAMP (2015). "Sources, fate and effects of microplastics in the marine environment: a global assessment". (Kershaw, P. J., ed.).

Box 4: Microplastics, the smallest pieces of plastic waste in the oceans

Microplastics are defined as minute particles of plastic waste (smaller than 5 mm), and these consist of both plastic matter synthesised to be used as small micro particles and particles formed from the weathering and fragmentation of large plastic waste items. Research expeditions have reported microplastics in water, sediment, polar ice, and beach sand from the most remote islands in the oceans, as well as in numerous marine species.[33] To clean up the seas from microplastics is virtually impossible, and the only way to avoid further microplastic pollution of the oceans is to stop the flow of large plastic litter items, to clean up the existing large plastic litter items, and to stop activities and products that generate microplastics on land.

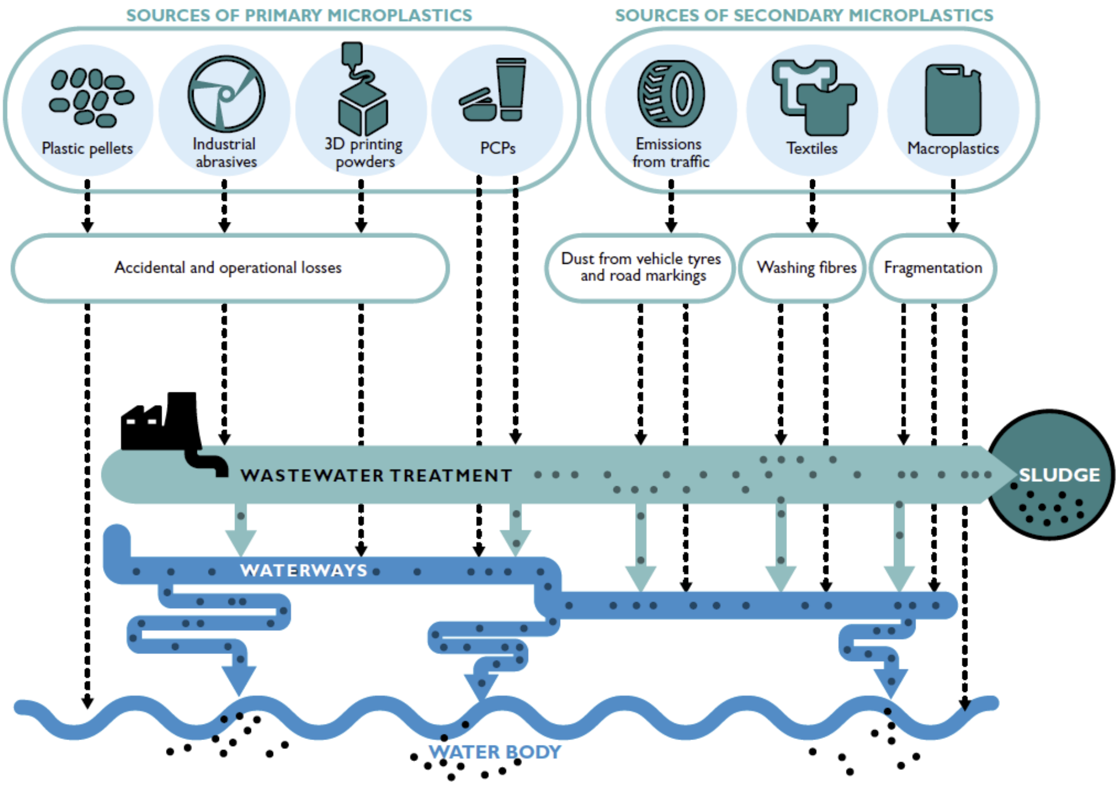

Figure 5: Land-based sources of microplastics and their pathways.[34]

33 GESAMP (2016). “Sources, fate and effects of microplastics in the marine environment: part two of a global assessment” (Kershaw, P.J., and Rochman, C.M., eds). (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP No. 93, 220 p. Page 117

34 Setälä, Outi; Fjäder, Päivi; Hakala, Olli; Kautto, Petrus; Lehtiniemi, Maiju; Raitanen, Elina; Sillanpää, Markus; Talvitie, Julia; Äystö, Lauri (2017). Microplastics - a growing environmental risk. Syke Policy Brief. Finnish Environment Institute.

1.2 HOW PLASTIC LITTER FLOWS TO SIDS

MULTIPLE SOURCES OF LEAKAGE

This section addresses the question of how plastic materials become litter, reaches the ocean, and ends up on a SIDS' beach. To understand this, a universal global product chain of plastics is used to indicate where leakages occur, which can be at any of the steps of the production chain (see Figure 6). The use phase might be the most intensely leaky step through users who do not dispose of materials properly. A large number of leakages also occur in the production phase through spills from industries as the result of accidents or imprudent handling.

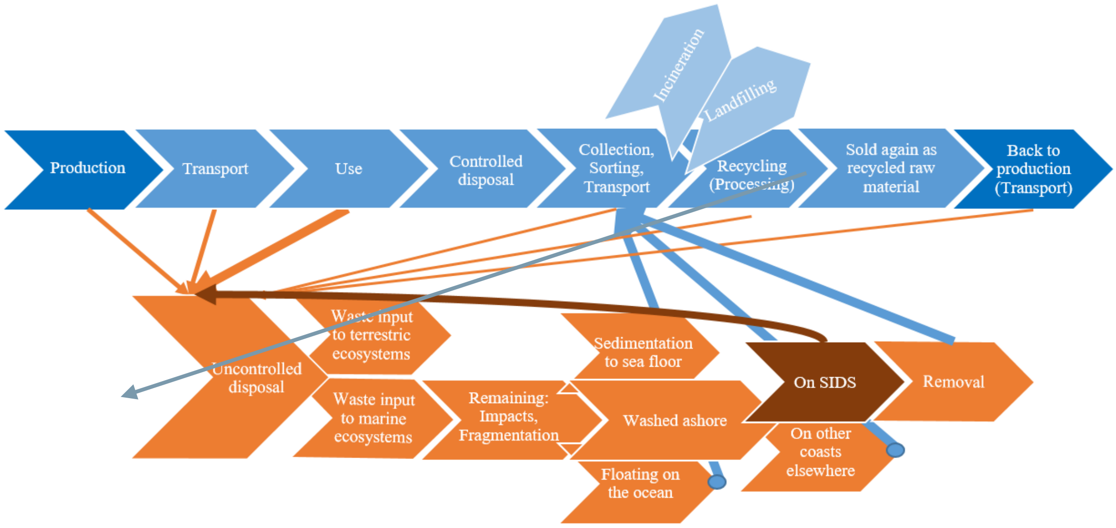

Figure 6: Product chain for plastics, including uncontrolled flows that leak into the environment.

A study on the origins of marine debris on the Seychelles pointed to insufficient waste-management as one of the key drivers for marine litter. It also highlighted that marine debris can even have a negative impact on very remote areas, which has been confirmed by the findings in several similar studies.[35] Plastics escaping the controlled product chains constitute uncontrolled disposal leading to a growing environmental threat. It is a particular threat for marine environments where it is difficult to collect plastics, especially if they have become fragmented and distributed across large areas.

Figure 7 shows how marine plastic litter—consisting of consumer goods and food packaging, single-use cutlery, personal care products, pellets, fishing gear, building materials, etc.—originates from both terrestrial and marine sources and activities. How much of the current annual production of 322 million tons ends up in the environment and is transported to the seas is

35 Duhec, A. V., Jeanne, R. F., Maximenko, N., & Hafner, J. (2015). Composition and potential origin of marine debris stranded in the Western Indian Ocean on remote Alphonse Island, Seychelles. Marine pollution bulletin, 96(1), 76-86.

uncertain, but has been estimated to be in the range of 4.8–12.7 million tons.[36] In comparison, 5.4 million tons of plastics were recycled in Europe in 2012.[37]

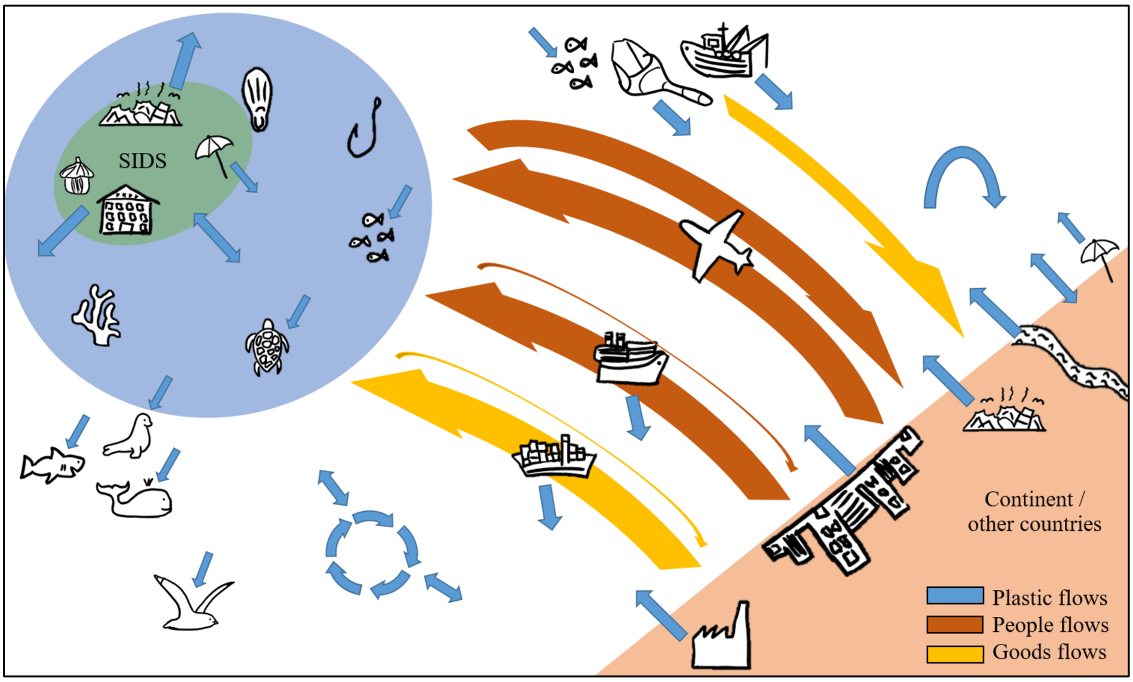

Figure 7: Marine plastic litter flows, adapted from Ryan et al., 2009.

Sea-based sources of marine plastic litter are fishing vessels and their activities, container ships, cruise liners, and leisure boats. The more apparent types of sea-based matter are parts of ropes, nets, and fishing crates, but also much more. Terrestrial sources are urban settlements and industry, sewage outfall, waterways transporting litter from inland to the ocean, litter transported by wind from landfills near the coast, and direct beach littering. A smaller but significant stream of plastic litter originates from SIDS themselves because many SIDS have difficulties establishing and maintaining efficient waste management systems. Like most, if not all, countries in the world, SIDS face the challenge of an increasing generation of waste as the combined result of economic growth, increasing population, growing urbanisation, and changes in consumption patterns.[38]

36 Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., ... & Law, K. L. (2015). Plastic waste inputs from land into the ocean. Science, 347(6223), 768-771.

37 EPRO, http://www.epro-plasticsrecycling.org/pages/75/epro_statistics

38 Wilson, D. C., Rodic, L., Modak, P., Soos, R., Carpintero, A., Velis, K., ... & Simonett, O. (2015). Global waste management outlook.

Box 5: Waste management on SIDS, according to the SAMOA pathway

"As the urban population of Small Island Developing States (SIDS) continues to grow significantly, the need for extensive waste management systems has likewise increased. Given SIDS' limited land areas, and landfills acting as the primary method of waste, their capacity to manage waste leaves them at risk to potential environmental damage and public health risks. The SAMOA Pathway seeks to enhance technical programmes and to strengthen national, regional and international mechanisms for the management of waste, including [...] marine plastic litter".[39]

Although there are significant differences among them, SIDS today generate an average of 1.29 kg of waste per person every day—which is only slightly under that of OECD countries at 1.35 kg.[40] Such quantities present SIDS with difficulties in both the collection and treatment of waste. Many SIDS need to serve a waste-producing population that is geographically dispersed and with an unequal economic ability to support the cost of waste collection. Uncontrolled dumping continues to remain a prevalent method of waste disposal, and the development of sanitary landfills meets siting difficulties. Moreover, recycling is generally not well developed in most of the islands because the small size of the population and geographic isolation of SIDS make recycling a relatively limited and expensive activity in relation to the volumes and prices of secondary materials on the world markets.[41] Moreover, tourism, often presented as decisive for the economic development of SIDS, adds to this challenge because tourists generate considerably more waste per capita than local residents do.[40]

MODELLING OF OCEAN CURRENTS

If the litter is spilled into the ocean, it will sink to the sea floor if it is heavier (denser) than seawater; however, if it is lighter (more buoyant) than seawater, it will float and thus be transported by ocean currents. Some plastic material will be washed back on nearby shores, while some material will be transported great distances by the large-scale ocean currents. Today a significant fraction of the buoyant debris accumulates in the subtropical convergence zones, the so-called ocean gyres or garbage patches where plastic particles accumulate in "large, wind-driven, circular systems with a quiet centre"[42]. It might take several years for the plastic to end up in these gyres. There is a leakage of particles from the gyres, and some of these particles might land on beaches given enough time, while other particles might sink to the bottom as they become incorporated into the food chain or become denser than water due to biofouling. It was recently estimated that there are at least 5.25 trillion pieces of plastic afloat

39 UN-DESA (2016). SIDS ACTION PLATFORM, 18 SAMOA pathway priority areas. Management of Chemicals and Waste, including Hazardous Waste. From: A/CONF.223/10. Retrieved 2017-03-16, from http://www.sids2014.org/partnerships/?area=11

40 Mohee, R., Mauthoor, S., Bundhoo, Z. M., Somaroo, G., Soobhany, N., & Gunasee, S. (2015). Current status of solid waste management in small island developing states: a review. Waste Management, 43, 539-549. Page 540.

41 Carpintero et al in Wilson 2015). Page 45

42 Kaiser, J. (2010). The dirt on ocean garbage patches. Science Vol. 328, Issue 5985. Page 1506.

on the oceans that weigh nearly 270,000 tons in total.[43] This equals the amount of municipal waste produced by about half a million Swedes over a whole year.[44]

To understand the dispersion of marine litter in the oceans, the distribution of plastic particles can be described by moving particles in a current field, and these currents might come from a composite of observations or from an ocean model (notably, the two approaches complement each other). Studies available in the literature[45,46,47] have mainly focused on the large-scale accumulation of buoyant debris in the subtropical convergence zones, which are somewhat poleward of the SIDS areas. Thus, the results from these studies are not easily translated into the impact of the subtropical debris field on the SIDS regions. To evaluate the likelihood of a distant piece of plastic debris arriving in a SIDS area, some model simulations on transport patterns of plastic debris in the North Atlantic are considered, and the impact is usually focused on the Antilles. More details on the simulations, which should be typical of, for example, plastic bags, are given in Appendix A.

The main result from our simulation is that the SIDS regions in the North Atlantic are on the rim of the subtropical garbage gyre. Debris leaking out from the subtropical gyre do hit the SIDS areas, but at the same time it is evident that the rate of the leakage depends on model formulation (e.g. what processes are included and how they are described). Preliminary studies show that larger objects that are closer to the surface (or actually at the surface such as plastic bottles and cups) are more likely to escape from the subtropical gyres and reach the SIDS areas.

By releasing particles from different seeding areas (such as Europe, Africa, South America, and North America), it can be seen that these areas have different impacts on the specific areas under investigation. For instance, particles released at the European coast will mainly beach at the European coastline or be transported northwards to the Arctic Ocean. The main exceptions are particles released on the Iberian Peninsula that travel southwards with some particles reaching the Caribbean (see Box 6).

Particles released at the northern Atlantic African coast travel with the trade winds and reach the investigated area after 0.5–1.5 years. For longer timescales, the particles either beach on the American coastline or becomes incorporated in the subtropical gyre. It should be noted that many particles released around the equatorial part of the African Atlantic also travel across the Atlantic and reach the SIDS region under investigation. Particles released from northern South America essentially stay quite close to the coast but might reach the western SIDS area, and the SIDS regions on the South American coast have some beaching of particles released further south on the South American coastline.

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43 Eriksen, M., Lebreton, L. C., Carson, H. S., Thiel, M., Moore, C. J., Borerro, J. C., ... & Reisser, J. (2014). Plastic pollution in the world's oceans: more than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. PloS one, 9(12), e111913.

44 The Swedish Waste Management Association (2016). Municipal waste quantities in 2015 of 478 kg per capita. www.avfallsverige.se/fileadmin/uploads/Arbete/Remissvar/swm_2016.pdf

45 Lebreton, L. M., Greer, S. D., & Borrero, J. C. (2012). Numerical modelling of floating debris in the world's oceans. *Marine pollution bulletin*, *64*(3), 653-661.

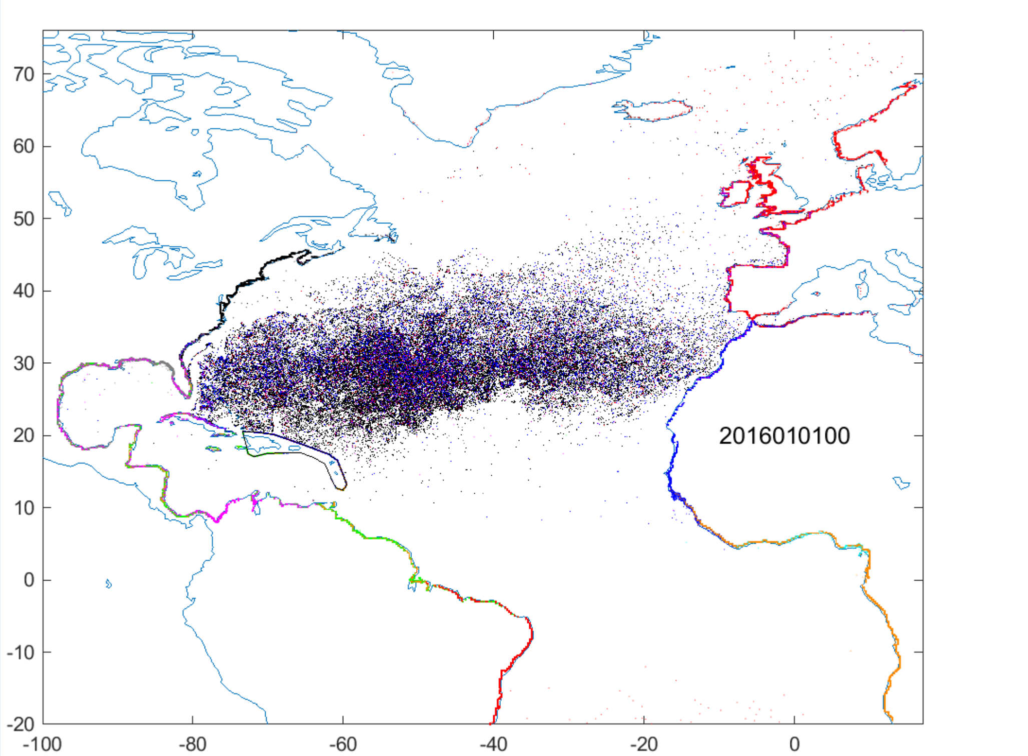
46 Maximenko, N., Hafner, J., & Niiler, P. (2012). Pathways of marine debris derived from trajectories of Lagrangian drifters. *Marine Pollution Bulletin*, *65*(1), 51-62.

47 Van Sebille, E., England, M. H., & Froyland, G. (2012). Origin, dynamics and evolution of ocean garbage patches from observed surface drifters. *Environmental Research Letters*, *7*(4), 044040.

Finally, particles released from the North American coastline tend to go northwards initially. They cross over the North Atlantic, and the majority of the particles become incorporated in the subtropical gyre garbage patch. It should be noted that there is a constant leakage from the subtropical gyre producing a steady stream of particles reaching the northern SIDS areas in the North Atlantic. Although the results outlined here should be considered as preliminary results, the main conclusions fit well with the predominating wind directions and the general ocean circulation, and are thus not surprising. The present studies focus on the North Atlantic, but similar patterns will most likely also be found in the other major oceans. More information about the ocean model used here can be found in Appendix 1.

Box 6: Global ocean transport of plastics and accumulation in subtropical gyres.

Buoyant litter travels with upper ocean currents, and the main wind and ocean currents tend to move such particles into the subtropical gyres. The exact pattern of the resulting litter field, and leakage from the fields, depends on particle size. How these move with the currents are also important (e.g., how close to the surface the particles are).



Geographical location of oceanographically predicted marine litter accumulation zones and beach strandings in the North Atlantic. For details and time-resolved distributions, see Appendix 1.

1.3 COMPOSITION AND ABUNDANCE OF MARINE PLASTIC LITTER ON SIDS

Because many SIDS are located simultaneously on the outer rim of several subtropical gyres, and within the trade wind belts, the flux of buoyant marine litter to SIDS can be expected to be high, and SIDS are believed to be exposed to long-range transported marine plastic litter more than many other coasts. Reports about the amounts of waste and its composition vary from island to island because accumulation rates on beaches vary widely depending on the proximity of urban centres, shore and coastal uses, wind, and ocean currents48. This results in an uneven distribution of marine litter, with local concentrations (“hotspots”), seasonal variations, and varying composition in stranded litter. Plastic litter was flagged as an emerging pollutant off the coast of Cape Verde by Heyerdahl already in the early 1970s.[49] In the early 1980s, pollution by preproduction pellets was documented on Bermuda[50] followed by another study of the coast that concluded that the pellets had built up in the area during the prior 15 years.[51]

Box 7: Scientific publications documenting plastic litter on SIDS

Publications were identified by searching for published articles about marine litter, marine plastics, and microplastics. Additionally, the online tool Litterbase was used for additional screening.[52]

A total of 31 studies published between 1971 and 2017 were identified (Appendix 4). The studies documented marine plastic litter on 37 of the 57 SIDS. Although the issue was first reported in 1971[49], more than half of the identified studies were published after 2010.

In 1988, about 1,000 tons of trash was removed from American beaches with the help of almost 50,000 volunteers, and more than 60% of the trash was identified as plastics. The numbers ranged from the highest of 76% on the mainland in the state of Pennsylvania to 55% on the Virgin Islands and to the lowest of 47% in Puerto Rico. Three months later, the MARPOL treaty (see Part **Fel! Det går inrte att hitta någon referenskälla.**) came into effect, which will hopefully bring about a positive effect in the long term.[53]

A few years later, a comparison of beach litter on St. Lucia and Dominica showed that 51% of the material was plastic and was dominated by cups and bags. The debris on Dominica, however, was dominated by driftwood, and plastic was the second most common type of debris and made up 16% of the total.[54] Another study on 10 beaches on Curacao in 1992–93 confirmed that plastic was the dominating type of debris here as well, with an average of 40% by number, although wood dominated in terms of weight.[55] The majority of the studies of plastic litter on SIDS have looked into bigger items on beaches or in surface waters, but in Singapore

48 Galgani, F., Hanke, G., & Maes, T. (2015). Global distribution, composition and abundance of marine litter. In *Marine anthropogenic litter* (pp. 29-56). Springer International Publishing.

49 Heyerdahl, T. (1971). "Atlantic Ocean pollution and biota observed by the ‘Ra’expeditions." Biological Conservation 3(3): 164-167.

50 Gregory, M. R. (1983). "Virgin plastic granules on some beaches of eastern Canada and Bermuda." Marine environmental research 10(2): 73-92.

51 Wilber, R. J. (1987). "Plastic in the North Atlantic." Oceanus 30(3): 61-68.

52 Bergmann, M., Tekman, M. B., & Gutow, L. (2016, May). LITTERBASE-Online-portal for marine debris and its effects on marine life.

53 O'Hara, K. J. and L. K. Younger (1990). Cleaning North America's Beaches: 1989 Beach Cleanup Results.

54 Corbin, C. and J. Singh (1993). "Marine debris contamination of beaches in St. Lucia and Dominica." Marine pollution bulletin 26(6): 325-328.

55 Debrot, A. O., et al. (1999). "Beach debris in Curacao." Marine pollution bulletin 38(9): 795-801.

microplastic has also been shown to be prevalent in both sediment and surface waters.[56] Another study of the seafloor in the Caribbean off Aruba, Bonaire, and Curacao showed especially high concentrations of plastics that were a magnitude higher than earlier deep-water studies.[57]

Later studies of plastic litter on beaches in the SIDS regions have reported higher relative proportions of plastic in the litter than what was reported during the 1980s and 1990s. On St. Brandon's Rock, 79% of the debris was plastic[58], and on Aruba plastic comprised 61% of the debris on the windward side and 98% on the leeward side.[59] Although later studies are not directly comparable with the earlier studies, there are no indications that the problem of marine litter on SIDS is decreasing.

Although the composition of plastic litter on SIDS is different in different studies and areas, commonly found items include fishing equipment, bottles, sandals, and mixed plastic materials.[60,61] One of the first long-term studies of beach litter accumulation reported a daily accumulation of 0.6–2.3 kg/km (corresponding to 219–839 kg/km annually) from a 1 km stretch of beach on Amchitka Island in the Aleutians.[62] Other, more recent assessments for various Pacific islands are presented in Table 1.

56 Ng, K. and J. Obbard (2006). "Prevalence of microplastics in Singapore's coastal marine environment." Marine pollution bulletin 52(7): 761-767.

57 Debrot, A., et al. (2014). "Deepwater marine litter densities and composition from submersible video-transects around the ABC-islands, Dutch Caribbean." Marine pollution bulletin 88(1): 361-365.

58 Bouwman, H., et al. (2016). "The flip-or-flop boutique: Marine debris on the shores of St Brandon's rock, an isolated tropical atoll in the Indian Ocean." Marine environmental research 114: 58-64.

59 de Scisciolo, T., et al. (2016). "Beach debris on Aruba, Southern Caribbean: Attribution to local land-based and distal marine-based sources." Marine pollution bulletin 106(1): 49-57.

60 Duhec, A. V., et al. (2015). "Composition and potential origin of marine debris stranded in the Western Indian Ocean on remote Alphonse Island, Seychelles." Marine pollution bulletin 96(1): 76-86.

61 Richardson, K., et al. (2016). "Marine pollution originating from purse seine and longline fishing vessel operations in the Western and Central Pacific Ocean, 2003–2015." Ambio: 1-11.

62 Merrell, T. R. (1980). Accumulation of plastic litter on beaches of Amchitka Island, Alaska. Marine Environmental Research, 3(3), 171-184.

Table 1: Amounts of litter accumulating on Pacific islands.

Location	Amounts of litter	Reference
Midway	617 kg/km annually, of which about 516 kg is plastics	from Ribic et al 2012[63]
North West Hawaiian Islands (including Midway)	52 tons/year	Dameron et al 2007[64]
Fiji	121 kg/km annually on the windward side; 1 kg/km on the leeward side	Hager 1991, in Coe and Rogers 1997[65]

One study found that quantities of marine debris appear to have stabilized in the oceans over the last decade but continue to increase on shorelines.[66] In a study of year-to-year variations in litter quantities, it was found that certain locations (3% of the beaches) in the East Asian marginal seas might experience a 250-fold increase in the amount of plastic beach litter washed ashore in the next 10 years *even if the outflow into the seas does not increase*.[67] This means that even if leakages of plastic waste into the seas are reduced, it will take time before a corresponding reduction is observed on beaches.

1.4 SUMMARY OF PART ONE

Plastics are a set of diverse polymers with a wide range of properties, and they can be found in endless different applications. Due to their diversity, plastics cannot be treated as one material, and each plastic polymer should be recycled separately. Further, plastics float or sink in the ocean according to their respective properties, and particles of all sizes can be found. The exposure to the marine environment makes the recycling of ocean plastic difficult due to the biota, sand, and salt that typically adheres to the material. Plastics leak from both sea- and land-based sources and from all steps of the industrial plastic product chain. Once the particles enter the ocean, they are distributed by ocean currents, and this makes the issue a global problem. A portion of the plastics are washed ashore on coastlines, especially on SIDS, because these often are located close to the ocean gyres where currents naturally concentrate floating material. Scientific evidence of these phenomena is growing rapidly, even though scholars have been observing the problem of marine plastic litter since the 1970s.

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63 Ribic, C. A., Sheavly, S. B., & Klavitter, J. (2012). Baseline for beached marine debris on Sand Island, Midway Atoll. *Marine pollution bulletin*, *64*(8), 1726-1729.

64 Dameron, O. J., Parke, M., Albins, M. A., & Brainard, R. (2007). Marine debris accumulation in the Northwestern Hawaiian Islands: An examination of rates and processes. *Marine Pollution Bulletin*, *54*(4), 423-433.

65 Coe, J. M., & Rogers, D. (Eds.). (2012). *Marine debris: sources, impacts, and solutions*. Springer Science & Business Media.

66 Barnes, D. K., Galgani, F., Thompson, R. C., & Barlaz, M. (2009). Accumulation and fragmentation of plastic debris in global environments. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *364*(1526), 1985-1998.

67 Kako, S. I., Isobe, A., Kataoka, T., & Hinata, H. (2014). A decadal prediction of the quantity of plastic marine debris littered on beaches of the East Asian marginal seas. *Marine pollution bulletin*, *81*(1), 174-184.

2 PART 2: THE IMPACT OF MACRO AND MICROPLASTIC LITTER ON ECOLOGICAL AND ECONOMIC ASSETS

Now that the origin, composition, and flows of plastics have been clarified, this section describes the impact of plastics in the marine environment on ecological and human systems.

Figure 8: Marine litter on a beach on Bali, Indonesia. Photo credit: Annelie Pompe

2.1 ECOLOGICAL IMPACT

MACROPLASTICS

Marine litter has been shown to impact the environment and organisms therein in a number of ways, including through entanglement, ingestion of litter, through chemical transfer, by smothering, or by otherwise altering habitats.[68] Globally, more than 800 species have been recorded as directly affected by marine litter.[69]

Entanglement is perhaps the most visually obvious cause of harm to organisms by marine litter. One report lists 161 species (ranging from invertebrates to whales) for which entanglement has been recorded.[70] The effects of entanglement on individuals can be lethal or sub-lethal but

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68 Werner, S., Budziak, A., van Franeker, J., Galgani, F., Hanke, G., Maes, T., Matiddi, M., Nilsson, P., Oosterbaan, L., Priestland, E., Thompson, R., Veiga, J. and Vlachogianni, T. (2016). *Harm caused* by Marine Litter. MSFD GES TG Marine Litter - Thematic Report; JRC Technical report; EUR 28317 EN; doi:10.2788/690366

69 CBD (2016). Marine Debris: Understanding, Preventing and Mitigating the Significant Adverse Impacts on Marine and Coastal Biodiversity. Technical Series No.83. Secretariat of the Convention on Biological Diversity, Montreal, 78 pages.

70 Kühn, S., Rebolledo, E. L. B., & van Franeker, J. A. (2015). Deleterious effects of litter on marine life. In *Marine anthropogenic litter* (pp. 75-116). Springer International Publishing.

chronic, and effects on populations have also been documented.[68] The most prevalent types of items associated with entanglement are net fragments, ropes and lines, monofilament lines, packing bands, plastic rings, and can yokes,[71] showing the importance of addressing fisheries-related and shipping-related litter items in measures against marine litter.[72]

Ingestion of litter items is another commonly documented impact on organisms by marine litter. One of the most recent studies reported that at least 40% of the world's seabird species (164 out of 406 species), 100% of turtle species (7 out of 7), and 50% of mammals (62 out of 123) have been documented to ingest marine plastic litter.[70] Direct lethal effects from ingestion of litter have been documented in birds, turtles, and whales, but most impacts recorded so far have been sub-lethal effects with partial blockage of guts/intestines leading to reduced viability, reproduction, and long-term survival.[68]

After 2010, other types of studies started looking more at local consequences of marine litter in some of the SIDS regions. In Majuro Lagoon on the Marshall Islands, large amounts of macro debris were found, and this debris was causing tissue abrasion, shading, suffocation, and mortality of the hard coral community.[73] In Puerto Rico, a stranded Gervais' beaked whale gained attention when it was found to have 4.5 kg of plastic in its stomach, which was considered to be the reason for its death.[74] Another study focused on the effects on mangroves in Papua New Guinea and found that the increasing levels of plastic litter were threatening the rehabilitation attempts of the mangrove forest.[75] A more specific type of litter, derelict fishing traps, has been found to cause economic losses to economically important assets in the US coastal waters such as fisheries or tourist destinations by harming organisms and habitats. This has for instance been documented on the Virgin Islands.[76] Lost fishing gear is a significant contributor to marine litter, and according to a summary of fisheries observation data more than 10,000 pollution incidents from longline and purse seine fisheries were reported between 2003 and 2015 in the Western and Central Pacific Ocean, of which a majority was the dumping of plastic waste.[77] The incidents took place both on open water and within the Exclusive Economic Zones[78] of more than 25 different Pacific countries.

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71 Butterworth, A., Clegg, I., & Bass, C. (2012). Untangled – Marine debris: a global picture of the impact on animal welfare and of animal-focused solutions. London: World Society for the Protection of Animals.

72 The Secretariat of the Convention on Migratory Species (2014). Report I: Migratory Species, Marine Debris and its Management Review Required under CMS Resolution 10.4 on Marine Debris. AC21/Inf.3.4.3.b

73 Richards, Z. T., & Beger, M. (2011). A quantification of the standing stock of macro-debris in Majuro lagoon and its effect on hard coral communities. *Marine Pollution Bulletin*, *62*(8), 1693-1701.

74 Simmonds, M. P. (2012). Cetaceans and marine debris: the great unknown. *Journal of Marine Biology*, *2012*.

75 Smith, S. D. (2012). Marine debris: A proximate threat to marine sustainability in Bootless Bay, Papua New Guinea. *Marine Pollution Bulletin*, *64*(9), 1880-1883.

76 Arthur, C., Sutton-Grier, A. E., Murphy, P., & Bamford, H. (2014). Out of sight but not out of mind: harmful effects of derelict traps in selected US coastal waters. *Marine pollution bulletin*, *86*(1), 19-28.

77 Richardson, K., et al. (2016). "Marine pollution originating from purse seine and longline fishing vessel operations in the Western and Central Pacific Ocean, 2003–2015." Ambio: 1-11.

78 Exclusive Economic Zone (EEZ), a concept adopted at the Third United Nations Conference on the Law of the Sea (1982), whereby a coastal State assumes jurisdiction over the exploration and exploitation of marine resources in its adjacent section of the continental shelf, taken to be a band extending 200 miles from the shore. From: OECD glossary of statistical terms, https://stats.oecd.org/glossary/detail.asp?ID=884

Marine plastics litter as a vehicle for alien invasive species

Alien invasive species (AIS) can have especially dramatic effects on island ecosystems and thus their economies, as identified by, for example, the Convention on Biological Diversity[79] and the Secretariat of the Pacific Regional Environment Programme (SPREP).[80] Because plastic litter can be carried over long distances, it can serve as a vehicle for introducing marine AIS to islands. A review of the composition of organisms found on marine litter showed that the number of species on litter items was higher in tropical waters than in temperate and polar waters[81], including species drifting beyond their natural distribution limits. Most Regional Action Plans against AIS focus on terrestrial species, but there is mounting evidence to suggest that this might also be an important issue for marine species. The primary strategy against AIS (as identified by SPREP and others) is the prevention of AIS reaching a country, and in this case this would mean preventing litter from spreading between regions.

MICROPLASTICS

The ecological impact of microscopic particles can differ considerably from that of macroplastics due to their much smaller size. Microplastics have been found in both surface and deep waters, in sediment, and in a wide range of organisms ranging from microscopic zooplankton to top predators. They can be taken up by marine organisms via dietary exposure, and they enter into the food chain on many different levels[82]. Organisms in which microplastics have been identified include a range of species with different niches and behaviours, indicating that many different life strategies will include a risk of exposure to microplastic particles. This includes, for example, filter feeders such as mussels and corals that extract particles from the water column, and lugworms, which are bottom-living sediment feeders. Zooplankton, which represent an important lower level in marine food webs, have been found to contain microplastics in their gut, including microplastic fibres from textiles[82]. Fish species in different regions of the ocean have been found to have ingested microplastic particles[83]. Species of marine birds are also known to ingest microplastics, and seabirds have been indicated as an important sentinel species for monitoring the levels of plastics in marine environments[82]. Microplastic particles have also been identified in the stomach contents whales and deep-sea organisms[82].

While the effects and consequences of macroplastic litter in the environment can be easily identified and evidence of microplastic ingestion can be documented in the field, the effects of exposure to microplastics can in large part only be identified via laboratory exposure studies using specific organisms. These effects can result from both the physical damage caused by the material and the chemical toxicity associated with the material[82]. Such laboratory studies have confirmed that microplastics can be accumulated via the food web leading to starvation and

79 https://www.cbd.int/island/invasive.shtml

80 http://www.sprep.org/Invasive-Species/bem-invasive-species, "Guidelines for invasive species management in the Pacific : a Pacific strategy for managing pests, weeds and other invasive species". SPREP, 2009

81 Kiessling, K., L. Gutow and M. Thiel (2015). Marine Litter as Habitat and Dispersal Vector. In M. Bergmann et al., (eds.), Marine Anthropogenic Litter, Chapter 6, 141-181. Doi 10.1007/978-3-319-16510-3

82 Auta HS, Emenike CU, Fauziah SH (2017): Distribution and importance of microplastics in the marine environment: A review of the sources, fate, effects, and potential solutions. Environment International 102, 165-176.

83 Lusher AL, McHugh M, Thompson RC (2013): Occurrence of microplastics in the gastrointestinal tract of pelagic and demersal fish from the English Channel. Marine Pollution Bulletin 67, 94-99.

disrupted metabolism of energy reserves. These studies also showed altered swimming behaviour and lower performance in prey capture in several fish species, which could affect survival in the long term. Oysters fed with microplastics displayed impaired reproductive output and larval growth[84]. Other observations indicate that microplastic exposure can also result in inflammation and damage to gut tissue[85].

Microplastics are thought to pose an additional threat in the environment due to their capacity to transport chemicals from the surrounding water or sediment into animals, much like a Trojan horse. Plastics in the oceans and on beaches have been shown to contain high levels of chemicals adsorbed from the environment.[86] This transport of chemicals from the water via microplastics into fish has been shown in laboratory exposure experiments where contaminated plastics were fed to fish. The chemicals in turn can have toxic effects in animals, including developmental effects, tissue damage, hormone disruption, and immunotoxic effects.[85]

As mentioned above, marine litter can act as a vehicle for AIS, and the same holds true for microplastics. Several species of bacteria have been identified on the surfaces of microplastics, and there is some concern that harmful pathogens might spread through the environment via these particles[87]. This is of course an important aspect to consider with regards to both marine ecosystems and human health. While there is currently no direct evidence demonstrating human health effects resulting from exposure to microplastics, these particles, usually in the form of fibres, have been found in our food, i.e. commercially important marine species. This includes squat lobsters,[88] Norwegian lobsters,[89] blue mussels,[90] and fish species such as mackerel, scad, and herring among others.[91] Microplastics are also found in sea salt. Chemicals in the environment also pose threats to human health (which is beyond the scope of the current report), and there is a concern that microplastics might be facilitating the uptake of chemicals into the food chain and ultimately reaching human consumers.

2.2 ECONOMIC IMPACT

A global assessment of the natural capital cost of plastic, defined as the “financial cost to companies were they to internalise impacts associated with their current practices”, estimates that

84 Sussarellu et al. (2016): Oyster reproduction is affected by exposure to polystyrene microplastics. Proceedings of the National Academy of Sciences 113, 2430-2435.

85 Auta HS, Emenike CU, Fauziah SH (2017): Distribution and importance of microplastics in the marine environment: A review of the sources, fate, effects, and potential solutions. Environment International 102, 165-176.

86 see International Pellet Watch http://www.pelletwatch.org/

87 Vethaak AD, Leslie HA (2016): Plastic Debris Is a Human Health Issue. Environmental Science & Technology 50, 6825-6826.

88 Taylor, M. L., Gwinnett, C., Robinson, L. F., & Woodall, L. C. (2016). Plastic microfibre ingestion by deep-sea organisms. *Scientific Reports*, *6*.

89 Murray, F., & Cowie, P. R. (2011). Plastic contamination in the decapod crustacean Nephrops norvegicus (Linnaeus, 1758). *Marine Pollution Bulletin*, *62*(6), 1207-1217.

90 Mathalon, A., & Hill, P. (2014). Microplastic fibers in the intertidal ecosystem surrounding Halifax Harbor, Nova Scotia. *Marine pollution bulletin*, *81*(1), 69-79.

91 Rochman, C. M., Tahir, A., Williams, S. L., Baxa, D. V., Lam, R., Miller, J. T., ... & Teh, S. J. (2015). Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumption. *Scientific reports*, *5*.

the total annual cost of plastics in marine ecosystems is US$ 13 billion.[92] Moreover, for the marine industry in the Asia-Pacific region alone, marine litter has been estimated to cost more than US$ 1 billion annually.[93] The extent of the economic impact that plastic litter might have on SIDS is not currently known, but their dependence on natural resources through tourism and fisheries, in combination with their exposed coastlines, make them economically vulnerable to plastic litter.

TOURISM

Tourism is an important means of economic development on SIDS. And although tourism does provide economic benefit, the extent of such benefit is not always obvious because only a portion of the revenues generated remains in the tourist destinations[94], and it has been argued that general governmental support of tourism is not enough and that stronger regulatory management is needed to enable sustainable tourism that also promotes equity.[95] Tourism might also be a contributing factor to marine litter, as a study on a remote Seychelles island found bottles that only could have come from cruise ships[96].

Most of the tourist activities on SIDS consist of diving, sport fishing, and whale and turtle-watching tours, and the economic benefit that SIDS receive from such tourism might be negatively affected by marine litter. For instance, beaches on Geoje Island in South Korea were covered in large amounts of marine litter due to heavy rainfalls in 2011. This was followed by a marked decrease in tourism in the region leading to estimated economic losses of US$ 29–37 million.[97] Furthermore, a study performed in California (U.S.) showed that a potential reduction of marine litter on local beaches by 75% during a period of three months would likely generate more than US$ 40 million in benefits from tourism.[98] Although the effect that marine litter might have on revenues from tourism is likely to be region dependent, these studies show that it always has at least some degree of negative effect anywhere that such litter is found.

FISHERIES AND SHIPPING

A survey of Scottish fishing vessels revealed that 86% had experienced a decrease in catch due to marine litter along with increased costs for cleaning their fishing gear. Based on the reported impacts, the estimated cost to the Scottish fishing fleet was about US$ 16 million.[99] Moreover

92 UNEP (2014). Valuing plastics: The Business Case for Measuring, Managing and Disclosing Plastic Use in the Consumer Goods Industry.

93 McIlgorm, A., et al. (2011). "The economic cost and control of marine debris damage in the Asia-Pacific region." Ocean & Coastal Management 54(9): 643-651.

94 Pratt, S. (2015). "The economic impact of tourism in SIDS." Annals of Tourism Research 52: 148-160.

95 Scheyvens, R. and J. H. Momsen (2008). "Tourism and poverty reduction: issues for small island states." Tourism Geographies 10(1): 22-41.

96 Duhec, A. V., Jeanne, R. F., Maximenko, N., & Hafner, J. (2015). Composition and potential origin of marine debris stranded in the Western Indian Ocean on remote Alphonse Island, Seychelles. *Marine pollution bulletin*, *96*(1), 76-86.

97 Jang, Y. C., et al. (2014). "Estimation of lost tourism revenue in Geoje Island from the 2011 marine debris pollution event in South Korea." Marine pollution bulletin 81(1): 49-54.

98 Leggett, C., Scherer, N., Curry, M., Bailey, R., & Haab, T. (2014). Assessing the economic benefits of reductions in marine debris: a pilot study of beach recreation in Orange County, California. *NOAA Mar Debris Progr Ind Econ Inc*, *45*.

99 Mouat, J., Lopez Lozano, R. & Bateson, H (2010). Economic Impacts of Marine Litter. KIMO.

approximately one annual incident per vessel was reported of blocked intake pipes or litter stuck in the vessel's propellers. The estimated costs for lost time at sea and for repairs correspond to about 5% of their total revenues.[99] Another impact from marine litter on fishing comes from their very own industry when nets, ropes, etc., are not disposed of properly but are left in the ocean. These nets, of course, still fulfil their purpose to catch fish. No one harvests the fish caught by discarded nets, and these are appropriately termed "ghost nets". The more scientific term for this in the literature is abandoned, lost, or otherwise discarded fishing gear (ALDFG). A study on ghost fishing in a sound in the USA found that the lost revenues for fisheries from a single ghost net can be up to US$ 20,000, whereas removing the net would cost only about US$ 1,400.[100]

2.3 THE VULNERABILITY OF SIDS TO PLASTIC LITTER

From the general impact of marine litter described above, the question arises of how this environmental pollutant specifically affects SIDS. As mentioned previously, SIDS are often confronted by similar constraints in their development, such as a narrow resource base, small domestic markets, a heavy dependence on fossil fuels, and high costs for transportation and communication. These and further special vulnerabilities are listed in Table 2.

100 Gilardi, K. V., Carlson-Bremer, D., June, J. A., Antonelis, K., Broadhurst, G., & Cowan, T. (2010). Marine species mortality in derelict fishing nets in Puget Sound, WA and the cost/benefits of derelict net removal. *Marine pollution bulletin*, *60*(3), 376-382.

Table 2: Illustrative factors contributing to vulnerabilities faced by SIDS. Original source: Compiled by DESA, based on MSI and SAMOA Pathway. Table adapted from UN, 2015.[101]

Economic	Social	Environmental
High poverty & unemployment	Weak institutional structures, low human resources	Climate change: Sea level rise, ocean acidification & coral bleaching, coastal erosion
High transportation costs, remoteness from global markets, lack of diversity in exports	High population densities and migration rates	Increased natural disasters & inadequate early warning systems
Large financial debts	Limited access to health care	Overexploitation of marine resources & ocean pollution
Overdependence on the tourism sector	Lack of access to quality education	Biodiversity issues: Invasive alien species, deforestation & desertification
Dependence on imported fossil fuels	Loss of traditional knowledge and cultural practices	Overexploitation of water resources, saline intrusion
Reliance on food imports, limited access to nutritious food		Insufficient waste treatment facilities

To sum up, SIDS are especially vulnerable to the impacts of marine plastic litter because such litter leads to reduced revenues from the tourism and fishing industries that their economies depend on. Due to the combination of being located near the so-called ocean gyres, which are known to accumulate marine litter[102], of focusing on a waste-intensive tourism industry, and of possessing sub-optimal waste collection and treatment systems, SIDS are exposed to concentrations of plastic litter that are disproportionate to their own consumption and populations. Their remote positions lead to additional challenges for organising inter-island logistics, and their limited resources lead to greater challenges regarding the management of plastic litter compared to their mainland counterparts.

101 UN (2015). Vulnerability-Resilience Country Profile (VRCP). Retrieved 2017-03-01, from https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=1982&menu=35

102 Kaiser, J. (2010). The dirt on ocean garbage patches. ***Science*** Vol. 328, Issue 5985, page 1506.

Box 8: Local opinions from SIDS

Maldives: "Marine debris, plastics and micro-plastics, are a global problem. The effects of plastic pollution in our oceans present an existential threat to SIDS since it has a direct bearing on our economies, marine biodiversity, food security and human health." [103]

St. Lucia: "Things that would normally end in the landfill – plastic, stainless, aluminium, cardboard, a lot of other items – we recycle it. We send the material all over the world, for example, to China, the United States, India. The more material we can divert from the landfill, the better it would be because there is not enough land to just dump things on it. […] As long as the government encourages recycling on the island, that work can be achieved.[104]

In the next section, different strategies for the mitigation of this pressing problem are discussed.

103 Statement by the Republic of Maldives on behalf of the Alliance of Small Island States at the United Nations Open-Ended Informal Consultative Process on Oceans and Law of the Sea on "Marine Debris, Plastics and Micro-Plastics" 13 June 2016. http://aosis.org/wp-content/uploads/2016/06/2016.06.13-AOSIS-Statement-ICP.pdf

104 Island solutions: Recycling sweeps into Saint Lucia. Video from UN Environment, published on Youtube Aug 20, 2014 https://www.youtube.com/watch?list=PLZ4sOGXTWw8Ev5ZhRUMTkM8uAtk9LQIYz&v=yeq-HNFHw-k

3 PART 3: TOWARD MITIGATION MEASURES

Since the early reports of marine plastic litter in the 1970s, general awareness about the problem has grown. Marine plastic pollution has now come to the forefront as a global pollution problem that requires widespread action and collaboration across national boundaries.[105] Beaches riddled with plastic litter might be unsightly. But even more important is the harmful effect of plastic litter on marine life, its ability to transport AIS and harmful chemicals, and the damage it causes to fisheries and the tourism industry. While a number of measures have been introduced, the scope of the problem has hardly diminished. It has become clear that it is necessary to tackle marine plastic litter at its many sources and to deal with it where it washes up.

The accumulation of plastics on SIDS is certainly not a sustainable solution. A way forward builds on legal frameworks, collaborative efforts, and action networks that aim to create a mass balance of plastic flows. To achieve this mass balance, the large volumes of plastic that reach SIDS through goods and as marine plastic litter need ways to leave, for instance, through recycling. Another approach could build on a reduction of single-use plastics and an increase of re-use, as well as the reduction of imports in general through substitution with local materials.[106,107] In the following section, international legal conventions that address the use of the ocean and issues of marine pollution are presented, and measures from Regional Action Plans as well as private sector initiatives and other projects that aim at the reduction of marine litter are described and examined. For the analysis, principles derived from the sustainability analysis of flow systems are employed in order to identify possible measures and missing links in the material flow systems.

3.1 INSTITUTIONAL FRAMEWORK

The legal framework for preventing and managing marine litter is found on multiple layers of governance, from international to national and local rules, and within many areas of law (biodiversity, shipping, production waste, storm water, etc.) and with different types of legal effects. Relevant multilateral agreements place general obligations on the parties that have ratified or accessed these agreements. The three most relevant multilateral agreements are 1) The United Nations Convention on the Law of the Sea (UNCLOS), which was adopted in 1982 and came into force in 1994 and has 167 state parties;[108] 2) The International Convention for the Prevention of Pollution from Ships (MARPOL), which was adopted in 1973 and amended in 1978 and has been ratified by 153 states;[109] and 3) The London Convention, or "Convention

105 Vince, J., & Hardesty, B. D. (2016). Plastic pollution challenges in marine and coastal environments: from local to global governance. *Restoration Ecology*.

106 Eckelman, M., W. Ashton, Y. Arakaki, K. Hanaki, L-C. Malone Lee, S. Nagashima (2014). Island Waste Management and Industrial Ecology. Journal of Industrial Ecology 18(2): 306–317.

107 Russell, S. and J. Allwood (2008). Environmental evaluation of localising production as a strategy for sustainable development: a case study of two consumer goods in Jamaica." Journal of Cleaner Production 16: 1327-1338.

108 IMO (2017a) *The United Nations Convention on the Law of the Sea*. Retrieved 2017-03-16, from http://www.imo.org/en/OurWork/Legal/Pages/UnitedNationsConventionOnTheLawOfTheSea.aspx

109 IMO (2017b) *The International Convention for the Prevention of Pollution from Ships*. Retrieved 2017-03-16, from http://www.imo.org/en/KnowledgeCentre/ReferencesAndArchives/IMO_Conferences_and_Meetings/MARPOL/Pages/default.aspx

on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972", which was adopted in 1975 and has been ratified by 87 states.[110] Many of the Regional Seas agreements (see the section Regional action plans below) have also included instruments addressing marine litter.

UNCLOS sets up a legal regime for all aspects of marine resources and uses of the oceans.[108] It establishes jurisdictional limits on the ocean area that countries may claim, and it requires parties to adopt regulations and laws to control pollution of the marine environment from land-based sources of pollution as well as pollution from ships. It calls on states to cooperate with other states on marine issues, including in areas beyond national jurisdiction. MARPOL includes regulations aimed at preventing and minimising pollution from ships, including both accidental losses and during normal operations.[109] Annex V of MARPOL, which came into force in 2013, addresses ocean-based litter pollution and prohibits the discharge of all plastics from ships. The London Convention promotes the control of marine pollution from human activities and aims at preventing pollution of the ocean from the dumping of wastes and other matter.[110]

Global agreements aiming at the protection of ecosystems and marine species or marine biodiversity in general are highly relevant to the issue of marine litter. Examples of such agreements are the Convention on Biological Diversity and the Convention on Migratory Species. Trade agreements like the General Agreement on Tariffs and Trade (GATT) and the 1995 Marrakech Agreement are also important to consider because they might inhibit states from adopting national legislation aiming at minimizing marine litter if such legislation were to also affect international trade.

Apart from binding agreements, there are a number of declarations and recommendations relevant to marine litter on SIDS.[111] One of them is the SAMOA Pathway, a declaration made at the third International Conference on Small Island Developing States in 2014, which calls for measures to manage waste, including marine plastic litter. Multilateral agreements require party states to take actions, but because these requirements are often generally formulated, the states can often choose what measures they wish to implement or not. Non-binding declarations, like the SAMOA Pathway, might guide states in more detail in how to proceed. Furthermore, they only possess a moral impetus to actually take action, and there are no legal compliance mechanisms linked to these declarations.

In most countries, the provisions related to marine litter are included in a number of more general legislations. Examples are legislation on the use of land-based materials or legislation

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110 IMO (2017c) *The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.* Retrieved 2017-03-16, from http://www.imo.org/en/KnowledgeCentre/ReferencesAndArchives/IMO_Conferences_and_Meetings/London_Convention/Pages/default.aspx

111 UNEP (2016). Marine Litter Legislation: A Toolkit for Policymakers. United Nations Environment Programme. http://wedocs.unep.org/bitstream/handle/20.500.11822/8630/-Marine_litter_legislation_A_policy_toolkit_for_policymakers-2016marine_litter_legislation.pdf.pdf?sequence=2&isAllowed=y

on waste management that often complemented marine litter polices or strategies.[112] There are particular bans in some countries on the import and manufacture of certain plastic products (like plastic bags, products of polystyrene foam, and microbeads), as well as requirements on the sales and use of such products.[113] There are also examples of countries using taxes and other levies to reduce marine plastic litter. The effectiveness of such alternatives for reducing marine litter depends on many different factors—enforcement capability being one of the most important.

National waste-management legislations address the following four categories of disposal: (1) land-based disposal; (2) clean-up of land-based waste; (3) ALDFG; and (4) litter from ships. Instruments to address these categories are, for example, prohibitions on dumping, legally required port reception facilities, designation of marine protected areas, and legislation specifically addressing waste from cruise ships. Legislation of land-based waste includes landfill siting and management, recycling programmes, incineration programmes, and disaster response. In addition, environmental impact assessments for the siting of landfills and for proper planning and recycling in disaster-prone areas are also important tools for reducing marine litter.[114]

3.2 COLLABORATIVE EFFORTS

REGIONAL ACTION PLANS

There are 18 Regional Seas programmes in the regions listed below (Box 9). The aim of this United Nations Environmental Program (UNEP) initiative is to protect the marine environment through a shared approach across national borders where neighbouring countries work together for the protection of the oceans and seas. Some of the Regional Seas programmes have written strategies to guide actions and efforts against marine litter. Supported by UNEP, the member governments of the respective region have agreed on political agendas for the management of marine litter, and these are outlined in their particular RAP.[115]

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112 UNEP (2016). Marine Litter Legislation: A Toolkit for Policymakers. United Nations Environment Programme. http://wedocs.unep.org/bitstream/handle/20.500.11822/8630/-Marine_litter_legislation_A_policy_toolkit_for_policymakers-2016marine_litter_legislation.pdf.pdf?sequence=2&isAllowed=y

113 See, e.g., the Haiti Polystyrene Ban: adopted 2013, available at: http://www.ipsnews.net/2013/08/despite-two-bans-styrofoam-trash-still-plagues-haiti/, and the prohibition on import of polystyrene foam and plastic packaging in the Vanuatu Ozone Protection Act 2010, http://www.ecolex.org/ecolex/ledge/view/RecordDetails;DIDPFDSIjsessionid=B4F37C03B789B0223982DC5F222121AB?id=LEX-FAOC110179&index=documents.

114 UNEP (2016). Marine Litter Legislation: A Toolkit for Policymakers. United Nations Environment Programme. http://wedocs.unep.org/bitstream/handle/20.500.11822/8630/-Marine_litter_legislation_A_policy_toolkit_for_policymakers-2016marine_litter_legislation.pdf.pdf?sequence=2&isAllowed=y

115 http://web.unep.org/regionalseas/who-we-are/regional-seas-action-plans

Box 9: UNEP Regional Seas Programmes for the protection of the marine and coastal environment, some of which have RAPs on Marine Litter (marked in bold).

Antarctic (CCAMLR, Commission for the Conservation of Antarctic Marine Living Resources)

Arctic (PAME, Protection of the Arctic Marine Environment)

Baltic (HELCOM, Helsinki Commission)

Black Sea (Commission on the Protection of the Black Sea against Pollution)

Caspian (Tehran Convention)

Eastern Africa (Nairobi Convention)

East Asian Seas (COBSEA, Coordinating Body on the Seas of East Asia)

Mediterranean (The Barcelona Convention; Mediterranean Action Plan)

North-East Atlantic (OSPAR, Oslo and Paris Commission)

North-East Pacific (Antigua Convention; not yet in force)

Northwest Pacific (NOWPAP, Northwest Pacific Action Plan)

Pacific (SPREP, Secretariat of the Pacific Regional Env. Prog.; CLEANER PACIFIC 2025)

Red Sea and Gulf of Aden (PERSGA, Programme for the Environment)

ROPME Sea Area (Persian Gulf and Gulf of Oman)

South Asian Seas [below India] (SASP, South Asian Seas Programme)

South-East Pacific [west of South America] (CPPS, Permanent Commission of South Pacific)

Western Africa (Abidjan Convention)

Wider Caribbean (CEP, Caribbean Environment Programme; RAPMaLi)

The measures proposed in some of the RAPs on marine litter are summarised in Table 3 and grouped—after a suggestion in the UNEP report *Marine plastic debris and microplastics*—into legislation, best practise, best techniques, education/awareness, and voluntary agreements.

Table 3: Measures for the mitigation of marine plastic pollution as suggested by different RAPs.

Measures from the HELCOM, OSPAR, Mediterranean, and Caribbean RAPs
Legislation
Better defined legislation for marine litter (regional, national & global level)
Identify the key lead, define clear roles and responsibilities
Ensure representation of all stakeholders
Close existing illegal dump sites and improve legal but risky sites
Specialised marine waste management for heavy weather events and natural disasters
Specialised marine litter management for public events
Standardised methods for data collection and reporting
Inclusion of marine litter issues into environmental certification (ISO)
National control programmes and “litter patrols” for compliance
Incentives for good behaviour and disincentives (fines) for littering
Extended producer responsibility and "gear marking for ownership" for fishing
Plastic bags: deposit fees, taxes, or bans to reduce their use
Bottles: deposit refund system, solutions between states for ships
BEP best practise
Best practice for disposal of old boats, ALDFG
Best practice for zero pellet loss, marine transport
Best practice for beach cleaning, tourism
Best practice for ship waste management
BAT techniques & technologies
Integrated solid waste management infrastructures, recycling, and composting
Adequate urban sewage plants and waste-water management to prevent run-off
Improve port reception facilities for ship-generated waste with no special fee system
Education / awareness
Community-based public education campaigns for litter prevention
Integrate marine litter into formal education curricula
Regional database for marine litter information
Voluntary agreements
Sustainable packaging: explore industry design improvements
“Fishing for Litter” to collect litter caught during normal fishing
Phase out microplastics in personal care products and cosmetics
Ban synthetic dolly ropes - use biodegradable alternatives
National clean-up actions and participation in international coastal clean-up (ICC) campaigns
Adopt-a-Beach or similar to enhance public participation

Some of the suggested measures tackle the problem rather far downstream of the production chain, that is, to clean up leakages where they appear, such as beach clean-up actions. However, there are also measures that address the problem further upstream, for example, improved waste management strategies or the ban of certain products that are prone to leak into the environment. In addition, education measures or the re-design for sustainable products from scratch are designed to prevent leakages from occurring in the first place. These different approaches are complementary to each other because it is necessary to stop leakages at the source and to remove the material that has already entered the marine environment. Table 4 show the geographic locations where the respective measures approach the problem, which actors are involved in carrying out the measures, and what types of waste governance the measures address. The column labelled "Flow part" addresses whether the measures try to reduce the impact upstream at the source or if they remove plastics downstream in the system when they already are in the marine environment. Additionally, there exists a so-called waste hierarchy commonly referred to in waste management, which sorts the treatment of waste into the following five categories (from worst to best): landfill, energy recovery, recycling, reuse, and prevention. For the measures suggested in the RAPs, the corresponding step in the waste hierarchy is given. For example, the measure "close illegal dump sites" is at the location of dumping sites, is carried out by the national governments, addresses the problem of marine litter downstream, is a regulatory measure of governance, and is in the waste hierarchy category of landfilling (Table 4**Fel! Det går inrte att hitta någon referenskälla.**).

Table 4: Proposed measures and their approaches. Gov = government.

Measures from the RAPs	Geographic location	Actors	Flow part	Waste governance	Waste hierarchy step
Legislation					
Better defined legislation for marine litter (regional, national and global)		National gov on SIDS	All	Regulations	
Identify the key lead, clear roles and responsibilities		National and local gov	All	Organising collection / treatment	All
Ensure representation of all stakeholders		National and local gov, industry, NGOs	All	Organising collection / treatment	All
Close existing illegal dump sites and improve legal but risky sites	Dumping sites	National gov on SIDS	Downstream	Regulations/Organising treatment	Landfill
Specialised marine waste management for heavy weather events and natural disasters	Coastal areas, near rivers	Waste management of national gov	Downstream Recovery	Organising collection / treatment	All
Specialised marine litter management for public events	Parks, city centres, beaches	Waste management of local communities	Downstream	Organising collection / treatment	All
Standardised methods for data collection and reporting	Shorelines and open ocean	Contextual		Information	
Inclusion of marine litter issues into environmental certification (ISO)	Shorelines and open ocean	Gov, standardisation bodies		Information	
National control programmes and “litter patrols” for compliance	Cities, parks, beaches, roadsides	National gov, local municipalities	Downstream	Regulations/Organising collection	All
Incentives for good behaviour and disincentives (fines) for littering	Cities, parks, beaches, roadsides	National gov, local municipalities	Downstream	Regulations/Organising collection	All
Extended producer responsibility and "gear marking for ownership" for fishing	Production sites, coastal waters	Gov, commercial fish licencing	Unclear	Regulations/Organising collection	All
Plastic bags: deposit fees, taxes, or bans to reduce their use	Stores	National gov	All	Regulations/Organising collection	Recycling, Reuse, Prevention
Bottles: deposit refund system, solutions between states for ships	Stores	Gov, industry / producers	All	Organising collection / treatment	Reuse, Recycling
BEP best practice					
Best practice for disposal of old boats, ALDFG		Users, Recyclers	All	Organising collection / treatment	Recycling, Landfill
Best practice for zero pellet loss, marine transport	Industrial areas, docks	Producers, national gov (inspectors)	Upstream	Organising collection / treatment	Prevention

Best practice for beach cleaning, tourism	Beaches, shorelines, parks	Waste management, local NGOs	Downstream	Organising collection	Recycling, Landfill
Best practice for ship waste management	At sea, in harbours	Producers, int. maritime gov	Downstream	Organising collection	Recycling, Landfill
BAT techniques & technologies					
Integrated solid waste management infrastructures, recycling, and composting	Cities	Recyclers, local municipalities	Downstream Recirculation	Organising collection / treatment	Recycling
Adequate urban sewage plants and waste water management to prevent run-off	Cities mostly	Waste management, local authorities	Downstream	Organising collection	(Waste water, not solid)
Improve port reception facilities for ship-generated waste with no special fee system	Harbours	Gov, local harbour authorities	Downstream Recirculation	Organising collection	Recycling, Landfill
Education / awareness					
Community-based public education campaigns for litter prevention	Schools, public events	NGOs, local groups		Information	
Integrate marine litter into formal education curricula		Schools, school authorities		Information	
Regional database for marine litter information	Shorelines and open ocean	NGOs, environmental agencies, researchers		Information	
Voluntary agreements					
Sustainable packaging: explore industrial design improvements		Producers	Upstream, Recirculation	Organising treatment	Prevention Recycling
“Fishing for Litter” to collect litter caught during normal fishing		Producers	Recovery, Downstream Recirculation	Organizing collection	Recycling, Landfill
Phase out microplastics in personal care products and cosmetics		Producers	Upstream	Organising treatment	Prevention
Ban synthetic dolly ropes - use biodegradable alternatives		Producers	Upstream	Organising treatment	Prevention
National clean-up actions and participation in ICC campaigns		Contextual, Outside actors	Recovery, Downstream Recirculation	Organising treatment	Recycling, Landfill
Adopt-a-Beach or similar to enhance public participation		Contextual, Outside actors	Recovery, Downstream Recirculation	Information	

MEASURES AGAINST MICROPLASTICS

Most of the measures listed above address macrolitter rather than microlitter, but to reduce the amount of macroplastics in the environment, microplastics also need to be reduced because then less material would be available for fragmenting into small particles. The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) organised by several UN institutions conducted a global assessment of microplastics in the marine environment.[33] Their key recommendations for the management of microplastics are listed below (Table 5). When comparing the measures against microplastics with the measures put forward in the RAPs, significant similarities can be seen. Both propose, for instance, extended producer responsibility and the improvement of port-reception facilities.

Table 5: Measures suggested in the GESAMP report "Sources, fate and effects of microplastics in the marine environment: part two of a global assessment".

Sources	Target mitigation in local waste streams. Phase out plastics that are prone to become marine litter (e.g. microbeads). Create incentives for recycling. Reduction of single-use items.
Distribution, "hot-spots"	Focus source reduction and clean-up efforts on heavier sources. Target hot-spots in Marine Protected Areas for mitigation. Raise awareness about the issue in hot-spot regions. Use government intervention to fund clean-up in areas of high concentrations of litter.
Ecological impacts	Develop and use educational and awareness programmes for the public and for all actors involved.
Fishing	Put identification markers on fishing nets to keep track of lost gear. Redesign fishing and aquaculture equipment to be more sustainable. Integrate microplastic into seafood guidelines for sustainability. Fishery gear recapture schemes that provide incentives for recovery. Increase port facility infrastructure for waste removal and recovery.
Socio-economic aspects	Create a cost for plastic polluters, e.g. extended producer responsibility. Increase the cost of plastic to make it more valuable (internalise all costs). Encourage separate waste collection by households. Put taxes/deposit-refund fees on (plastic) bottles and bags. Pay fishermen to collect litter. Invest in improved waste management and port and beach infrastructures. Increase awareness campaigns and engage more stakeholders.
Methods	Record litter removed from beaches using globally standardised units. Create a global standardised technology for monitoring. Harmonize sampling and quantification methodologies.

A WASTE AND POLLUTION STRATEGY FOR THE PACIFIC REGION

There also exist some marine pollution plans specifically for SIDS regions. *The Cleaner Pacific 2025: Pacific Regional Waste and Pollution Management Strategy 2016* is an example of a comprehensive long-term strategy for integrated waste management and pollution prevention and control aimed at being adapted to the needs and means of SIDS. [116]

Box 10: Locally adapted waste management

> A key condition for the development of sustainable waste management systems is that "waste collection and disposal technologies need to be both appropriate and financially sustainable under local conditions".[117]

Cleaner Pacific 2025 rests on 14 principles. Some of these principles are conventional waste management principles such as *reduce, reuse, recycle and return*; *product stewardship*; *the polluter pays principle*; and *the proximity principle*.[118] Product stewardship "is the act of minimizing the health, safety, environmental, and social impacts of a product and its packaging throughout all lifecycle stages"[119], and the proximity principle says that "waste should be disposed of as closely as possible to where it is produced"[120]. Others are procedural principles such as *transparency*, *public consultation and participation*, and *involvement of multiple sectors*. Yet others are organisational principles such as *public-private partnerships*, which might run against the transparency ambition mentioned above, and *selection of appropriate and affordable technology*, which again expresses the global embedment of local solutions.

Four strategic goals are derived from these principles: to prevent and minimize the generation of wastes and pollution and their associated impacts; to recover resources from wastes and pollution; to improve life-cycle management of residuals; and to improve monitoring of the receiving environment. Significantly, *Cleaner Pacific 2025* breaks with the long tradition of privileging end-of-pipe solutions such as landfills, although rehabilitation of the remaining open dumpsites into semi-aerobic landfills remains a priority. Likewise, the strategy considers waste-to-energy being unsuitable for the majority of Pacific SIDS. The goals set by *Cleaner Pacific 2025* are, in turn, translated into strategic actions that aim at strengthening institutional capacity (e.g., through data collection and policy development), promoting public-private partnerships, implementing best practices (e.g., resource recovery, prevention and reduction programmes, and expanded user-pays collection services), developing human capacity, dis-

116 Cleaner Pacific 2025: Pacific Regional Waste and Pollution Manage ment Strategy 2016–2025. – Apia, Samoa: SPREP, 2016.

117 Scheinberg, A., Wilson, D. C., & Rodic, L. (2010). Solid Waste Management in the World's Cities: in UN-Habitat's State of Water and Sanitation in the World's Cities Series. Published by Earthscan for UN-Habitat. Page 24

118 Zapata, M. J., & Hall, M. (2013). Organising waste in the city. Policy Press.

119 https://productstewardship.site-ym.com/?page=Definitions

120 European Commission (1999). EU focus on waste management. Page 10

seminating knowledge, and promoting regional and national cooperation. Performance indicators are attached to these goals and actions for monitoring purposes (e.g., recycling rates and waste collection coverage as a percentage of the population) (see Table 6).

Cleaner Pacific 2025 insists on being evidence-based and stresses that "Pacific experience shows that the most successful examples of sustainable waste management programmes are supported by sustainable financing mechanisms[121] and mechanisms that create a value chain for waste[122]". The economic sustainability of the waste system is a pre-condition to its ecological sustainability. In promoting a "Reduction, Reuse, Recycling and Return (3R+ Return)" approach, *Cleaner Pacific 2025* states:

> "The vast majority of recycling activities in Pacific island countries and territories are led by the private sector and are driven by prices in the international recycling commodity markets. While recycling plants exist in Fiji for paper and lead acid batteries, and in Palau for converting plastics to oil, the vast majority of recycling activities are limited to the consolidation and export (typically to East Asia, Southeast Asia, Australia and New Zealand) of valuable commodities such as aluminium beverage cans, ferrous and non-ferrous scrap metal, and used lead acid batteries. In Pacific island countries and territories with successful recycling programmes (including Kiribati, Federated States of Micronesia [Yap and Kosrae States], New Caledonia and Palau), recycling activities are incentivised by container deposit laws and extended producer responsibility laws which help to sustain the recycling programme in the face of fluctuating commodity prices".

Effective waste policy intertwines market-based activities with administrative steering instruments.

121 For example, waste collection and tipping fees in Fiji and a prepaid bag system in Kiribati

122 For example, container deposit programmes in Kiribati, the Federated States of Micronesia, and Palau

Table 6: Overview of Cleaner Pacific 2025. Source: Secretariat of the Pacific Regional Environment Programme (SPREP) (2016) Cleaner Pacific 2025: Pacific Regional Waste and Pollution Management Strategy 2016–2025. Apia, Samoa: SPREP

<table>
<tr><td>Vision</td><td colspan="6">A cleaner Pacific environment</td></tr>
<tr><td>Mission</td><td colspan="6">To implement practical and sustainable solutions for the prevention and management of waste and pollution in the Pacific</td></tr>
<tr><th rowspan="2">Guiding Principles</th><th rowspan="2">Strategic Goals</th><th rowspan="2">Performance Indicators</th><th rowspan="2">2014 Baseline</th><th colspan="2">Targets</th><th rowspan="2">Strategic Actions</th></tr>
<tr><th>By 2020</th><th>By 2025</th></tr>
<tr><td rowspan="20">1. Reduce, Reuse, Recycle, Return (3Rs +Return)
2. Product stewardship
3. Polluter pays principle
4. Proximity principle
5. Transparency
6. Public consultation and participation
7. Multisectoral approach
8. Regionalism
9. Sound decision-making
10. Precautionary approach
11. Proactive approach
12. Adherence to regional and international conventions
13. Public-private partnership
14. Selection of appropriate and affordable technology</td><td rowspan="3">Prevent and minimise generation of wastes and pollution and their associated impacts</td><td>Per capita generation of municipal solid waste (kg/person/day)</td><td>1.3</td><td>1.3</td><td>1.3</td><td rowspan="20">Strengthen institutional capacity
1. Undertake regular WCP data collection and management (including storage, interpretation, dissemination and sharing)
2. Develop and enforce national policies, strategies, plans and legislation, and strengthen institutional arrangements
Promote public-private partnerships
3. Develop new public private partnerships including through strengthened public-private partnership frameworks
Implement sustainable best practices in WCP management
4. Implement best practice occupational health and safety measures
5. Implement WCP prevention and reduction programmes
6. Implement resource recovery programmes
7. Remediate contaminated sites and WCP stockpiles
8. Expand user-pays WCP collection services
9. Improve WCP management infrastructure and support sustainable operation and maintenance
10. Implement best practice environmental monitoring and reporting
Develop human capacity
11. Implement sustainable human capacity development programmes
Improve dissemination of outcomes and experiences in WCP management
12. Utilise project outcomes to implement regional and national WCP education and behavioural change campaigns
Promote regional and national cooperation
13. Establish a regional Clean Pacific Roundtable
14. Strengthen national and regional cooperation and coordination
15. Cooperate to ensure timely monitoring of Cleaner Pacific 2025</td></tr>
<tr><td>No. of marine pollution incidents</td><td>6 (2 PICTs)</td><td>0</td><td>0</td></tr>
<tr><td>No. of port waste reception facilities</td><td>5</td><td>10</td><td>20</td></tr>
<tr><td rowspan="5">Recover resources from wastes and pollution</td><td>Waste recycling rate (=amount recycled, reused, returned/amount recyclable) (%)</td><td>47%</td><td>60%</td><td>75%</td></tr>
<tr><td>No. of national or municipal composting programmes</td><td>18</td><td>30</td><td>40</td></tr>
<tr><td>No. of national or state container deposit programmes</td><td>4 (KI, PA, Kosrae, Yap)</td><td>7</td><td>10</td></tr>
<tr><td>No. of national EPR programmes for used oil</td><td>2 (NC, FP)</td><td>3</td><td>10</td></tr>
<tr><td>No. of national EPR programmes for e-waste</td><td>1 (NC)</td><td>5</td><td>8</td></tr>
<tr><td rowspan="10">Improve life-cycle management of residuals</td><td>No. of national or state user-pays systems for waste collection</td><td>9</td><td>14</td><td>21</td></tr>
<tr><td>Waste collection coverage (% of population)</td><td>88% (urban) (= 35% nationally)</td><td>100% (urban) (= 40% nationally)</td><td>60% (nationally)</td></tr>
<tr><td>Waste capture rate (= amount collected/amount generated) (%)</td><td>Insufficient data</td><td colspan="2">Establish baseline & targets</td></tr>
<tr><td>No. of temporary, unregulated and open dumps</td><td>Over 250</td><td>237</td><td>225</td></tr>
<tr><td>Quantity of asbestos stockpiles (m³)</td><td>> 187,891 m²</td><td>159,700 m²</td><td>131,500 m²</td></tr>
<tr><td>Quantity of healthcare waste stockpiles (tonnes)</td><td>> 76 tonnes</td><td>< 20 tonnes</td><td>0 tonnes</td></tr>
<tr><td>Quantity of e-waste stockpiles (tonnes)</td><td>Insufficient data</td><td colspan="2">Establish baseline & targets</td></tr>
<tr><td>Quantity of used oil stockpiles (m³)</td><td>2,960 m³</td><td>1,480 m³</td><td>0 m³</td></tr>
<tr><td>Quantity of pharmaceutical and chemical stockpiles (tonnes)</td><td>Insufficient data</td><td colspan="2">Establish baseline & targets</td></tr>
<tr><td>Urban sewage treated to secondary standards (%)</td><td>65%</td><td colspan="2">Establish after regional assessment</td></tr>
<tr><td rowspan="2">Improve monitoring of the receiving environment</td><td>No. of water and environmental quality monitoring programmes</td><td>~ 3 (AS, CI, GU)</td><td>5</td><td>7</td></tr>
<tr><td>No. of national chemicals and pollution inventories</td><td>2 (SA, PA)</td><td>3</td><td>6</td></tr>
</table>

CORPORATE MEASURES FOR THE RECIRCULATION AND REMOVAL OF MATERIALS

In addition to these official strategies and proposals for mitigation measures, there is also a wide range of corporate and public-private initiatives working against marine litter. These often include technical solutions for the recycling of plastic materials that are prone to end up in the ocean, for example, the chemical recycling of nylon that can substitute for virgin raw materials in the production of numerous products (see box below).

Box 11: Example of a technical solution for the recycling of marine litter

The ECONYL® regeneration system can recover nylon from fishing nets and other applications and turn it into ECONYL® nylon yarn. This is done through the de- and re-polymerisation of the polymer, which can then be used just as raw material for the production of swimming and sports apparel, carpet products, etc. [123]

Further, there are some social solutions as well that create incentives for low-income people to collect beach litter or other mismanaged waste in order to bring it back into the controlled material chain (see box below). This promotes the collection of wastes by informal collectors and aims at decreasing the amount that leaks into the oceans.

Box 12: Example of a social solution for the removal of marine litter

A start-up project called The Plastic Bank developed the concept of Social Plastic®. That allows residents of impoverished communities in developing nations to collect plastic that is littering beaches and other waterways and turn it into a form of currency by trading the material with recycling centres for various goods. The plastic gets recycled and is then sold to corporations that use the material for the production of i.a. packaging branded as Social Plastic.[124]

These initiatives contribute to the recirculation of materials in the flow system, which improves resource efficiency through the reduced environmental impact from avoided resource extraction, averted landfilling, and mitigated marine litter impacts. All plastics that come to SIDS as packaging or other products also need to leave the SIDS again. It should be considered here that island populations usually need to import more goods due to a limited space for agriculture and a typically low number of industries. To reduce the dependence on foreign, highly-packaged goods will likely require cultural changes, but this could also be an opportunity to strengthen local markets. Basically, this is a “what comes in, must get out” principle, which is more perceptible on a small island than on a continent, even though the principle is the same everywhere. Therefore, is does good on several levels to divert flows of waste and to

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123 http://www.aquafil.com/sustainability/econyl/

124 http://socialplastic.org/; https://www.youtube.com/watch?v=y7aRQN9zQV0

recirculate the material. Similar ideas are also applied, for example, in the New Plastics Economy initiative that campaigns for increased recycling, reuse, and re-design of packaging.[125]

In addition to the initiatives that re-use marine litter for the production of new items and materials, there are also projects that try to clean up litter from the ocean. However, it should be noted that while there are many suggestions for field clean-up techniques, the environmental effects of these techniques are still poorly studied. Most suggested clean-up techniques are based on some forms of nets, trawls, pumps, and filters, all designed to sieve out litter items or particles. Because litter items are still less common than natural particles, the process of filtering litter will probably capture and remove many more natural organisms than litter items. This might even be the case for filtering techniques that aim to clean up areas of litter accumulation. Beach cleaning is possibly an exception to this because it is much more selective, although it could have other ecological consequences such as the disturbance of breeding grounds.

3.3 GUIDING PRINCIPLES

MITIGATION AND REMEDIATION

Mitigation and remediation are the main approaches against environmental problems. For environmental problems related to plastics in general, this means the reduction, reuse, and recycling of plastics in many applications. Environmental mitigation is defined as "the action of reducing the severity, seriousness, or painfulness of something"[126] in order to limit the negative flow, while remediation is "the removal of pollution or contaminants from water (both ground water and surface water) [or] soil"[127], that is, to repair what has been damaged. Remediation measures thus remove marine litter from coastal zones and surface waters and could thus be seen as treating the symptoms of the problem. In contrast to this, mitigation measures attempt to prevent the damage caused by marine litter on the ecological and human environment. This implies the improved control and management of plastics in order to limit leakages and can be seen as curing the source of the problem. For plastic litter on SIDS, both remediation and mitigation, especially through waste management and recycling, become necessary. When assigning priorities and drafting policies, the two principles provide two different starting points that complement each other.

UPSTREAM AND LEAKAGE REDUCTION

The most pressing mitigation measure is to curb the flows of plastics entering the oceans, and reducing the use of plastics in litter-prone applications is an important step towards reducing pressure from marine plastic debris on SIDS. Several countries are considering, and some have

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125 Ellen MacArthur Foundation (2017). *The New Plastics Economy, Catalysing action*. Retrieved 2017-03-02, from https://newplasticseconomy.org/report-2017

126 Oxford dictionary (n.d.). *Definition of mitigation in English*. Retrieved 2017-03-22, from https://en.oxforddictionaries.com/definition/mitigation

127 Hamilton J (2012). *Careers in Environmental Remediation.* U.S. Bureau of Labor Statistics. In: Green Jobs: Environmental remediation, Report 8.

even introduced, bans or fees on plastic bags and other single-use packaging plastics and microbeads.[128] This should lead to material substitution and shifts towards other solutions and material choices. There is a growing trend in the use of biodegradable bio-based plastics as packaging. Although this development is driven by the search for sustainable solutions, these new materials are often met with scepticism because they lack sufficient long-term field studies on their effects and they have unclear implications for waste management and recycling.[129]

Upstream mitigation of litter and microplastic pollution in other countries will also reduce pressure on SIDS. This includes more eco-friendly design of products that simplifies recycling and better-developed recycling networks. Given that on average only 14% of plastics are recycled globally[130], and with that rate being even lower on SIDS because they often lack recycling facilities, there is substantial room for improvement. On SIDS, organic waste stands accounts for 44% of municipal solid waste[131], and thus the potential to develop biological treatment processes such as composting and anaerobic digestion is high. The barriers that constrain such developments include structural, technical, and financial challenges. Also, cleaner production measures are needed to reduce plastic pollution. For example, laundry traps for plastic microfibers[132] and methods for preventing industrial spills of plastic granulates[133] are being introduced. Each of these measures can reduce the upstream leaks of plastics into the marine environment. The extent to which these efforts will result in any substantial reduction of marine plastic litter remains to be seen, but the initiatives constitute positive signs for change.

ACTIONS NETS FOR GOVERNANCE AND RECIRCULATION

The *Cleaner Pacific 2025* illustrates that a plastic waste policy can hardly be developed without a comprehensive waste policy that fosters sustainable consumption and production. Such a policy must associate programmes that target waste streams (e.g., single-use plastic bags, Styrofoam containers, or tyres) with extended producer responsibility schemes that attach a legal responsibility and an economic potential to waste. Pilot projects, such as the one implemented by Palau to convert waste plastic into oil, and several formal and informal commercial ventures in material recovery (e.g., waste pickers) are examples of this.

Reducing the flow of marine litter to SIDS requires collection services that are more attractive than illegal dumping and backyard incineration, landfills that do not leak plastics to the sea, sensitisation campaigns, and programmes aimed at fishing gear. In addition, to reach a mass balance will require that all plastic materials without use on SIDS are taken offshore. Such

128 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*.

129 Wilson, D. C., Rodic, L., Modak, P., Soos, R., Carpintero, A., Velis, K., ... & Simonett, O. (2015). Global waste management outlook. Report commissioned by UNEP and the international Waste Management Association.

130 Ellen Macarthur foundation (2017) *The New Plastics Economy, Catalysing action*. Retrieved 2017-03-02, from https://newplasticseconomy.org/report-2017

131 Mohee, R., Mauthoor, S., Bundhoo, Z. M., Somaroo, G., Soobhany, N., & Gunasee, S. (2015). Current status of solid waste management in small island developing states: a review. *Waste Management*, *43*, 539-549.

132 e.g. the Guppy Friend wash bag, http://guppyfriend.com/ or Cora ball, https://www.kickstarter.com/projects/879498424/cora-ball-microfiber-catching-laundry-ball

133 Operation Clean Sweep, http://www.opcleansweep.eu/

achievements can only be attained if tight action nets are created and stabilised, that is, people acting in coordinated ways that bring together technological advances, modes of financing, existing infrastructures, waste expertise, and public participation.[134] Local initiatives need to be scaled up, reproduced in new places, and made permanent, and international initiatives need to address the transnational, and even transcontinental, movements of marine plastic litter.

Furthermore, marine plastic litter is not so much a matter of management or government than of governance, which is defined as "sustaining coordination and coherence among a wide variety of actors with different purposes and objectives"[135]. The difference between governance and management is that management takes place within an organization and under hierarchical conditions. It is usually linked to a distinct person or organisation and is permeated by agential rationality. Governance takes place in networks and among a plurality of actors without hierarchical relations. It is typically multi-level, multilateral, and permeated by conflicts and global dynamics rather than by hierarchy. Governance requires collaboration, whereas management can rely on coercion.

It is important to note that single actors cannot address the issue of marine litter alone. What is needed is an array of actions, from local to global, with different actors collaborating to achieve common goals. A number of recycling networks for marine plastic litter are being developed that aim at bringing the plastic in marine litter back into the regular product chain. They have evolved around companies that seek to make a positive environmental impact by recovering marine plastic litter and providing a market for marine plastic litter from SIDS. Typically, a recycling network addresses one specific polymer and engages multiple actors around the world. The production volumes of recycled plastics from these networks are still very small in comparison to the global plastic turnover, but they are growing as experience and product applications gain traction (see Appendix 3).

3.4 MARINE PLASTIC LITTER IN THE FRAME OF THE UN SUSTAINABLE DEVELOPMENT GOALS

The 17 Sustainable Development Goals (SDGs) (Figure 9) set up by world leaders at a UN Summit in 2015 aim to promote sustainability in the most important issues for human life on earth. In contrast to the Millennium Development Goals, the SDGs have a broader scope and function as drivers for ending poverty and inequalities and for developing responsible use of our natural resources and life-support systems. There is a strong interlinkage between the SDGs and measures taken to achieve the targets under Goal 14: Life under water, and these also influence the achievement of other SDGs (see Box 13). Thus efforts against marine litter not only help to combat that very problem but can also have a positive impact on these development goals.

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134 Corvellec, H., & Czarniawska, B. (2015). Waste prevention action nets. *Waste management and sustainable consumption. Reflections on consumer waste*, 88-100.

135 Pierre, Jon, *Debating Governance: Authority, Steering, and Democracy*, Oxford University Press, 2000, cited in United Nations, Economic and Social Council (2006) Definition of basic concepts and terminologies in governance and public administration, E/C.16/2006/4

Figure 9: United Nations´ Sustainable Development Goals[136]

To address the problem of marine litter for SIDS, it is important to understand these linkages so as to avoid undermining and instead promote other important development goals. In places where basic human needs are not met, such needs are of immediate priority. However, in the long term marine litter might become a vital human problem. The relation between locally generated waste that enters the ocean and globally distributed marine litter being washed ashore on SIDS is unclear, and there are no data available for a comparison of litter coming from and to SIDS. The negative impacts of marine plastic litter on SIDS also occur in other countries but might not be as vitally important as they are on SIDS. Due to the strong economic dependence of SIDS on tourism, excessive beach litter could cause extensive losses in revenues from this sector, and from an ecological perspective litter ingestion and death through entanglement might diminish the marine food resources available for the local population. Legally, it is a question of responsibility and how to transfer resources from those polluting the sea to those able to take measures to prevent and clean up such pollution. Finally, marine litter can pose an obstacle for sustainable development on SIDS because it threatens the tourism and marine resources that these societies rely on. Several measures for the mitigation of marine litter foster other goals as well, so positive synergies can occur here.

In the comparison of marine litter measures with the situation of SIDS, some interesting and important links can be seen:

- National clean-up campaigns and participation in International Coastal Cleanup actions as well as the employment of local people as "litter patrols" could help fight the high unemployment rates on SIDS if people are paid for their engagement. Here, tour operators on the respective islands could supply financing for these measures. The initiatives of "fishing for litter" and The Plastic Bank could be opportunities for locals to make some more money during their normal fishing activities or to exchange collected beach litter for needed household goods.

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136 UN-DESA (n.d.). Sustainable Development Goals. Retrieved 2017-03-20, from https://sustainabledevelopment.un.org/sdgs

- Education and awareness efforts regarding marine litter will likely improve the access to education for people living on SIDS, and legislative measures such as better defined roles, responsibilities, and enforcement regarding marine litter will likely improve the often weak institutional structures on SIDS.
- Specialised waste management systems are needed for extreme weather events and natural disasters because floods and storms often lead to the entry of large amounts of waste from inland into the ocean. This might be of special importance for SIDS because they have large amounts of coastline and are mostly located in storm-prone areas. A side-effect of such waste management systems might even be improved risk awareness and early warning systems for natural disasters.
- Integrated solid waste and wastewater management infrastructures and port reception facilities will likely help to combat the problems of insufficient waste treatment facilities on islands. Wastewater typically carries high loads of particles, especially where no or insufficient wastewater treatment is in place. Microscopic fibres are too small to be filtered out by any treatment plants using current technologies.
- High transportation costs on remote island states require local and low-technology waste-handling strategies.
- Industrial design improvements in packaging might lead to reduced packaging waste, which would also save resources and maybe even reduce transportation costs.

Box 13: SDG targets related to marine litter[137]

6.3 By 2030, the proportion of untreated wastewater should be halved

11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

12.1 Implement the 10-year framework of programmes on sustainable consumption and production, with all countries taking action and with developed countries taking the lead, taking into account the development and capabilities of developing countries

12.2 By 2030, achieve the sustainable management and efficient use of natural resources

12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle in accordance with agreed international frameworks, and significantly reduce their release into the air, water, and soil in order to minimize their adverse impacts on human health and the environment

12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse

12.b Develop and implement tools to monitor sustainable development impacts for a sustainable tourism industry that creates jobs and promotes local culture and products

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

14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience and taking action for their restoration in order to achieve healthy and productive oceans

14.7 By 2030, increase the economic benefits to SIDS and to LDCs from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture, and tourism

14.a Increase scientific knowledge, develop research capacity, and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular SIDS and LDCs

14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of *The Future We Want*

15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity, and, by 2020, protect and prevent the extinction of threatened species

3.5 SUMMARY OF MEASURES

The measures described here to tackle the problem of marine plastic litter include institutional legislation, official RAPs for several regions, and commercial solutions for both the collection of litter and the recycling and reuse of the material. The legal framework for preventing and managing marine plastic litter is found in multiple layers of governance, from international to national and local rules, and within many areas of law and with different types of legal effects. Global agreements that aim at the protection of ecosystems and marine species or marine biodiversity in general are highly related to the issue of marine plastic litter. There are both binding agreements and a number of declarations and recommendations, such as the SAMOA Pathway, that are relevant for marine litter on SIDS. Supported by UNEP, member governments of many regions have agreed on political agendas for the management of marine plastic litter, as documented in RAPs. The contents of different plans show strong similarities and commonly include measures for improved legislation, the use of best practices and best techniques, and awareness raising through education.

Moreover, many businesses and NGOs have started initiatives to replace and reduce the use of plastic materials in order to reduce the amount of litter that enters the oceans. Various beach cleaning projects contribute to a part of the litter being removed from the ocean environment. Likewise, several companies are using recycled litter in their packaging, which also raises awareness about the issue. For SIDS, marine plastic litter is a problem that needs to be addressed, but not at the expense of general human development. Where basic human needs are not met, these needs are of immediate priority. However, in the long term marine litter might also become a vital human problem if current practices do not change significantly. It poses a threat to coastal communities around the world, and specifically to SIDS because it threatens the tourism and marine resources that these societies rely on.

137 UNEP (2016). Marine plastic debris and microplastics – Global lessons and research to inspire action and guide policy change. United Nations Environment Programme, Nairobi. Page 7.

4 CONCLUSIONS: A PRESSING ISSUE IN NEED OF ATTENTION

Marine plastic litter threatens the livelihoods of people living on SIDS because they rely on marine resources such as fish for their daily food supply. The transboundary nature of the marine plastic litter problem and the multiple actors, sources, pathways, and impacts require global collaboration and international action. Scientific knowledge, market-based instruments to create incentives for good behaviour, stakeholder engagement, and local participation should all be applied to solve the problem. Although the RAPs contain strategies for addressing the problem at different stages, the main focus is on end-of-pipe solutions. Because it is known that measures taken closer to the source are more efficient both in terms of the level of risk prevention and from an economic perspective, it might be suitable to put more emphasis on this. From a global perspective, this would require a significant reduction in plastic consumption coupled with better waste management, which should lower the amount of waste generated outside SIDS flowing to SIDS. In order to reduce the amount of mismanaged waste on SIDS that might become marine litter, the establishment and maintenance of an integrated solid waste management system is crucial. Therefore, "waste has been recognised as one of the areas for priority attention for SIDS"[138]. Frequently, waste management infrastructures on SIDS are insufficient and lack regulations and enforcement. In addition, the limited land and population size leads to restricted recycling possibilities, though this could be increased by creating incentives for recycling. Likewise, the transportation of waste to the mainland is often not efficient due to the remoteness of most SIDS.[138] Moreover, further studies are needed to better understand the origins of plastic waste on SIDS, the movement of plastics in ocean currents, and the ecological and human health impacts of both macro- and microplastics.

4.1 RECOMMENDATIONS: IMPORTANT AREAS FOR FUTURE COOPERATION

PREVENT UNNECESSARY MATERIAL/LITTER FROM REACHING SIDS: SUPPORT COOPERATION IN REGIONAL AND INTERNATIONAL AGREEMENTS

Rationale:
A common theme in the RAPs and various reports is that the number one priority is to reduce the generation of (plastic) litter, both globally and on SIDS, in order to tackle the root of the problem (e.g. Principles 1 and 2 of the Cleaner Pacific 2025). Because most of the plastic material used (and possibly lost) on SIDS have their origin somewhere else, regional and international cooperation is essential for solving the marine litter problem (e.g. Principles 8 and 12 of the Cleaner Pacific 2025).

Important actors and forms for cooperation:
There are a number of fora where countries (bilaterally or in cooperative groups), NGOs, and others can work with and support initiatives by SIDS to include measures against marine litter

138 Wilson, D. C., Rodic, L., Modak, P., Soos, R., Carpintero, A., Velis, K., ... & Simonett, O. (2015). Global waste management outlook. Report commissioned by UNEP and the international Waste Management Association.

in regional and international agreements and processes. This could include regional and international cooperation on things like international tourism certifications and regulation, shipping, fisheries, and packaging standards (e.g. Principle 7 of the Cleaner Pacific 2025).

ENSURE THAT PLASTIC MATERIAL THAT REACHES SIDS IS NOT RELEASED INTO THE ENVIRONMENT: TECHNICAL COOPERATION AND SUPPORT FOR LOCAL WASTE MANAGEMENT AND RECYCLING

Rationale:
As outlined in section 3.5 in our report and in numerous other reports, setting up efficient waste management and recycling operations is essential but challenging for SIDS. Technical solutions that work in other geographical settings might not work under the conditions on SIDS. Thus, financial, logistic, and geographic constraints make it necessary to find solutions that work on SIDS (e.g. principle 14 of the Cleaner Pacific 2025).

Important actors and forms for cooperation:
We believe that there are excellent opportunities for cooperation not only among countries, but also across different sectors of society (including business and research) to develop new cost-efficient and robust solutions of waste management technologies, including through financing, support for infrastructure, exchange of experiences, and perhaps international scholarships and visiting scholar programmes in the field of waste management and recycling (in line with, for example, Principle 13 of the Cleaner Pacific 2025).

IF WASTE REACHES THE ENVIRONMENT, COLLECT IT WHERE APPROPRIATE: SUPPORT BEACH CLEAN-UP CAMPAIGNS AND OTHER REMEDIATION MEASURES

Rationale:
As outlined above, for example, in section 1.3, and in numerous reports, litter enters the environment from many sources, including some very far away from where the litter ends up. While mitigation measures such as those suggested above should be the main priority, remediation in the form of clean-up campaigns plays an important role in minimising the impact of marine litter. An additional value of clean-up campaigns would be if they could be standardised in such a way that they could be used to monitor the global progress of measures against marine litter, which might be a particularly important issue for countries with limited resources for environmental monitoring. Such organised campaigns require infrastructure, material, and management. In addition, clean-up campaigns are important as a means to promote participation and partnership and to give people and local businesses a sense of empowerment against this environmental threat (e.g. Principles 6 and 13 of the Cleaner Pacific 2025).

Important actors and forms for cooperation:
There are many good examples (in both SIDS and elsewhere) of how clean-up campaigns can be organised and maintained. Beach cleaning can be done on a voluntary basis, or it can be part of a business activity. There are excellent possibilities for international organisations, NGOs, businesses, and nations to cooperate with SIDS financially and logistically and with regard to standards to facilitate things like sustainable networks of beach litter clean-up operations. However, it should be noted that while there are many suggestions for field clean-up techniques, the environmental side-effects of these are still little studied.

WHEN WASTE/LITTER HAS BEEN COLLECTED, ENSURE THAT IS HAS A VALUE: DEVELOP RECYCLING MARKETS AND OPPORTUNITIES

Rationale:
If waste/litter is collected, it should be put into use again in order to close the flow of material (see, e.g., the section on material flows in the current report, Principle 1 of the Cleaner Pacific 2025, and numerous other reports). This might be an additional challenge for SIDS because transportation routes to existing markets might be long (see, e.g., Principle 4 of the Cleaner Pacific 2025). Developing a market value for the waste, preferably in the SIDS themselves, but otherwise in cooperation with markets abroad, is therefore essential to make the work against marine plastic litter economically sustainable.

Important actors and forms for cooperation:
There are many ways that countries, businesses, researchers, and international organisations can cooperate to develop the economic value of products emanating from recycling and waste management, preferably through developing local/regional uses. This could, for example, be in the form of financing and support for infrastructure, exchange of experiences, and perhaps international scholarships and visiting scholar programmes. Alternative ways to facilitate infrastructure for selling collected material to plastic industries abroad should also be developed. In this context, cooperation with the plastics industry is important to decide on recycling industry standards in order to increase the value of collected material, while at the same time not setting such standards so high that they prevent material collected on SIDS from being used.

COMMUNICATE SYSTEMATICALLY ON THE NEGATIVE IMPACT OF PLASTIC LITTER: MAKE PLASTIC LITTER A GLOBAL ISSUE THAT RECEIVES GLOBAL ATTENTION

Rationale:
General awareness of the problem should be raised in order to induce behavioural change. If the public understanding of the problem were greater, people would most likely reduce their littering behaviour. Further, public pressure could lead to stricter legislation and thus reduced inputs of plastics into the oceans.

Important actors and forms of cooperation:
Because plastic litter is distributed by ocean currents around the globe, any long-term solutions need to acknowledge the global dimensions of the issue. Therefore, international cooperation bodies such as the UN have an important role for communication and for reaching agreements. In addition to commitments from all nations, teaching materials could be shared and adapted to the respective local situation of each region.

MORE RECOMMENDATIONS BASED ON THE FINDINGS OF THIS REPORT:

- Support the development of local multi-stakeholder fora (e.g., with representatives of fishing activities, the tourism industry, and waste management organisations) in order to assess the actual impact of plastic litter on local communities

- Set up international financial schemes that support an upscaling and internationalisation of successful local initiatives in the realms of prevention, reuse, and recycling of plastic litter
- Strengthen interregional exchanges within RAPs and other regional initiatives so as to foster their enhancement and publicity
- Stress the multiple connections that exist between the prevention and mitigation of plastic litter and UN SDGs in order to promote initiatives against the problem

APPENDIX 1: OCEAN MODELLING FOR THE DISTRIBUTION OF PLASTIC PARTICLES

Buoyant plastic particles tend to rise to the sea surface. If there is wind-generated mixing, or turbulence, in the upper ocean, the particles are mixed down into the water column. If the wind is steady for some time (say a few days), a balance between the rise of particles and the downward mixing of particles develops, and typically the particle concentration decreases (exponentially) with depth.[139,140] The exact details of this process are important for how the plastic particles will move in the ocean.

The particles will follow the ocean current, and because the current varies with depth (in both strength and direction) the vertical distribution of the particles is an important parameter to consider when designing a reliable drift model [3-5]. For the present study, we assumed that particles are relatively large such that they reside in the upper metre or so in the ocean, yet they are submerged in the water and thus not exposed to direct wind forces at the sea surface. Notably, ocean models reflect the mean current of the uppermost 5–10 m of the ocean, and it might be crucial to take into account that particles have a stronger drift in the wind direction than described by the ocean model. This is known as the windage factor, which can be added to the model current. The windage factor is based on observations showing that objects typically drift at 3% of the wind speed and with a deflection of 30° to the right in the Northern and 30° to the left in the Southern hemisphere. The deflection is due to the Earth's rotation, while surface waves give rise to a drift in the direction of the waves (and thus in the wind direction). The Stokes drift is typically not included in the ocean model, but it is included in the "3% rule", so if the wave drift (or Stokes drift) is included, the 3% rule must be adjusted. Notably, the 3% rule must also be adjusted if using an ocean model that resolves the current shear in the upper most part of the ocean. Thus, here we did not include the windage factor because the upper ocean dynamics were resolved in our model.

In this study, we considered the drift of relatively large plastic objects that reside in the upper metre of the ocean. We also used output from a wave model to evaluate the Stokes drift and an ocean model that described the currents at the surface relatively well (i.e. a model having high resolution, i.e. 2 m resolution, at the sea surface). Thus for plastic bags we did not need to use a windage factor, but for material floating on the surface we might need to include a windage factor (perhaps 1% of the wind speed). Our results for transport toward the SIDS regions show that the exact formulation of the drift is an important factor for evaluating the plastic flow to the SIDS regions (which are outside the subtropical gyres).

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139 Kukulka, T., Proskurowski, G., Morét-Ferguson, S., Meyer, D. W., & Law, K. L. (2012). The effect of wind mixing on the vertical distribution of buoyant plastic debris. *Geophysical Research Letters*, *39*(7).

140 Reisser, J., Slat, B., Noble, K., du Plessis, K., Epp, M., Proietti, M., ... & Pattiaratchi, C. (2015). The vertical distribution of buoyant plastics at sea: an observational study in the North Atlantic Gyre. *Biogeosciences*, *12*(4), 1249.

DETAILS OF THE DRIFT MODEL

We assumed that particles follow the surface current, and we included the Stokes drift as well. The ocean currents came from the HYCOM model, and data were downloaded from hycom.org. We used the GLBu.0.8, 19.1 dataset. This is a global dataset with about 11 km resolution (i.e., 0.08 degrees). Stokes drift was taken from global ECMWF climatology data known as the ERA40. The Stokes drift was calculated from the available wave model (the WAM wave model) spectra, and the spectral tail missing in the wave model was taken into account.

We released particles from positions within three grid points from the coast in the ocean model (i.e. within about 30 km from the coast); the reason for not releasing the particles at the coast was to avoid particles being beached too quickly at the model land mask. We kept track of particles from different areas and considered Europe, North Africa, Gulf of Guinea, Equatorial Africa, Equatorial South America, the northern part of South America (south of the equatorial region), Central America, the Gulf of Mexico, and eastern North America. The seeding areas were chosen to roughly correspond to areas with constant release of plastic debris and to reflect a typical pathway of particles. We released 3,000 particles from each of these coastlines every 10 days during 2012 (Fig. A1a). The release areas and number of particles released from each area could be improved, but at the present time we only have forcing data for 2012. We reran the 2012 scenario a number of times to investigate how particles move over a longer time frame, but because of limitations in the available data the present results should be viewed with some caution.

RESULTS

To give a first impression of how particles move, Figure 10 shows the positions of particles after 0.5, 1, 2 and 4 years. The particles are colour coded according to their origin. We clearly see that the drift to a large degree followed the mean wind direction and crossed the Atlantic westwards in the trade wind regions and followed the west wind belt (i.e., moving eastwards) in the mid-latitudes. We accordingly found that particles from northern Africa and southern Europe moved quickly (over the course of 0.5–1 year) into the SIDS region in the North Atlantic. The exact rate at which particles encountered the different islands is beyond the scope of this preliminary study. As time progresses, the particles accumulated in the subtropical convergence zone. However, random eddies and wind events will create a flow of particles out from the subtropical gyre, and some particles will enter the SIDS areas from the north. This happens at about 3–4 years after the initial release of the particles, and here the North American particles become quite important.

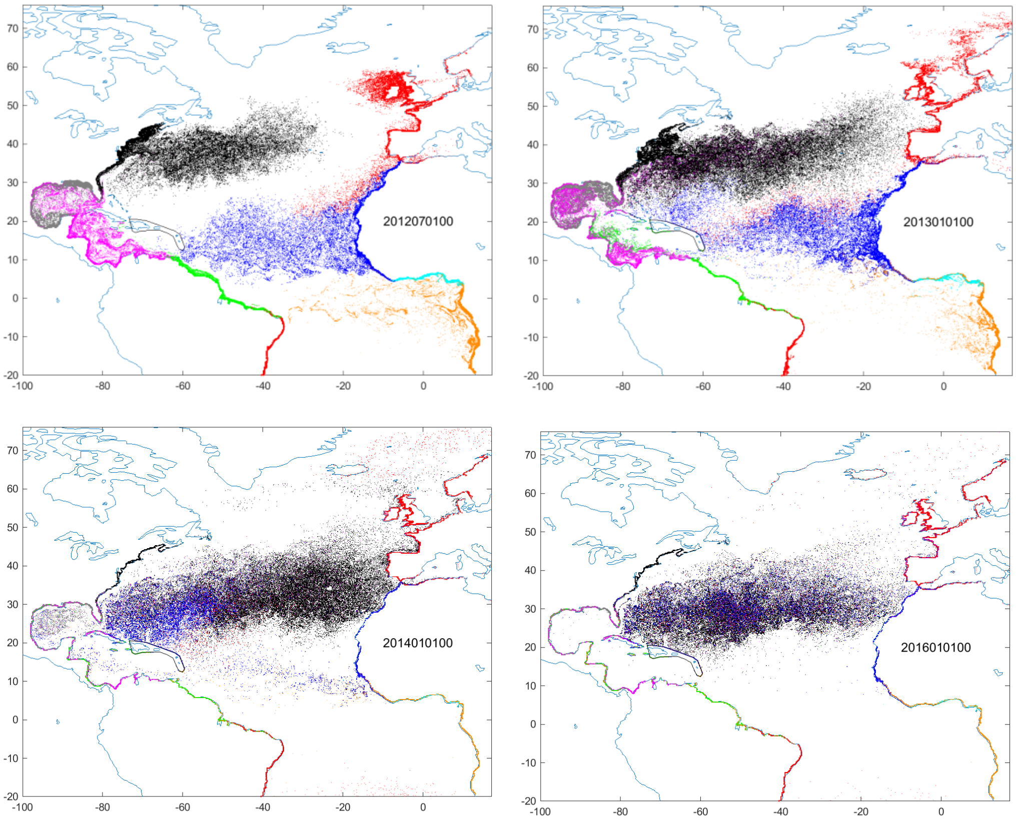

Figure 10: Particles after 0.5, 1, 2, and 4, years into the simulation. The black polygon surrounding the Antilles is a simple capturing zone in the simulation to investigate how particles from different areas move into the SIDS regions. For color-coding of particle origin, see Figure 11.

A detailed analysis of the timing and number of particles entering SIDS regions is beyond the scope of the present study. However, by keeping track of particles entering the "Antilles" area (See Figure 11) we can make some simple estimates. North Africa appears to be an important region because particles in our simulation moved in the direction of the trade winds. Here the Stokes drift was important for this result, and its contribution must be included. Particles coming from Europe contributed with a smaller but still significant amount, and they came essentially from the Iberian Peninsula. Particles from the North American coast moved into the subtropical gyre and were transported by random processes from the subtropical gyre to our area of investigation. The exact location of the particles in the gyre, and the random release of particles were somewhat sensitive to the exact formulation of the model and to the representation of how particles are transported by wind, waves, and ocean currents. This needs to be quantified and analysed in more detail in future work.

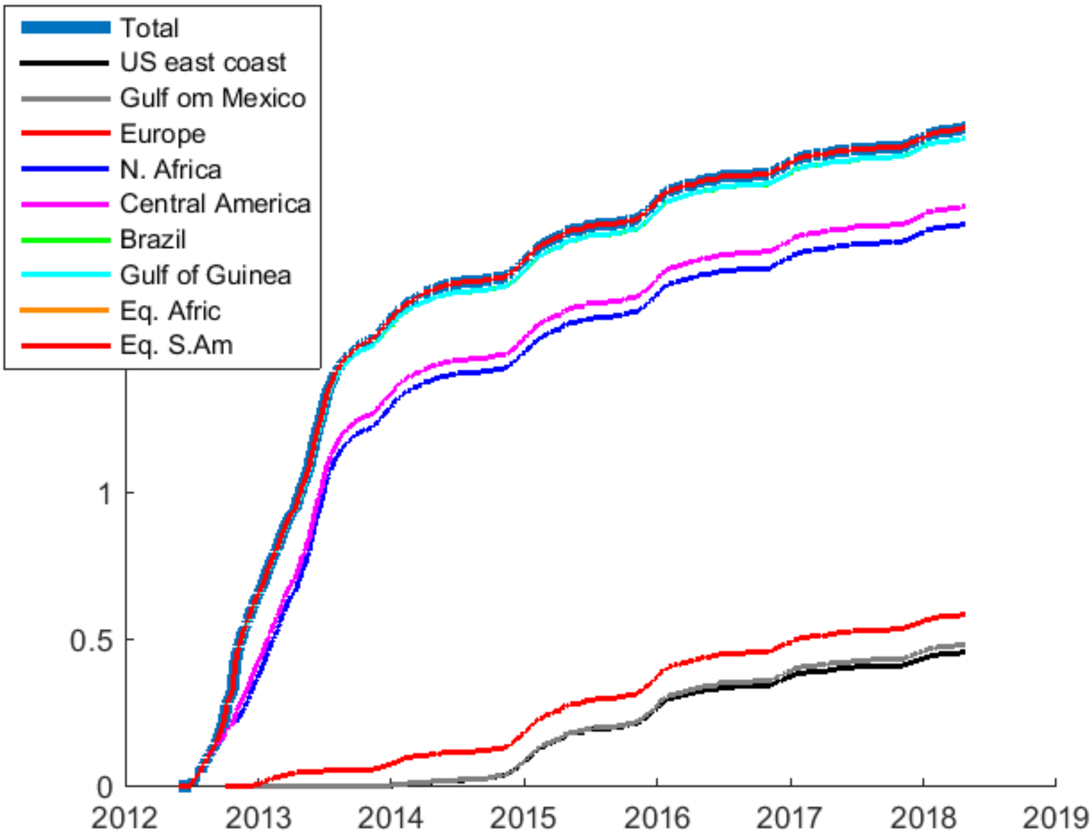

Figure 11: The cumulative number of particles (arbitrary units) entering the simple "Antilles" SIDS area as a function of time. We have added each release area to the former area such that each curve is a cumulative plot of each area as well. As an example, in 2017, the US east coast reached about 0.4, the Gulf of Mexico added a few particles, Europe contributed about 0.1, while North Africa was the main contributor. The next large contributor was northern South America, while the other areas had negligible contributions (actually implying that the Green "northern South America" curve becomes hidden in the plot). The numbers on the plot are arbitrary, but about 15% of the particles released from North Africa reached the "Antilles" SIDS region we investigated. However, making a leap to estimating the number of particles that beach in the region is well beyond the scope of the present study. Note also that areas with small contributions plot on top of each other in the total curve.

GENERAL COMMENTS

To understand the main drift pathways in the ocean, it is useful to start with the global wind patterns. Between about 5º and 30º (north and south) there are steady easterly winds known as the trade winds, and these winds have a greater impact on the wind and wave components closer to the equator. Further north, the winds shift direction, and we have westerly winds between about 35º and 60º (north and south), and this is known as the west wind belt. Thus, these winds create waves that essentially move in the same directions, and the Stokes drift is more or less aligned with this wind pattern. The ocean currents to a large extent follow the same structure as the wind because they are largely forced by the wind. However, ocean currents cannot go through the north-south–oriented land masses that divide the Atlantic from the Pacific-Indian Ocean basins. Thus, close to land the currents move parallel to the coastlines, and the result is strong currents along the eastern US coast (the Gulf Stream), the eastern Asian coast (the Kuroshio Current), Australia (the Western Australian Current), and Africa (the Agulhas Current) and in the South Atlantic (the Brazil Current). These currents are important for distributing water, and plastic particles, poleward. At the eastern sides of the ocean basins, we have slow southward flow between about 40ºS to 40ºN and poleward flow south or north of these latitudes. In the ocean, the wind-driven surface currents are turned to the right of the wind direction due to the Earth's rotation, which is known as the Ekman transport. Thus buoyant particles will tend to be deflected to the right of the wind, and the main wind directions will thus transport buoyant particles into the subtropical gyres where they to some degree become trapped.[141142,143]

141 Lebreton, L. M., Greer, S. D., & Borrero, J. C. (2012). Numerical modelling of floating debris in the world's oceans. *Marine pollution bulletin*, *64*(3), 653-661.

142 Maximenko, N., Hafner, J., & Niiler, P. (2012). Pathways of marine debris derived from trajectories of Lagrangian drifters. *Marine Pollution Bulletin*, *65*(1), 51-62.

143 Van Sebille, E., England, M. H., & Froyland, G. (2012). Origin, dynamics and evolution of ocean garbage patches from observed surface drifters. *Environmental Research Letters*, *7*(4), 044040.

APPENDIX 2: EXAMPLES OF GLOBAL COOPERATION FOR A CHANGE PROCESS RELATING TO MARINE DEBRIS

There already exist different projects where developed countries support SIDS financially. Here, two examples are given for such projects in the Pacific region.

Support for solid waste management in the Pacific region from the Japan International Cooperation Agency (JICA),[144] donor JICA & receptor Pacific SIDS (2015)

1. Developing the capacity of human resources
JICA has placed an emphasis on developing the capacity of local human resources that can lead solid waste management in their own countries and not rely on support from overseas. It also seeks to develop leaders who help each other in the efforts to address solid waste management issues within the Pacific region.

2. Improving solid waste management
Proper collection, transportation, and disposal of waste play an integral part in solid waste management. JICA's support has helped an increasing number of countries in the Pacific region to initiate and improve waste collection service and to introduce semi-aerobic landfill systems.

3. Creating a recycling-oriented society
In order to respond to rapidly increasing amounts of solid waste, JICA has supported efforts to create a recycling-oriented society with the slogan of 3R (Reduce, Reuse, Recycle) +Return that considers not only the 3Rs, but also the circumstances unique to island countries.

4. Cooperation at the grassroots level
Urban solid waste is generated through everyday life, and raising people's awareness of the issue is critical in solid waste management. Experiences and technologies of the people and municipal governments in Japan are now being developed throughout the Pacific region.

5. South-south cooperation and intraregional cooperation
Japan's cooperation over the years is producing human resources that are committed to cross-border activities within the Pacific region. Not does will JICA share Japan's experiences, but it also continues to support mutual learning within the Pacific region.

144 https://www.jica.go.jp/english/publications/brochures/...att/solidwaste.pdf

Project for improved hazardous waste management in the Pacific by the Secretariat of the Pacific Regional Environment Programme,[145] donor EU European Development Fund & receptor Pacific SIDS (2014)

The SPREP is implementing a four year, 8 million euro project to provide fundamental on-site improvements in the way that high-priority and high-risk wastes are managed in Pacific island countries to help build a healthy and economically and environmentally sustainable Pacific for future generations. The Pacific Hazardous Waste (PacWaste) project is funded by the European Union as part of its 10th European Development Fund. The project focuses on three priority hazardous waste streams, including asbestos, electronics waste, and healthcare waste, which are not currently adequately funded through other management programmes. This project includes the establishment of integrated and on-going systems to manage or destroy such wastes. These systems aim to result in a reduction in local population exposure to high-risk and cancer-causing waste streams, as well as to cleaner local and regional environments. Improvements in port reception facilities to handle waste shipments are an essential component of this project to improve on-site waste management.

145 https://www.sprep.org/pacwaste/what-is-pacwaste

APPENDIX 3: DETAILS FOR INITIATIVES THAT (RE-)USE PLASTIC LITTER

Plastic litter use initiatives: Social solutions

- The Plastic Bank developed by Social Plastic® allows residents of impoverished communities in developing nations to collect plastic that is littering beaches and other waterways and to turn it into a form of currency by trading the material with recycling centres for various goods. The start-up recycles the plastic and then sells it to corporations interested in finding creative ways to be environmentally responsible.
  - http://plasticbank.org/
  - https://www.youtube.com/watch?v=y7aRQN9zQV0
  - https://www.kickstarter.com/projects/nortonpoint/sea-plastic-differently-recycled-ocean-plastic-sun
- Garbage Clinical Insurance (GCI) is a micro health-insurance program that uses recyclable waste as a financial resource. With this program, the community is able to pay for clinical services by using garbage as payment into an insurance scheme. The project predominately targets waste collectors and encourages the community to mobilize their own unused resources to improve their access to health services.
  - https://www.empowering-people-network.siemens-stiftung.org/fr/solutions/projects/garbage-clinical-insurance/

Plastic litter use initiatives: Cooperation platforms for initiatives

- Parley for the Oceans. A "space where creators, thinkers, and leaders [can] come together to raise awareness for the […] oceans and collaborate on projects that [aim to] end their destruction." Parley A.I.R. strategy: Avoid virgin plastic, Intercept plastic waste, and Redesign alternatives.
  - http://www.parley.tv/#fortheoceans
- The Ocean Conservancy creates science-based solutions for healthy oceans and the wildlife and communities that depend on them.

Plastic litter use initiatives: Technical solutions

- TerraCycle is an innovative American waste management company that focuses on hard-to-recycle waste.
  - Aims at **eliminating the Idea of Waste**® by recycling the "non-recyclable". They collect and recycle almost any form of waste and partner with individual collectors, major consumer product companies, retailers, manufacturers, municipalities, and small businesses in different countries.
  - http://www.terracycle.com/
- ECONYLl® is a recycling process that can regenerate recovered fishing nets into ECONYL® nylon yarn in order to close the loop.
  - http://www.econyl.com/

- EcoPost® uses 100% recycled plastics to make environmentally friendly plastic lumber for use in applications ranging from fencing to landscaping. It is a social enterprise that addresses the challenges of urban waste management (plastic pollution), youth unemployment, deforestation, and climate change.
    - http://www.ecopost.co.ke/
- COREC (Continental Renewable Energy Co. Ltd.) is a Kenya-registered manufacturer of composite building materials, including roofing tiles, fencing posts, and plastic lumber, using recycled plastic waste and sand.
    - http://www.coreclimited.com/
- Recycled Park is a proposal to retrieve plastic waste from the Maas River just before it reaches the North Sea. The plastics are recycled to give new value to the river and to construct floating platforms out of the material.
    - http://recycledpark.com/introduction.html
- TOMRA is a Norwegian recycling solutions company that creates sensor-based solutions for optimal resource productivity.
    - https://www.tomra.com/en/

Plastic litter use initiatives: Experimental solutions for consumer products

- Adidas and Parley for the Oceans collaborate in single projects to produce sports shoes and swimming gear from recycled plastics.
    - http://www.adidas.com/us/parley
- Procter & Gamble has partnered with TerraCycle and Suez (Europe´s largest waste management company) to produce Head & Shoulders shampoo bottles made with 25% recycled beach litter.
    - http://www.headandshoulders.com/en-us/whats-new/new-head-shoulders-bottle-to-be-made-with-recycled-beach-plastic
- The open-source Sea Chair by Studio Swine is made entirely from plastic recovered from the ocean. Local fisherman can collect marine plastic and process it into a stool directly at sea using simple plans and instructions available online.
    - http://www.studioswine.com/sea-chair/
- Project Vortex is an international collective of artists, designers, and architects actively working with plastic litter; supporting projects that intercept the plastic waste stream in innovative ways; and supporting non-profit organizations around the world that are conducting clean-ups of various waters and waterways.
    - http://www.projectvortex.org/what-we-do.html

Plastic litter use initiatives: Organisational solutions for circular product chains

- Healthy Seas is a cross-sector initiative created by the following three founders—one NGO and two enterprises—that have joined forces to tackle the problem of marine litter:

  - ECNC Group: a European expertise centre for biodiversity and sustainability with experts on marine conservation. With the help of dive teams, the ECNC Group coordinates the recovery of abandoned fishing nets and runs activities to raise awareness among the fishing industry and local communities.
  - Aquafil Group: Italian and global Nylon 6 producer. In 2011 Aquafil developed and launched the ECONYL® Regeneration System that can regenerate recovered fishing nets into ECONYL® nylon yarn that is then used for the production of new apparel and carpet products.
  - Star Sock: a sock-partner for the international retail market that was the first company to use the ECONYL® regenerated from fishing nets for their products.
  - http://healthyseas.org/
- Net-Works® is an innovative, cross-sector initiative designed to tackle the growing environmental problem of discarded fishing nets in poor coastal communities in the Philippines and Cameroon. The following two companies and one NGO work together for a reduction in ghost nets, reduced use of virgin materials, and new sources of income for local communities:
  - The Zoological Society of London (ZSL): an international scientific, conservation, and educational charity that helps fishing communities to organise the recovery and sale of waste fishing nets into a global supply chain. It sets up community banks for local access to finance, and earnings from net sales can be saved or small loans can be taken out.
  - Aquafil: recycles the nets into new yarn for carpet tiles.
  - Interface: a manufacturer of commercial carpet tile that develops modular carpet and aims to be environmentally friendly.
  - http://net-works.com
- Plastic Mining Cooperation is a Dutch company that plans to sell a package to islands for on-site plastic recycling, and it also focuses on the following points that could be financed by governments, NGOs, crowd funding, and consumer product companies that want to use ocean plastics:
  - Awareness-raising talks and campaigns
  - A shipping container that has a shredder, washer, and dryer inside for the processing of plastic waste (done by a local recycler) built by an international machine-building company
  - Monitoring for improvements in illegal dumping and beach cleanliness through cooperation with local NGOs
  - Access to trading platforms to sell the materials after compounding

APPENDIX 4: RESEARCH STUDIES ABOUT MARINE PLASTIC LITTER ON SIDS

Caribbean	
State	**Study**
Antigua and Barbuda	
Bahamas	
Barbados	Coe, J. M., et al. (1997). Marine debris in the Caribbean region. Marine Debris, Springer**:** 25-33.
Belize	Bennett-Martin, P., et al. (2015). "Mapping marine debris across coastal communities in Belize: developing a baseline for understanding the distribution of litter on beaches using geographic information systems." Environmental monitoring and assessment **188**(10): 557.
Cuba	Botero, C., et al. (2017). "Litter assessment on 99 Cuban beaches: A baseline to identify sources of pollution and impacts for tourism and recreation." Marine pollution bulletin.
Dominica	Corbin, C. and J. Singh (1993). "Marine debris contamination of beaches in St. Lucia and Dominica." Marine pollution bulletin **26**(6): 325-328. do Sul, J. A. I. and M. F. Costa (2007). "Marine debris review for Latin America and the wider Caribbean region: from the 1970s until now, and where do we go from here?" Marine pollution bulletin **54**(8): 1087-1104.
Dominican Republic	
Grenada	De Tender, C., et al. (2017). "A review of microscopy and comparative molecular-based methods to characterize “Plastisphere” communities." Analytical Methods.
Guyana	Amaral-Zettler, L. A., et al. (2015). "The biogeography of the Plastisphere: implications for policy." Frontiers in Ecology and the Environment **13**(10): 541-546.
Haiti	
Jamaica	Wade, B. A., et al. (1991). "A study of beach litter in Jamaica." Caribbean Journal of Science **27**(3-4): 190-197. Debrot, A. O., et al. (1999). "Beach debris in Curacao." Marine pollution bulletin **38**(9): 795-801.
Saint Kitts and Nevis	
Saint Lucia	Corbin, C. and J. Singh (1993). Coe, J. M., et al. (1997). Singh, J. G. and B. Xavier (1997). Land-based sources of marine debris and contamination of the coastal areas of the Caribbean Islands of St. Lucia, Dominica, and the British Virgin Islands. Marine debris, Springer**:** 371-380.

Saint Vincent and the Grenadines	
Suriname	
Trinidad and Tobago	
Pacific	
State	**Study**
Fiji	Gregory, M. R. (1999). "Plastics and South Pacific Island shores: environmental implications." Ocean & Coastal Management **42**(6): 603-615. Richardson, K., et al. (2016). "Marine pollution originating from purse seine and longline fishing vessel operations in the Western and Central Pacific Ocean, 2003–2015." Ambio: 1-11.
Kiribati	Richardson, K., et al. (2016).
Marshall Islands	Richardson, K., et al. (2016). Richards, Z. T. and M. Beger (2011). "A quantification of the standing stock of macro-debris in Majuro lagoon and its effect on hard coral communities." Marine pollution bulletin **62**(8): 1693-1701.
Micronesia (Federated States of)	Richardson, K., et al. (2016).
Nauru	Richardson, K., et al. (2016).
Palau	Richardson, K., et al. (2016).
Papua New Guinea	Smith, S. D. (2012). "Marine debris: A proximate threat to marine sustainability in Bootless Bay, Papua New Guinea." Marine pollution bulletin **64**(9): 1880-1883. Richardson, K., et al. (2016).
Samoa	Richardson, K., et al. (2016).
Solomon Islands	Maes, C. and B. Blanke (2015). "Tracking the origins of plastic debris across the Coral Sea: A case study from the Ouvéa Island, New Caledonia." Marine pollution bulletin **97**(1): 160-168. Richardson, K., et al. (2016).
Timor-Leste	
Tonga	Richardson, K., et al. (2016). Gregory, M. R. (1999).
Tuvalu	Richardson, K., et al. (2016).
Vanuatu	Richardson, K., et al. (2016).

AIMS	
State	**Study**
Cape Verde	Heyerdahl, T. (1971). "Atlantic Ocean pollution and biota observed by the ‘Ra’expeditions." Biological Conservation **3**(3): 164-167. Barnes, D. and P. Milner (2005). "Drifting plastic and its consequences for sessile organism dispersal in the Atlantic Ocean." Marine biology **146**(4): 815-825.
Comoros	
Guinea Bissau	
Maldives	Imhof, H. K., et al. (2017). "Spatial and temporal variation of macro-, meso- and microplastic abundance on a remote coral island of the Maldives, Indian Ocean." Marine pollution bulletin **116**(1): 340-347.
Mauritius	Shelbourne, G. and N. Ray "A Plastic Survey of Blue Bay and Pointe D’Esny, Mauritius." Bouwman, H., et al. (2016). "The flip-or-flop boutique: Marine debris on the shores of St Brandon's rock, an isolated tropical atoll in the Indian Ocean." Marine environmental research **114**: 58-64.
Sao Tome and Principe	
Seychelles	Duhec, A. V., et al. (2015). "Composition and potential origin of marine debris stranded in the Western Indian Ocean on remote Alphonse Island, Seychelles." Marine pollution bulletin **96**(1): 76-86.
Singapore	Ng, K. and J. Obbard (2006). "Prevalence of microplastics in Singapore’s coastal marine environment." Marine pollution bulletin **52**(7): 761-767.

Non-UN	
State	**Study**
American Samoa	Richardson, K., et al. (2016).
Anguilla	
Aruba	de Scisciolo, T., et al. (2016). "Beach debris on Aruba, Southern Caribbean: Attribution to local land-based and distal marine-based sources." Marine pollution bulletin **106**(1): 49-57.
Bermuda	Gregory, M. R. (1999). Wilber, R. J. (1987). "Plastic in the North Atlantic." Oceanus **30**(3): 61-68.
British Virgin Islands	Singh, J. G. and B. Xavier (1997).
Cayman Islands	
Commonwealth of Northern Marianas	Richardson, K., et al. (2016).
Cook Islands	Richardson, K., et al. (2016).
Curacao	do Sul, J. A. I. and M. F. Costa (2007).

	Debrot, A. O., et al. (1999).
French Polynesia	Richardson, K., et al. (2016).
Guadeloupe	
Guam	
Martinique	
Montserrat	
New Caledonia	Reisser, J., et al. (2013). "Marine plastic pollution in waters around Australia: characteristics, concentrations, and pathways." *PLoS One* **8**(11): e80466. Maes, C. and B. Blanke (2015).
Niue	Richardson, K., et al. (2016).
Puerto Rico	O'Hara, K. J. and L. K. Younger (1990). *Cleaning North America's Beaches: 1989 Beach Cleanup Results*. Chaparro, R. and J. Vélez (1997). Upland sources of marine debris on the shorelines of Puerto Rico. *Marine Debris*, Springer**:** 367-370. Coe, J. M., et al. (1997). Simmonds, M. P. (2012). "Cetaceans and marine debris: the great unknown." *Journal of Marine Biology* **2012**.
Sint Maarten	
Turks and Caicos Islands	
US Virgin Islands	O'Hara, K. J. and L. K. Younger (1990). Arthur, C., et al. (2014). "Out of sight but not out of mind: harmful effects of derelict traps in selected US coastal waters." *Marine pollution bulletin* **86**(1): 19-28.

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