A REVIEW OF THE CURRENT STATUS OF MARINE LITTER AND MICROPLASTICS KNOWLEDGE IN THE WESTERN INDIAN OCEAN REGION:
amounts, sources, fate and resultant ecological impacts on the coastal and marine environment and on human health

UN environment programme

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WESTERN INDIAN OCEAN MARINE SCIENCE ASSOCIATION

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Compiled and prepared by: Daniela Honorato-Zimmer, Eleanor A. Weideman, Lorien Pichegru, Peter G. Ryan and Martin Thiel

Cover photos: *Bottles collected from a remote South African beach to infer key sources; over 70% come from offshore sources.* @ Peter Ryan

Many resort beaches, such as this site at Diani Beach, Kenya, are cleaned daily to reduce the impact of stranded litter on tourism. @ Peter Ryan

Designed by: Gordon Arara

Coordinated by: Jared Bosire, Arthur Tuda and Julius Francis

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Executive summary

The Western Indian Ocean (WIO) is a region where high biodiversity is increasingly being impacted by anthropogenic marine debris. However, information about the amounts, types, and sources of marine litter are scattered widely in the literature. To synthesize existing knowledge, we reviewed 136 studies on marine litter and microplastics in the WIO region (79% articles from peer-reviewed scientific journals, 20% grey literature reports, 1% book chapters). We also interviewed scientists, NGO coordinators, citizens and park rangers with experience in marine litter monitoring and management to supplement the information presented in the literature and to further improve our knowledge of marine litter in the region.

Most studies had sampled for macrolitter (>25 mm), but knowledge about the distribution of microplastics on the seashore has also improved since the publication of the 2008 UNEP/WIOMSA review of marine plastics in the WIO region. Studies were mostly from South Africa (57%), followed by Kenya (8%) and Mozambique (5%), while Madagascar, Seychelles, Comoros, Tanzania, Mauritius and La Réunion accounted for smaller proportions; 27 studies (20%) included data from several countries, international waters, or covered seabirds that forage widely across the Indian and Atlantic Oceans. The best-studied coastal habitat was the seashore (mostly sandy beaches), followed by the sea surface. However, it was often difficult to compare litter densities between studies because of differences in sampling methods; for example, most studies reported litter per linear metre of shoreline while some reported densities per unit area. Furthermore, studies differed on the lower size limit sampled (e.g., using different mesh sizes to sample floating litter). It was also difficult to compare litter densities on shorelines determined using standing stock versus accumulation surveys, and even among accumulation studies sampled at different intervals. Greater efforts are needed to harmonise survey methods and reporting units.

Higher macrolitter densities on the seashore were generally found on urban or popular recreational beaches close to point sources. In most studies, plastics dominated with generally > 50% of all recorded items by number being plastics. Of particular concern is plastic packaging, which often dominates litter loads at least numerically, especially on urban sandy beaches. However, litter items on urban and tourist beaches are often smaller and have a faster turnover rate due to increased cleaning efforts, which tend to target larger items, whereas large litter items tend to persist for longer periods on seldom cleaned beaches. Therefore, while the number of items on tourist beaches may be higher, the mass of litter is normally concentrated on rural beaches, highlighting the importance of also reporting litter densities by mass.

Data on the density and distribution of meso- (5-25 mm) and microplastics (<5 mm) on the seashore are only available for sandy beaches and estuaries. In South Africa, the average density of mesoplastics increased between the years 1984 and 1989, whereas little change in densities was detected in surveys between the 1990s and the 2010s. In Kenya, only one study has been conducted using sieve transects on sandy beaches (i.e., to sieve sand along a transect perpendicular to the shoreline to sample mesolitter), which reported higher densities of mesolitter on beaches closer to populated areas compared to semi-populated and remote areas. In both countries, >90% of items were plastic. Most research on microplastics on the seashore has been conducted in South Africa, with one study available from Tanzania and one from the Comoros Archipelago. These show that microplastics (most of which are microfibres) tend to be concentrated around large coastal cities, but nearshore surface water currents may also play a role in determining their distribution on the seashore. One study extrapolated microplastic densities across the entire beach profile and found an average density which completely dwarfed counts of macro- or mesolitter but only contributed <0.01% to the total mass of litter, highlighting that a few large items dominate the mass of litter.

Floating macrolitter has been studied off the coasts of Kenya and South Africa, where densities are much higher than in the Southern Ocean off South Africa, likely due to higher inputs and shorter distances from land-based sources. Twelve studies conducted net tows for floating meso- and microlitter while five collected bulk surface water samples for microplastics. Plastics were the most common anthropogenic material caught in the nets. Several studies suggested that ocean currents play a significant role in determining the distribution and accumulation of meso/microplastics. Microfibres were common in the bulk water samples, although most fibres in surface waters are not synthetic. Only one study from the WIO region sampled for litter in the water column (along a transect from Cape Town to the Prince Edward Islands), which remains one of the least studied marine habitats. Five studies have surveyed macrolitter on the seafloor (in Mayotte, South Africa, and international waters), with highest litter densities found at deep-sea sites along the Southwest Indian Ocean Ridge, >1 300 km south of Madagascar, most of which was fishing gear. Macrolitter densities on the continental shelf off the south and west coasts of South Africa were lower and most of this litter was plastic packaging and disposable plastics, which may have originated from land-based sources or ships. Dive transects on coral reefs in the Comoros Archipelago also found mostly discarded fishing gear, suggesting that most reef litter comes from fishing activity. Three studies reported microplastic densities from bottom sediments in the WIO region (in South Africa and international waters). The highest densities were generally found close to point sources such as sewage overflows, stormwater drains and river mouths.

Identification of litter types and local concentration around urban source areas indicates that most litter is from local, land-based sources, reaching the ocean via rain run-off or direct deposition by beachgoers. Recent studies show that much litter does not disperse far from the source, suggesting that shorelines in the WIO region are important sinks for litter (although buried plastics in beaches will be exposed as coasts erode due to rising sea levels). The type of habitat and its physical characteristics play a significant role in determining the fate of stranded litter. For example, mangroves and rocky shores are significant sinks for larger or heavier litter items. While most of land-based macrolitter strands on shorelines close to where it washes into the sea, a small proportion may also be transported offshore. The WIO region is downstream of south-east Asia, and ocean models suggest that some of the litter reaches the WIO countries after extended oceanic journeys; this is supported by reports of Asian-branded packaging covered in epibionts and the predominance of HDPE bottles and lids from Indonesia (compared to PET bottles from China, Singapore/Malaysia and UAE, many of which are dumped illegally from ships). The lack of data on the characteristics and densities of litter on the seafloor of the WIO region makes it difficult to ascertain to what degree the seafloor acts as the ultimate sink for marine litter, but some studies already confirm accumulations of litter on the seafloor, both in coastal as well as in offshore regions.

More than one-third of the 136 reviewed studies (38%) reported interactions between organisms and marine litter or microplastics (in all countries except Somalia); ingestion and entanglement were documented most commonly. Plastic ingestion has been studied in 111 species from the WIO region, including many seabirds, bony fishes and sharks. All four species of sea turtles studied have presented plastic debris in stomach contents or faecal samples, but none of four species of marine mammals studied had ingested macrolitter. Invertebrates (mussels, oysters, crabs, sea anemones and some zooplankton) have also been found with microplastics in their guts. Further studies will likely find microplastic ingestion in virtually all marine species. Entanglement has been reported for seabirds, marine mammals, sea turtles, bony fishes and sharks, but few systematic studies have been conducted. Of particular concern are fish aggregating devices (FADs) because they are often reported with entangled, dead sea turtles. Fisheries litter (nets and lines) is also often observed entangled on coral reefs, macro-algae and horny corals. Some invertebrates (echinoderms, sea anemones) also attach plastics to their body surface. Ten studies have reported data on organisms growing on marine litter (i.e., epibionts; in Kenya, Mozambique, Tanzania, South Africa, Madagascar, Mauritius, and at deep-sea sites east of Madagascar), with floating substrata colonized by various species including bryozoans, spirorbid worms and six species of goose barnacles. Long-distance transport of some species on floating plastics has been suggested.

The potential impact of marine litter on human health remains severely understudied. One study from Tanzania confirmed high concentrations of human pathogens and multi-drug resistant bacteria growing on waste plastics. The ingestion of microplastics is potentially harmful to humans because of the toxicity of plastic additives and the sorption of persistent organic pollutants (POPs), which have been detected on the surfaces of polyethylene pellets in Mozambique and South Africa. However, the transfer of these compounds to humans remains speculative, and the effects of marine litter and microplastics on human health remain a largely unknown and understudied field.

The current level of knowledge about the sources, distribution and impacts of plastic litter in the WIO region suggests that most macrolitter has local land-based origins. Some litter is also dumped illegally from ships, while some arrives from distant sources. Knowledge on the sources, fate and impacts of microplastics is mostly limited. Concentrations around urban centres suggest coastal sources, but field observations suggest that ocean currents rapidly redistribute microplastics. Ingestion of microplastics has been documented for many vertebrates and some invertebrates, but the impacts on the organismal and population level require further studies. Current information suggests that although humans could be impacted by plastic ingestion, evidence is limited, suggesting at most weak or subtle impacts.

The findings suggest that to effectively reduce current levels of plastic pollution it is fundamental to stop littering at the sources, and to substantially improve waste collection and management. The main recommendation is to modify local production and convert the current production of single-use plastics to reusable materials (which could also be reusable plastics). International efforts are required to reduce the input of litter from fisheries. As current information shows that most litter in the WIO region has local sources and is retained on nearby beaches, coastal clean-up programmes could be helpful mitigation strategies until effective prevention and management measures are put in place to stop the release of litter from land-based sources.

Chapter 1: Introduction

1.1. Background

Marine anthropogenic litter is a pervasive and growing problem. Of particular concern are waste plastics, of which at least 710 million metric tons are projected to be released into the environment by 2040 (Lau *et al*. 2020). These plastics can persist for long periods and tend to accumulate in aquatic systems, especially in the sea. Marine plastics can have many impacts, including being ingested by and entangling marine organisms (Kühn *et al*. 2015), smothering the seabed (Gregory 2009; Green *et al*. 2015) and facilitating the spread of invasive species and diseases (Barnes 2002; Lamb *et al*. 2018; Rasool *et al*. 2021). As a result, plastics have been listed as a threat to marine biodiversity (Moore 2008; Deudero & Alomar 2015) and it is therefore vitally important that effective mitigation measures aimed at stopping the release of waste plastics into marine environments are implemented (Coe & Rogers 1997). To do this, up-to-date information on the origins, density, distribution and fate of plastic pollution, as well as the main sources of waste plastics, is urgently needed.

The Western Indian Ocean (WIO) is a highly biodiverse region that is home to many endangered IUCN red-listed species to which plastics and other forms of marine litter pose a serious threat (Ryan *et al*. 2016a; Abreo *et al*. 2019; Cartraud *et al*. 2019). The region is also well known for its beaches, the beauty and value of which are threatened by increasing amounts of stranded litter (Ballance *et al*. 2000; Dunlop *et al*. 2020) and the cost of cleaning these beaches can be extreme (Burt *et al*. 2020; Rodríguez *et al*. 2020). Moreover, marine anthropogenic debris could negatively affect tourists' experiences and discourage them from returning or recommending these areas to fellow travelers (Jang *et al*. 2014; Krelling *et al*. 2017), potentially affecting the income of many WIO coastal communities.

While comprehensive national hotspotting assessments about plastic waste have been recently implemented in four WIO continental countries which provide up-to-date information on the sources, density, and distribution of plastic waste, and recommended interventions to curb its generation and release to the environment (IUCN-EA-QUANTIS 2020a,b,c,d), no recent region-wide review of the densities, distribution, sources, fate and threats of waste plastics has been conducted. Moreover, there is currently a lack of clarity concerning the knowledge gaps that remain unattended and the most adequate actions actions to tackle plastic waste at the regional level. The main goal of this review is to identify the principal sources of marine litter in the WIO countries, which is essential knowledge for effective prevention and management measures.

The last review of the topic across the region was published in 2008 by the United Nations Environment Programme (UNEP) and the Western Indian Ocean Marine Science Association (WIOMSA). Entitled *Marine Litter in the Eastern Africa Region: An Overview Assessment*, the report focused on eight countries within the WIO region (South Africa, Mozambique, Madagascar, Tanzania, Kenya, Mauritius, Comoros and Seychelles), most of which have a large coastal population generating large amounts of marine litter (Figures 1A&B). That report also indicated that most of the litter found in the region likely originates on land, although some also was attributed to at-sea activities such as illegal dumping from ships and fishing industry. Mismanaged plastic waste has been identified as a main issue in the continental countries of the WIO (with mismanagement rates ranging from 58% in South Africa to 99% in

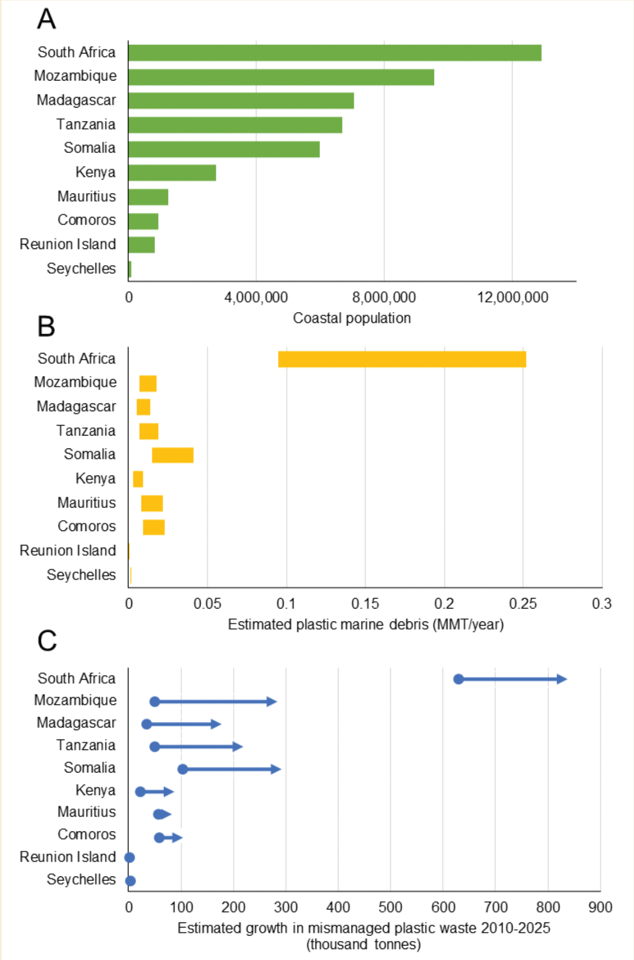


Figure 1: (A) The number of people living within 50 km of the coast in each of the WIO countries, (B) the amount of plastic litter estimated to have been released into the sea in 2010 and (C) the expected growth in mismanaged plastic waste between 2010 and 2025 (the dots indicate the amount of mismanaged plastic waste in 2010 and the tips of the arrows show the estimated amount in 2025). All data are from Jambeck et al. (2015).

Mozambique; IUCN-EA-QUANTIS 2020a,b,c,d), and the amount of mismanaged plastic waste is predicted to increase significantly in the WIO countries, particularly in the continental ones (Figure 1C; Jambeck *et al*. 2015, 2018), which could result in even more litter entering the WIO in the future. Furthermore, the WIO region is a western boundary current system that lies downstream from south-east Asia, one of the world's largest sources of land-based plastics (Jambeck *et al*. 2015). Marine litter may therefore also be transported across the Indian Ocean to the region via the South Equatorial Current (Ryan 2020a), and from there throughout the WIO region via the Somali, East African Coastal, Mozambique and Agulhas currents (Van der Mheen *et al*. 2020), underscoring the need for regional solutions that complement national strategies.

While the 2008 UNEP/WIOMSA report highlighted large knowledge gaps in all countries in the region except South Africa, substantially more research on marine litter has subsequently been published. This research provides a much better understanding of the characteristics, sources, distribution and sinks of macro- (>25 mm), meso- (5-25 mm) and micro-litter (<5 mm) in the WIO (according to the size classification by GESAMP 2019), and a review of the latest research for the entire WIO region is urgently needed. Realising this, the Group of Experts on Marine Litter and Microplastics – which was set up by WIOMSA and the Nairobi Convention Secretariat in 2018 – commissioned three inter-related studies at the end of 2020, the first of which is presented here. This report reviews and assesses the status of marine litter and microplastics knowledge in the WIO region. To do this, we conducted a comprehensive review of the existing literature on the amounts, sources and fate of marine litter and microplastics in the WIO region, and their resultant ecological and human health impacts. Furthermore, we interviewed scientists, NGO coordinators, citizens and park rangers with experience in marine litter monitoring and management to supplement the information presented in the literature and to further improve our knowledge of marine litter in the region. For these interviews, we created a standard questionnaire (Appendix I), which was conducted either verbally via a Zoom meeting or through written feedback.

1.2. Analysis of literature

To conduct the review, we first did an online search of literature in Google, Google Scholar, and the Web of Science, using combinations of several keywords such as *litter, marine litter, beach litter, microplastics, mesoplastics, plastic, Africa, wio, Western Indian Ocean, South Africa, Tanzania, Mozambique, Kenya, Somalia, Madagascar, Seychelles, Mauritius, Comoros, and Reunion*. We looked for any type of literature, including peer-reviewed papers, grey literature and book chapters, as well as different types of studies, such as field studies, modelling studies, and reviews. In the case of South Africa, we included all studies conducted in the country (i.e., in both the Atlantic and Indian Oceans).

We gathered a first stock of several references, which we quickly scanned in order to determine their appropriateness for the present review, considering whether they covered any of the topics of interest: amounts, distribution, characteristics, sources, fate, transport, ecological impacts and/or human health impacts of marine litter and/or microplastics, in any given marine compartment/habitat in the WIO region. Following this filtering, we examined the references cited in the selected studies, and searched for any that we might have been missing. We then evaluated their appropriateness and scanned through their respective references as well, repeating this cycle until we could not find any new titles that we had not already included in our database. To complete the database, during the stakeholder consultations we shared the references lists by country with each stakeholder, and asked them to check the list corresponding to their country and share with us any study that we might have missed.

Following the construction of the database, we reviewed 136 studies on marine litter and microplastics in the WIO region (Appendix II). Of these, 79% were articles published in peer-reviewed scientific journals, 20% were grey literature (student theses, NGO, government, internship and consultancy reports, a meeting document, a conference output, a colloquium presentation, and a paper published in an undergraduate journal) and two studies (1%) were published as book chapters (Figure 2).

Most studies (57%) reported data from South Africa, followed by Kenya (8%), Mozambique (5%), and smaller proportions from Madagascar, Seychelles, Comoros, Tanzania, Mauritius and La Réunion; no studies have been found from Somalia (Figure 2). We classified 27 studies (20%) as "International WIO" as these studies included data (i) on more than one WIO country without distinguishing between the countries, (ii) from areas within the WIO region not relating to a specific country (e.g., international waters), (iii) from areas outside the WIO region but relevant to it, for example ingestion of plastics by seabirds that forage widely across the Indian and Atlantic Oceans, or (iv) from the entire Indian Ocean without identifying the data specific to the WIO region.

The reviewed studies were further classified according to the size of the reported litter following the classification by GESAMP (2019), although excluding megalitter. Thus, we classified litter as macro (>25 mm), meso (5-25 mm) and micro (<5 mm). However, given that many studies did not clearly distinguish between meso- and microplastics, the studies which sampled for mesoplastics using sieves, cores or nets were pooled with microplastic studies, whereas those in which mesoplastics were sampled without sieving or filtering (e.g., as part of beach transects) were included in macrolitter (in the main text, figures, and supplementary tables in Appendix III). Among the studies reporting amounts and distribution of litter in the marine environment, most of them (46 out of 68) reported on macrolitter (>25 mm), although our understanding of the distribution of microplastics on the seashore has greatly improved since the 2008 UNEP/WIOMSA report (Figure 3, Figure 4).

The following chapters (2 through 4) present detailed descriptions of the research that has been done on marine litter and microplastics in different compartments/ habitats and the ecological and human health impacts of marine litter. This is followed by the information gathered in the stakeholder consultations (see Chapter 5), which aimed to obtain a clear picture of the different monitoring activities and programmes currently being conducted in the WIO countries, and to supplement the information gathered in the literature with respect to composition, sources, transport, fate and impacts of litter, according to the field observations of the stakeholders. Chapter 6 highlights the main knowledge gaps that still need to be addressed in the WIO region, whereas Chapter 7 provides recommendations on actions to curb the production and release of litter to the environment at the local, national and regional level, based on the information presented in this review.

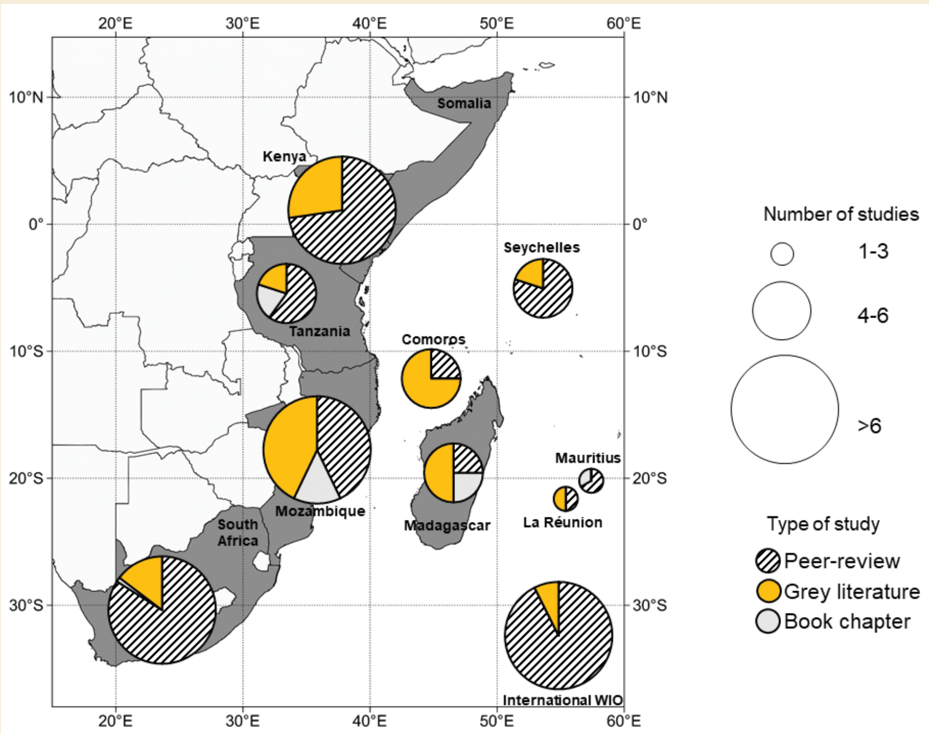


Figure 2: Map of the Western Indian Ocean (WIO) region where the size of the pie charts indicates the number of studies on marine litter or microplastics from each of the WIO countries (n = 136 across entire region) and size of the slices showing the proportion of studies which are grey literature (NGO and government reports, student theses etc.), book chapters and papers published in peer-reviewed scientific journals. Western Indian Ocean countries included in this review are shown in dark grey, where Comoros also includes Mayotte. No studies were available for Somalia. An additional 27 studies were grouped as "international WIO" (refer to main text for details).

Chapter 2: Status of marine litter and microplastics knowledge in the WIO

2.1. Seashore – sandy beaches, rocky coasts, mangroves, and estuaries

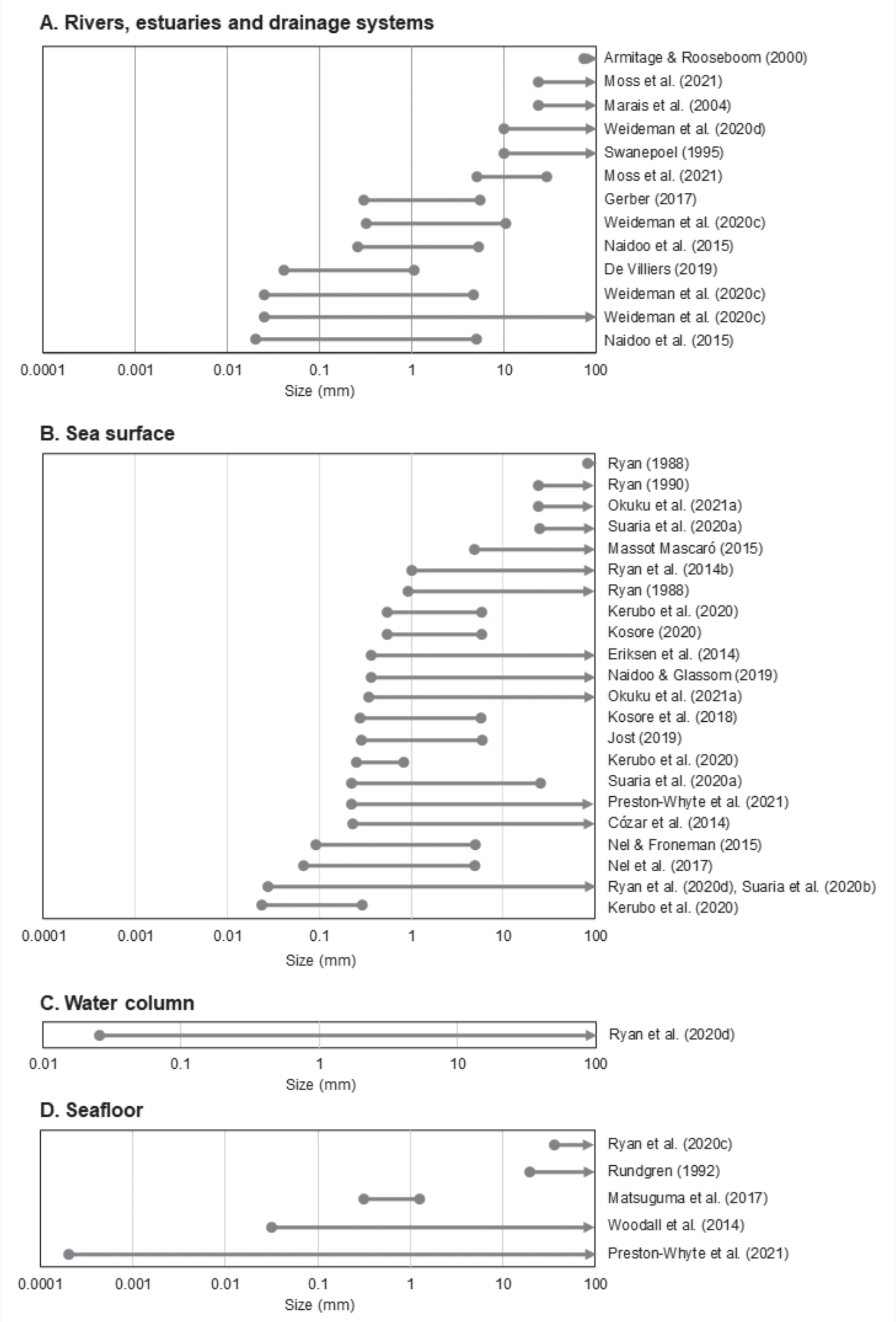
The most well-documented habitat was the seashore (Figure 3, Figure 4, Figure 5), especially sandy beaches for which there were data available for all countries except La Réunion and Somalia (Figure 3D, Figure 5, see also Tables S1 and S5 in Appendix III). Most studies sampled for macrolitter (>25 mm), either by conducting standing stock or accumulation studies, although surveys of meso- and microplastic pollution on sandy beaches have been conducted in Tanzania (Mayoma *et al*. 2020), Kenya (Okuku *et al*. 2020a), Mayotte (Jost 2019) and South Africa (Ryan & Moloney 1990; Gregory & Ryan 1997; Naidoo *et al*. 2015; Nel & Froneman 2015; Gerber 2017; Nel *et al*. 2017; De Villiers 2018; Ryan *et al*. 2018; Ryan *et al*. 2020a). The greater focus on macroplastics on beaches is perhaps justified given the overwhelming dominance of macrolitter in terms of the mass of plastic on beaches (Ryan *et al*. 2020a) and macrolitter is also more informative for the identification of litter sources (Ryan *et al*. 2020b). Furthermore, macrolitter can be tackled more effectively through clean-ups than microplastics, but if left *in situ* will break down into microplastics. Only two studies have sampled for litter in estuaries, both of which were conducted in South Africa and only sampled for microplastics (Naidoo *et al*. 2015; Gerber 2017), although Ryan & Perold (2021) report on the transference of litter between the sea and an estuary in South Africa. Similarly, only two studies have been published on litter in mangroves (Stokes & Manning 2019; Seeruttun *et al*. 2021), and only one has been conducted on a rocky shore (Weideman *et al*. 2020a,b), although two studies have documented interactions between litter and rocky shore organisms (Spencer 2020; Weideman *et al*. 2020a; see Section 4.1.5 below).

2.1.1. Macrolitter

2.1.1a. Amounts, mass and distribution

While several studies have sampled for macrolitter on seashores in the WIO region, it is difficult to compare litter densities between studies given that different sampling methods were applied; for example, most studies report litter per linear metre of shoreline (e.g., Bouwman *et al*. 2016; Ryan 2020b; Opie 2020) but some report densities per unit area (e.g., Pereira *et al*. 2001; Gjerdseth 2017; Figure 6A). It is also difficult to compare litter densities on shorelines determined using standing stock versus accumulation surveys (although both these types of sampling provide valuable information; Ryan *et al*. 2020b), and even among accumulation studies sampled at different intervals (Ryan *et al*. 2014a). Efforts should thus be made to harmonise beach survey methods (Ryan *et al*. 2009; GESAMP 2019; Galgani *et al*. 2021), which have already been initiated by the Sustainable Seas Trust (SST) with the support of WIOMSA (Barnardo & Ribbink 2020), whose methodologies have been implemented in the region for the last two years.

A selection of litter collected from an urban beach in South Africa that is cleaned daily, showing how small litter items are often ignored by municipal cleaning teams. @ Peter Ryan


A. Rivers, estuaries and drainage systems
Armitage & Rooseboom (2000)
Moss et al. (2021)
Marais et al. (2004)
Weideman et al. (2020d)
Swanepoel (1995)
Moss et al. (2021)
Gerber (2017)
Weideman et al. (2020c)
Naidoo et al. (2015)
De Villiers (2019)
Weideman et al. (2020c)
Weideman et al. (2020c)
Naidoo et al. (2015)
0.0001
0.001
0.01
0.1
1
10
100
Size (mm)
B. Sea surface
Ryan (1988)
Ryan (1990)
Okuku et al. (2021a)
Suaria et al. (2020a)
Massot Mascaró (2015)
Ryan et al. (2014b)
Ryan (1988)
Kerubo et al. (2020)
Kosore (2020)
Eriksen et al. (2014)
Naidoo & Glassom (2019)
Okuku et al. (2021a)
Kosore et al. (2018)
Jost (2019)
Kerubo et al. (2020)
Suaria et al. (2020a)
Preston-Whyte et al. (2021)
Cózar et al. (2014)
Nel & Froneman (2015)
Nel et al. (2017)
Ryan et al. (2020d), Suaria et al. (2020b)
Kerubo et al. (2020)
0.0001
0.001
0.01
0.1
1
10
100
Size (mm)
C. Water column
Ryan et al. (2020d)
0.01
0.1
1
10
100
Size (mm)
D. Seafloor
Ryan et al. (2020c)
Rundgren (1992)
Matsuguma et al. (2017)
Woodall et al. (2014)
Preston-Whyte et al. (2021)
0.0001
0.001
0.01
0.1
1
10
100
Size (mm)

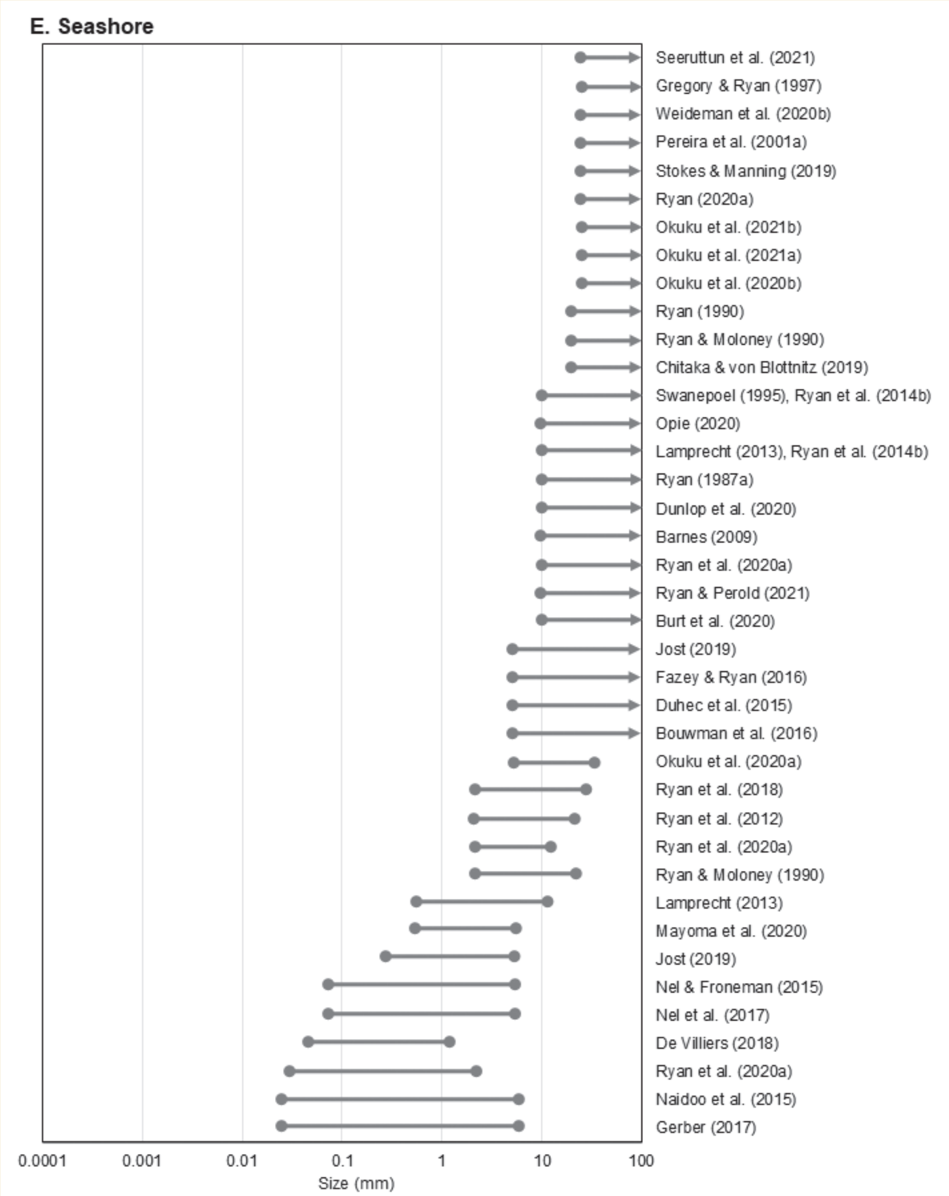


Figure 3: Size ranges of macro- (>25 mm), meso- (5-25 mm) and micro-litter (<5 mm) sampled in (A) rivers, estuaries and drainage systems, (B) on the sea surface, (C) in the water column (5 m deep), (D) on the seafloor (studies ranged from the subtidal zone to 1000 m depth), and (E) on the seashore of the WIO region. The circles show the minimum and maximum sizes sampled, while lines ending in an arrow indicate studies which sampled for all litter larger than the minimum size (i.e., there was no maximum size). The smallest size used by studies was 1 cm^2 or 5 cm^2 – these have not been included here (see Appendix III Tables S1-S9 for details).

In South Africa, sandy beach surveys have been conducted since the 1980s (Ryan 1987a; Ryan 1990; Ryan & Moloney 1990), thus providing valuable baselines against which trends in litter characteristics and densities can be compared (Ryan *et al*. 2020b). Subsequent surveys showed that litter densities increased significantly between 1984 and 1989, and that this increase was driven by increases in locally produced plastic packaging (Ryan & Moloney 1990). However, more recent surveys have struggled to detect the rise in the amount of litter but show that macrolitter is consistently concentrated around coastal urban centres despite greater cleaning effort on urban beaches (Ryan 2020b; Appendix III Table S1). This suggests that most litter comes from local land-based sources (see Section 3.1 below) and that litter does not disperse far from source (see Section 3.3 below). In Madagascar, litter densities were higher on a popular tourist beach than on more rural beaches (Gjerdseth 2017; Appendix III Table S1). However, litter items on tourist beaches are often smaller and have a faster turnover rate due to increased cleaning efforts, which tend to target larger items, whereas large litter items tend to persist for longer periods on rural beaches. Therefore, while the number of items on tourist beaches may be higher, the mass of litter is normally concentrated on rural beaches, highlighting the importance of also reporting litter densities by mass (Ryan *et al*. 2020a). Macrolitter standing stock surveys have also been conducted on sandy beaches in Kenya (Okuku *et al*. 2021a,b), Mozambique (Pereira *et al*. 2001), the Seychelles (Duhec *et al*. 2015; Burt *et al*. 2020), in Mayotte (Comoros Archipelago; Jost 2019) and on St. Brandon's Rock, an isolated atoll 430 km northeast of Mauritius (Bouwman *et al*. 2016; Appendix III Table S1).

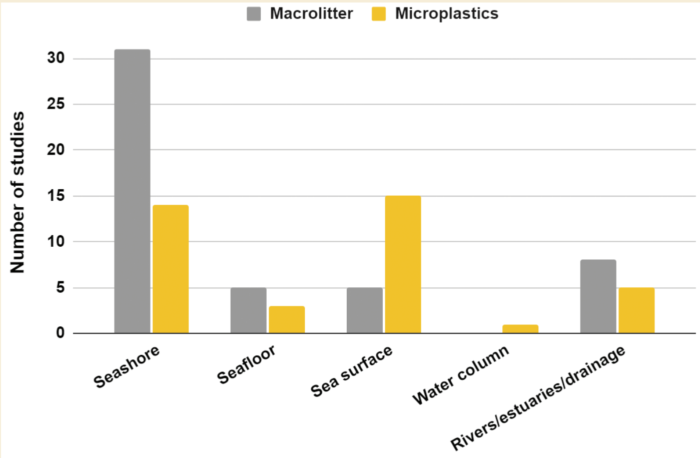


Figure 4: The number of studies on marine litter (n = 136 for entire region) that sampled for macrolitter (>25 mm) and/or microplastics (<5 mm) in each type of marine compartment/habitat. Studies which sampled for mesoplastics (5-25 mm) using sieves, cores or nets are included in "microplastics", whereas those where mesoplastics were sampled without sieving or filtering are included in "macrolitter". Some studies reported data on more than one compartment and/or more than one litter size, and are thus included in all the respective categories.

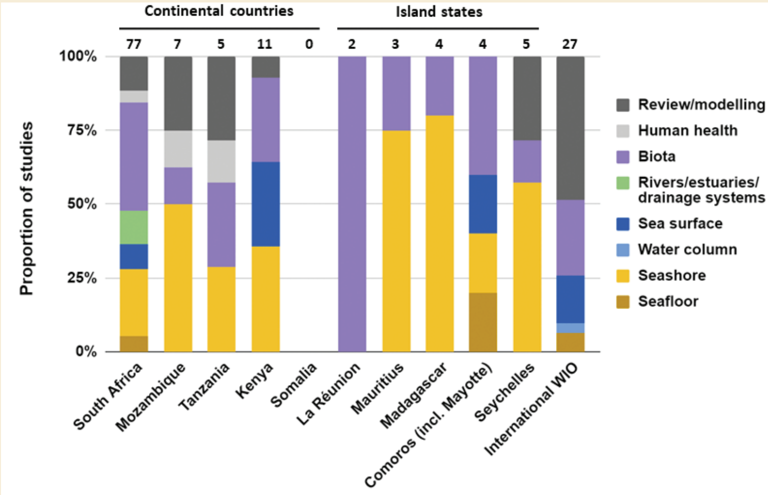


Figure 5: The proportion of studies from each of the WIO countries (n = 136 for entire region) focusing on different aspects of marine litter or microplastics and different compartments/habitats. Numbers above the bars indicate studies reporting data on corresponding country; they do not add up to 136, because seven studies reported data on more than one country. Also, several studies reported data on more than one compartment and thus are included in more than one category.

These studies support the findings that most marine litter is land-based, most particularly in the continental countries and Mayotte (Pereira *et al*. 2001; Jost 2019; Okuku *et al*. 2021b); however, in island states there is an important input from sea-based sources as well, such as from long-distance drift (Duhec *et al*. 2015; Bouwman *et al*. 2016; Burt *et al*. 2020; see Sections 3.1 and 3.2 below). Interestingly, Okuku *et al*. (2021b) further demonstrated that conducting standing stock surveys repeatedly within a time frame (e.g., monthly during each monsoon season) can be useful to determine temporal variations, and suggested that litter densities, diversity and the relative contributions of different sources are seasonally influenced by monsoons (see Section 3.1).

Daily accumulation studies have been conducted in South Africa (Swanepoel 1995; Lamprecht 2013; Ryan *et al*. 2014a; Chitaka & von Blottnitz 2019; Opie 2020), Kenya (Okuku *et al*. 2020b) and on Cousine and Alphonse Islands in the Seychelles (Duhec *et al*. 2015; Dunlop *et al*. 2020). Accumulation rates tend to be higher on popular recreational beaches and on urban beaches closer to source areas; for example, ongoing monitoring of two beaches in South Africa since 1995 has shown that litter accumulation rates are consistently an order of magnitude higher close to central Cape Town than 30 km away (Table 1; Swanepoel 1995; Lamprecht 2013; Ryan *et al*. 2014; Opie 2020; Appendix III Table S1). Similarly, Chitaka & von Blottnitz (2019) found significantly higher accumulation rates on popular urban beaches in Cape Town than at a more remote nature reserve (Appendix III Table S1). In Kenya, accumulation rates by counts tended to be higher on popular, easily accessible tourist beaches, while the highest accumulation rate by mass was found on a less crowded but still popular beach (Okuku *et al*. 2020b). The high accumulation rate by mass on this beach was driven by the wash up of a few heavy items not found on other beaches (Okuku *et al*. 2020b). On remote islands, wind plays a pivotal role in determining how much litter strands. For example, at two remote islands in the Seychelles, litter accumulation rates were much lower at a sheltered beach on Cousine Island (Dunlop *et al*. 2020) than on the windward side of Alphonse Island (Table 1; Duhec *et al*. 2015). This highlights the importance of litter originating from offshore sources for small island states in the WIO region (Duhec *et al*. 2015; Dunlop *et al*. 2020).

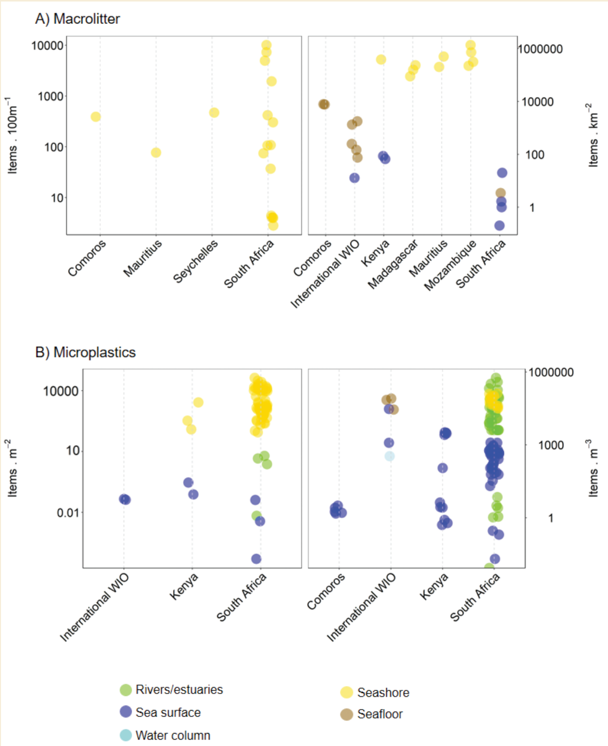


Figure 6: Comparison of (A) macrolitter and (B) microplastic densities in different habitats in WIO countries with the different reporting units shown in the different panels. Panel A includes macrolitter (>25 mm) and mesoplastics (5-25 mm) collected without sieving/filtering, while panel B includes microplastics (<5 mm) and mesoplastics (5-25 mm) collected by sieving/filtering or towing net. Only studies that reported all types of litter (i.e., not just the density of bottles or packaging) are included. The units are expressed on a logarithmic scale and the different reporting units are shown (items 100 m^{-1}, items km^{-2}, items m^{-2}, items m^{-3}). Each point represents the mean density of litter at the finest scale reported in the study; for example, the mean value for each sampling site is included when studies reported at the site-level, whereas the overall mean density when studies reported on a broader scale.

Table 1: Summary of litter accumulation rates on sandy beaches in the WIO region.

Country	Beach	Type of beach	Year of study	Density ($nm^{-1}day^{-1}$)	Mass ($gm^{-1}day^{-1}$)	Reference
South Africa	Milnerton	Urban, close to Cape Town	1995	1.57 ± 0.70	Not given	Swanepoel (1995)
South Africa	Koeberg	Remote, 30km from Cape Town	1995	0.35 ± 0.03	Not given	Swanepoel (1995)
South Africa	Milnerton	Urban, close to Cape Town	2013	14.58 ± 2.73	Not given	Lamprecht (2013)
South Africa	Koeberg	Remote, 30km from Cape Town	2013	1.02 ± 0.43	Not given	Lamprecht (2013)
South Africa	Hout Bay	Harbour, popular recreational beach	2017	5.94 ± 4.94 [SE]	12.94 ± 7.32 [SE]	Chitaka & von Blottnitz (2019)
South Africa	Milnerton	Popular recreational beach	2017	5.21 ± 3.64 [SE]	8.27 ± 8.71 [SE]	Chitaka & von Blottnitz (2019)
South Africa	Muizenberg	Popular recreational beach	2017	0.36 ± 0.28 [SE]	1.34 ± 1.34 [SE]	Chitaka & von Blottnitz (2019)
South Africa	Paarden Eiland	Light industrial zone	2017	29.61 ± 23.86 [SE]	44.21 ± 33.29 [SE]	Chitaka & von Blottnitz (2019)
South Africa	Wolfgat	Coastal nature reserve	2017	21.97 ± 8.25 [SE]	23.40 ± 11.81 [SE]	Chitaka & von Blottnitz (2019)
South Africa	Milnerton	Urban, close to Cape Town	2019	3.29 ± 4.10	12.15 ± 15.21	Opie (2020)
South Africa	Koeberg	Remote, 30km from Cape Town	2019	1.00 ± 0.85	1.70 ± 0.93	Opie (2020)
Kenya	Baobab	Semi-populated, used by fishermen and beachgoers	2019	12.7 ± 12.5	0.04 ± 0.02	Okuku *et al*. (2020b)
Kenya	Kenyatta	Popular tourist beach, easily accessible	2019	18.2 ± 13.6	0.12 ± 0.08	Okuku *et al*. (2020b)
Kenya	Mkomani	Popular tourist beach, easily accessible	2019	16.5 ± 12.5	0.31 ± 0.20	Okuku *et al*. (2020b)
Kenya	Pirates	Popular tourist beach, easily accessible	2019	24.9 ± 19.1	0.16 ± 0.06	Okuku *et al*. (2020b)
Kenya	Tradewinds 1	Popular tourist beach	2019	3.8 ± 3.1	0.04 ± 0.02	Okuku *et al*. (2020b)
Kenya	Tradewinds 2	Popular tourist beach	2019	9.0 ± 7.8	0.08 ± 0.05	Okuku *et al*. (2020b)
Seychelles	Cousine Island	Remote island	2003-2019	0.008 ± 0.008	Not given	Dunlop *et al*. (2020)
Seychelles	Alphonse Island	Remote island	2013	0.78 items·m^{-1}·$week^{-1}$	23.7 kg·km^{-1}·$week^{-1}$	Duhec *et al*. (2015)

Little is known about the vertical distribution of litter on beaches because few studies sample for buried litter (Ryan *et al*. 2020a). On a remote, uncleaned sandy beach in South Africa, over 80% of macrolitter items were buried below the surface, but buried items only contributed 6 - 34% of the total mass of plastic debris because smaller items are more easily buried than larger items (Ryan 2020b; Ryan *et al*. 2020a). The proportion of buried litter is higher on regularly cleaned beaches (Ryan 2020b). This suggests that burial is not a major factor affecting the total mass of litter on a beach, although this should be investigated in other WIO countries. However, it is important to note that buried items are exposed when storm seas erode sandy beaches, and that as sea levels rise we are likely to witness increasing amounts of buried litter being released from beaches and perhaps even from coastal landfills if they are located close to sea (e.g., in Cape Town and Mombasa).

Much less is known about the densities, distribution, and characteristics of litter on other types of shorelines. Only one study has been conducted on a rocky shore in the WIO region (Appendix III Table S1). This survey found higher litter loads at the beginning of the rainy season when litter from streets and stormwater systems were washed into False Bay, Cape Town (Weideman *et al*. 2020b). Similarly, only two studies have sampled for macroplastics in mangroves: Seeruttun *et al*. (2021) sampled in two mangroves on the east coast of Mauritius while Stokes & Manning (2019) sampled along a stretch of sandy beach and in a mangrove close to a village in Madagascar. Litter was significantly more abundant on the beach close to the village than along a transect farther away (although specific litter densities were not reported). The authors did not differentiate between litter in the mangrove versus that on the beach, so it is difficult to tell if densities differed between these two habitats (Stokes & Manning 2019). While no systematic surveys of macrolitter in estuaries are available for the WIO region, Ryan & Perold (2021) conducted daily beach surveys adjacent to the Zandvlei Estuary mouth in False Bay, South Africa. They showed that litter densities were much more varied during the rainy season and litter densities peaked throughout the season 1 to 3 days after rain events, suggesting that most beach litter is washed out of the estuary. Furthermore, experimental releases of marked litter blocks showed that most blocks were washed into the estuary by a rising tide despite strong offshore winds, illustrating that exchanges of litter between estuaries, the sea and nearby beaches can be complex (Ryan & Perold 2021).

2.1.1b. Characteristics and composition

Almost all surveys show that plastics are the most common material found on sandy beaches, although denser materials such as glass, rubber and metal can contribute more to the mass of litter (but few studies report litter mass). Plastics generally make up at least >50% of litter items on beaches, and the daily accumulation rate of plastic litter on sandy beaches in Kenya was one to three orders of magnitude higher than that of other types of litter (Okuku *et al*. 2020b). However, plastics can contribute an even higher proportion of litter, especially on remote beaches (Madzena & Lasiak 1997; Pereira *et al*. 2001; Duhec *et al*. 2015; Bouwman *et al*. 2016; Gjerdseth 2017; Jost 2019; Stokes & Manning 2019; Dunlop *et al*. 2020; Appendix III Table S1).

Of particular concern is plastic packaging (food wrappers, packing strips, bottles, take away cups, etc.), which often dominates litter loads at least numerically, especially on urban sandy beaches (e.g., Ryan & Moloney 1990; Chitaka & von Blottnitz 2017; Okuku *et al*. 2020b; Opie 2020; Ryan 2020b). This type of litter is either left by beachgoers or tourists or washed onto the local beaches as part of river and urban run-off (see Section 3.1 below). This should not be unexpected, given that the packaging sector has been identified as a main source for litter in Kenya, Mozambique, South Africa and Tanzania, contributing from 50% to more than 70% of the total plastic leakage into oceans and waterways, compared to other sectors (IUCN-EA-QUANTIS 2020a,b,c,d). Fish aggregating devices (FADs) are also items of concern, given that significant numbers of them are predicted to get stranded along the coast of east Africa, especially in Somalia and the Seychelles (Maufroy *et al*. 2015). FADs play a significant role in ghost fishing in the WIO region and are regularly found with dead sea turtles and corals entangled in their nets (Balderson & Martin 2015).

Little is known about the types of litter found on other types of shorelines in the WIO region. Surveys of litter stranding on a rocky shore in False Bay, South Africa showed that dense items such as glass and rubber make up a larger proportion of litter than on nearby sandy beaches, although less dense items such as plastic bags can be trapped on the rocky shore if they become filled with sand (Weideman *et al*. 2020b). In Mauritius, Seeruttun *et al*. (2021) showed that plastics were the most common type of material in mangroves, both in terms of number and mass, although the proportions of other materials differed between two study areas (Appendix III Table S1), highlighting how the contribution of specific materials differs locally. For instance, a few large items tend to dominate the mass of litter at certain sites and these almost always come from offshore sources (e.g., fishing gear, dunnage, and other shipping waste; Ryan *et al*. 2020a,c), while Ryan (2020b) showed that plastics become increasingly dominant in terms of litter mass as you move from land-based litter (e.g., street litter) to continental beaches to oceanic islands. However, much more research is needed to determine how the types of litter differ between different regions and how this relates to different litter sources.

2.1.2. Meso- and microplastics

2.1.2a. Amounts, mass and distribution

Data on the density and distribution of meso- and microplastics on the seashore are only available for sandy beaches and estuaries, with no studies having sampled for meso- or microplastics on any other type of shoreline in the WIO region (although there are few data from rocky shores globally, due to the difficulty of sampling, GESAMP 2019). As is the case with macrolitter studies, it is difficult to compare meso- and microplastic densities among studies and sites due to the variety of different sampling methods (e.g., sieving transects, sediment cores, bulk sediment samples), as well as different size classes and reporting units (Figure 3; Figure 6; Appendix III Table S5). The first surveys of mesolitter on sandy beaches were conducted at 52 beaches in South Africa in the 1980s and reported an increase in the average densities from 1984 to 1989 (Ryan & Moloney 1990; Appendix III Table S5). However, subsequent surveys between the 1990s to the 2010s detected little change in the density of mesolitter, with an overall density of 708 items m^{-1}, ranging from 8 to >10,000 items m^{-1} (Ryan *et al*. 2018). As is the case with macrolitter, mesolitter was concentrated around coastal urban centres, although high densities were also seen around the smaller industrial port of Mossel Bay and around the mouth of the Breede River, which drains small inland industrial areas at Worcester and Robertson (Ryan *et al*. 2018). In Kenya, only one study has conducted sieve transects on sandy beaches (i.e., to sieve sand along a transect perpendicular to the shoreline to sample mesolitter), and reported higher densities of mesolitter on beaches closer to populated areas than to semi-populated and remote beaches (Okuku *et al*. 2020a; Appendix III Table S5). No studies have been published about mesolitter on the seashore in the other WIO countries.

There has been great improvement in our knowledge of the density and distribution of microplastics on the seashore of the WIO region since the 2008 UNEP/WIOMSA review, although this field of research is still in its infancy. Most research has been conducted in South Africa; for example, Nel & Froneman (2015) collected sediment cores from 21 South African beaches and showed that almost all particles are microfibres (although they did not identify the polymer types and it therefore remains unclear whether these fibres are plastic). However, they found little difference in microfibre densities between beaches, suggesting that the distribution of microfibres and microplastics is governed by water circulation instead of by population density or the proximity to land-based sources (Nel & Froneman 2015). However, a more recent and comprehensive study by De Villiers (2018) showed that microfibres on 175 sandy beaches were concentrated around coastal urban centres, as is the case with macro- and mesolitter. Both De Villiers (2018) and Ryan *et al*. (2020a) found similar densities of microplastics in sediment cores on the west coast of South Africa, but De Villiers (2018) only sampled at the high tide mark while Ryan *et al*. (2020a) sampled at set intervals across the width of the beach, from spring low to the storm high tide line. This showed that microfibres are distributed across the entire beach profile, unlike more buoyant meso- and macrolitter which tend to accumulate on the high shore. Studies that only sample for microfibres along the high tide mark thus provide a distorted view of microfibre densities and distribution. When extrapolated across the entire beach profile, Ryan *et al*. (2020a) found an average density of 188 000 microfibres/m^{-1}, which completely dwarfed counts of macro- or mesolitter but contributed <0.01% to the total mass of litter (<0.1 g of 1.45 kg·m^{-1}), again highlighting that larger items dominate the mass of litter on beaches (and floating in oceanic gyres, Lebreton *et al*. 2018).

Within urban centres, harbours may act as significant sources of microplastics into the marine environment as they often receive high levels of urban runoff via stormwater drainage systems. Nel *et al*. (2017) sampled at 13 sandy beaches and 3 harbours spanning the entire coastline of South Africa and found the highest densities of microplastics at sites near harbours. Similarly, the highest densities of microplastics on sandy beaches from Tanzania were reported near the industrial port in Dar es Salaam, being significantly higher than the densities found on 17 other sites (Mayoma *et al*. 2020; Appendix III Table S5).

Only two studies have sampled microplastics in estuaries, both in KwaZulu-Natal, South Africa (Naidoo *et al*. 2015; Gerber 2017). Gerber (2017) collected sediment cores from three estuaries while Naidoo *et al*. (2015) sampled at another four (Appendix III Table S5). Interestingly, both studies also measured microplastics on adjacent beaches, but while Naidoo *et al*. (2015) found no change in microplastic densities with distance from the estuary mouth, Gerber (2017) showed that microplastic densities decreased with distance from the estuary mouths, suggesting that estuaries may act as sources of microplastics into the sea and onto adjacent beaches. In support of this, a longitudinal survey of micro-, meso- and macrolitter in the Orange-Vaal River system in South Africa showed that larger meso- and macrolitter were retained upstream near point sources, while microfibres were more evenly distributed along the length of the river with particularly high concentrations of microfibres found near the river mouth in the dry season before seasonal rains flushed the system (Weideman *et al*. 2020c). This suggests that smaller items are more easily transported long distances by rivers, but more research is needed to verify this.

2.1.2b. Characteristics and composition

All studies surveying mesolitter on sandy beaches indicated that plastics were the most frequent material found: they made up >99% of items by number in South Africa (Lamprecht 2013; Ryan *et al*. 2018; Ryan *et al*. 2020a) and 90% of items on Kenyan beaches (Okuku *et al*. 2020a). However, the composition of mesolitter tends to vary according to proximity to urban areas, with a more diverse array of litter on beaches close to urban areas than on remote beaches where only plastics tend to be found (Okuku *et al*. 2020a; Ryan 2020b). In South Africa, most plastics were industrial pellets (Ryan & Moloney 1990; Lamprecht 2013), most of which were either polyethylene or polypropylene (Ryan *et al*. 2012). However, it should be noted that the proportion of industrial pellets has decreased over time, from 80% in 1984 to 68% in 1989 (Ryan & Moloney 1990; Gregory & Ryan 1997) and Ryan *et al*. (2018) showed that pellets are now concentrated at a few beaches where they have probably accumulated over decades. At most beaches, pellets are now scarce (except after accidental container spills, Schumann *et al*. 2019) and there has been a significant decrease in the proportion of pellets ingested by seabirds in the region (Ryan 2008).

Microfibres are by far the most common kind of item found on sandy beaches in South Africa (Naidoo *et al*. 2015; Nel & Froneman 2015; Gerber 2017; Nel *et al*. 2017; Ryan *et al*. 2020a; see Appendix III Table S5) and Mayotte (Jost 2019), and in estuary mouths in South Africa (Naidoo *et al*. 2015; Gerber 2017). While the composition of microlitter varied among 18 beaches along the Tanzanian coastline, fibres and fragments were found at all sites (Mayoma *et al*. 2020). Only one study identified polymer types among microplastics on the seashore and showed that most microfibres were either polyethylene or polypropylene (Mayoma *et al*. 2020), although this is surprising givent that most fibres in sea water samples are not synthetic, like cellulose or animal origin fibers (Suaria *et al*. 2020b).

2.2. Sea surface

2.2.1. Macrolitter

Observations for floating macrolitter have been conducted off the coasts of Kenya (Okuku *et al*. 2021a) and South Africa (Ryan 1988; Ryan 1990; Ryan *et al*. 2014b), as well as along a transect stretching southeast from South Africa to Marion Island (Suaria *et al*. 2020a) and a transect running southeast from South Africa to Crozet and Kerguelen islands (Connan *et al*. 2021; Appendix III Table S2). These studies show that macrolitter is orders of magnitude more abundant in coastal waters closer to land-based sources than those farther away, although there is some evidence that litter accumulates in the southern Indian Ocean gyre (Connan *et al*. 2021). For example, litter densities were particularly high in coastal waters of Kenya (Okuku *et al*. 2021a), and in South Africa, litter densities were significantly higher 10 km offshore compared to 50 km offshore (Ryan 1988; Appendix III Table S2). In contrast, litter was scarce in the Agulhas Current and its retroflection (Ryan 1990; Ryan *et al*. 2014b), in temperate waters southwest of Cape Town, South Africa (Ryan *et al*. 2014b) as well as in international temperate waters southeast of South Africa (Suaria *et al*. 2020a; Figure 6A; Appendix III Table S2). While the types of macrolitter floating off the coast of Kenya were not specified, >90% of macrolitter off South Africa was plastic, with the most common types being plastic packaging (Ryan *et al*. 2014b) and larger items being more abundant at sites further offshore than those close to the coast (Ryan 1988).

2.2.2. Meso- and microplastics

There have been significant improvements in our understanding of the densities, distribution, and characteristics of floating meso- and microplastics since the 2008 UNEP/WIOMSA review. However, few studies used the same mesh sizes or reporting units, making it difficult to directly compare meso- and microplastic densities across the region (Figure 3; Figure 6B; Appendix III Table S6), once again highlighting the need for harmonised approaches to microplastics sampling (Twiss 2016; GESAMP 2019; Provencher *et al*. 2020; Galgani *et al*. 2021).

Of the 12 studies that sampled for floating micro- and mesoplastics with nets (0.2 - 0.5 mm mesh), five were conducted in South Africa (Ryan 1988; Ryan 1990; Massot Mascaró 2015; Nel & Froneman 2015; Naidoo & Glassom 2019), three in international waters in the WIO region (Cózar *et al*. 2014; Eriksen *et al*. 2014; Suaria *et al*. 2020a), three in Kenya (Kerubo *et al*. 2020; Kosore 2020; Okuku *et al*. 2021a) and one in Mayotte, Comoros Archipelago (Jost 2019; Figure 6B; Appendix III Table S6). The highest densities were found in coastal waters in Kenya (mesh size = 0.3 mm, Kosore 2020; Okuku *et al*.2021a) and South Africa (mesh = 0.08 mm, Nel & Froneman 2015; mesh size = 0.2 mm, Suaria *et al*. 2020a; Appendix III Table S6). All studies reported that plastics were the most common anthropogenic material caught in the nets. Interestingly, Nel & Froneman (2015) did not find a correlation between microplastic and human population densities, and thus suggested that microplastic abundance is more likely governed by surface water currents than proximity to land-based sources. In contrast, Naidoo & Glassom (2019) found the highest concentrations of micro- and mesoplastics at sites close to the urban centre of Durban, thus suggesting that urban run-off is a major source of litter into the sea. Naidoo & Glassom (2019) did, however, also state that ocean currents played a significant role in determining the distribution and accumulation of meso- and microplastics, particularly in winter. In Kenya, seasonal variations (i.e., southeast monsoon and northeast monsoon) were found to influence microplastics abundance in surface waters, with the highest densities reported during the southeast monsoon season (Kosore 2020).

Five studies sampled for microplastics and microfibres by collecting bulk surface water samples. In South Africa, Nel *et al*. (2017) collected samples from 16 coastal sites while Preston-Whyte *et al*. (2021) sampled at nine sites in Durban Harbour. Of the sites sampled by Nel *et al*. (2017), Durban Harbour was the most polluted, although Preston-Whyte *et al*. (2021) found significantly lower concentrations in the harbour. This difference is likely explained by the different mesh sizes used; Nel *et al*. (2017) used a 0.063 mm mesh while Preston-Whyte *et al*. (2021) used a 0.2 mm mesh. In other studies, microplastic densities were significantly higher in samples collected with smaller mesh sizes versus those collected with large meshes (Lindeque *et al*. 2020; Ryan *et al*. 2020d), illustrating the importance of considering mesh size when comparing studies, especially for fibres (Ryan *et al*. 2020d). Both Nel *et al*. (2017) and Preston-Whyte *et al*. (2021) found mostly microfibres, although most fibres in surface waters are not synthetic (Suaria *et al* 2020b). Nel *et al*. (2017) and Preston-Whyte *et al*. (2021) also suggested that harbours may be important sources of microplastics and microfibres into the sea because they often receive stormwater and other runoff from adjacent urban areas, which is in agreement with several studies from other parts of the world (e.g., Ballent *et al*. 2016; Rose & Webber 2019). More research is needed to determine whether this is true for the rest of the WIO region. No study has examined whether there is a relationship between wastewater discharges and microplastics in coastal waters.

Outside of South Africa, bulk water samples have been collected along the coasts of Mozambique and Tanzania (Suaria *et al*. 2020b), and in Kenya's Exclusive Economic Zone (EEZ; Kosore *et al*. 2018) and within coastal creeks (Kerubo *et al*. 2020). Suaria *et al*. (2020b) used a mesh of 0.02 mm and found a median density of 1200 items m^{-3}, although there was large variation between samples (interquartile range = 300 - 3000 items m^{-3}). They showed that most particles were microfibres and that >90% were of natural origin rather than synthetic. In Kenya, Kosore *et al*. (2018) used a 0.25 mm mesh and found an overall density of 110 items m^{-3}. They also found that most particles were fibres, but unlike Suaria *et al*. (2020b), Kosore *et al*. (2018) only identified synthetic polymers, of which polypropylene (PP) was the most common. At the surface waters of three creeks along the Kenyan coast, Kerubo *et al*. (2020) reported a considerably higher overall mean microplastics density (2 898 items m^{-3} using a mesh of 0.02 mm), of which 93% corresponded to fibres.

2.3. Water column

Macrolitter observations off the coast of South Africa have detected some sub-surface litter, but it is unclear what proportion of litter was missed due to poor visibility below the surface of the water (Ryan 1988; Ryan 1990; Ryan *et al*. 2014b). Litter in the water column is either made of materials with a higher density than seawater that will automatically sink, or litter that has become colonised by epibionts, which reduces its buoyancy (Fazey & Ryan 2016a,b). For example, a bread bag was recently found at a depth of 185 m off the coast of South Africa (Ryan *et al*. 2020c). The date stamp on the bag indicated that it was only three months old and, judging by the size of the goose barnacles growing on it, had floated at sea for 20-30 days before becoming fouled enough to sink (Ryan *et al*. 2020c). Litter that sinks in this way could "yo-yo" up and down the water column (see Section 3.3.4 for details) or become trapped on the seabed if it becomes buried in bottom sediments or further fouled by benthic organisms.

Only one study sampled for microlitter in the water column in the WIO region by collecting bulk water samples from the ship's underway system (5 m depth) along a transect from Cape Town to the Prince Edward Islands (Ryan *et al*. 2020d; Appendix III Table S7). The study showed that microfibres are significantly less abundant in the water column than at the sea surface and that most microfibres are of natural origin rather than made of plastic polymers (Ryan *et al*. 2020d; Suaria *et al*. 2020b). While several studies have sampled for microplastics in the water column in other parts of the world's oceans (e.g., Reisser *et al*. 2015; Kanhai *et al*. 2018; Choy *et al*. 2019; Erni-Cassola *et al*. 2019), this remains one of the least studied marine habitats globally and there is an urgent need for more research on the vertical distribution, movement, and fate of marine litter in the water column.

2.4. Seafloor

2.4.1. Macrolitter

Five studies have conducted macrolitter surveys on the seafloor of the WIO region (Figure 6; Appendix III Table S3). The highest densities of litter were found using Remotely Operated Vehicles (ROVs) at deep-sea sites (100-1,500 m deep) along the Southwest Indian Ocean Ridge >1300 km south of Madagascar (Woodall *et al*. 2015). Most of this litter was fishing gear, suggesting that the deep seafloor off the coast of southern Africa might be a long-term sink for litter originating from fisheries. In contrast, trawl surveys conducted on the continental shelf (30-850 m deep) off the south and west coasts of South Africa found significantly lower densities of litter (Ryan *et al*. 2020c). Most (48%) of this litter was plastic packaging and 17% were discarded fishing gear, suggesting that items littering the seafloor originate from both land-based sources and at-sea activities (Ryan *et al*. 2020c). These low litter densities were confirmed by ROV footage taken in several habitat types on the South African continental shelf and slope, which found almost no litter (Ryan 2020b). In False Bay, South Africa, underwater transects conducted at 18 sites found 557 litter items, mostly flexible packaging and bottles trapped in reef areas (although the density of litter was not reported, Rundgren 1992). However, Ryan (2020b) found no litter items in 421 images taken on the seabed of False Bay.

Mulochau *et al*. (2020) conducted dive transects on reefs fringing the island of Mayotte (Comoros Archipelago) where they found similar litter densities in both winter and summer. More than 90% of litter was plastic (Appendix III Table S3) and >60% of litter in both seasons was discarded fishing gear, suggesting that most of the litter found on the reefs comes from fisheries operating in the area. However, bags and bottles made up a significant proportion of litter, which the authors postulate were washed into the local marine environment as part of urban and river run-off (Mulochau *et al*. 2020). More than half of the corals surveyed by Mulochau *et al*. (2020) showed signs of damage associated with marine litter (mostly breakage and abrasion) and similar effects have been seen on reefs in Sodwana Bay, South Africa (Schleyer & Tomalin 2000). Given that plastics have been associated with diseases in coral reefs (Lamb *et al*. 2018), more research is needed to determine the density, types, and possible sources of marine litter on other coral reef systems in the rest of the WIO region.

2.4.2. Meso- and microplastics

Only three studies report microplastic densities in bottom sediments in the WIO region, two of which sampled in Durban harbour, South Africa (Matsuguma *et al*. 2017; Preston-Whyte *et al*. 2021) and one which sampled at deep-sea sites off the east coast of South Africa between 40°E and 60°E (Woodall *et al*. 2014). It is, however, difficult to directly compare these three studies because they used different filter sizes (Figure 3B; Appendix III Table S8). In Durban harbour, Matsuguma *et al*. (2017) reported 1.3 ± 0.79 microplastics/g^{-1} dry sediment in a single sediment core, with most microplastics either polyethylene (PE, 38%), polyethylene-polypropylene copolymer (PEP, 26%) or polyethyleneterphthalates (PET, 10%). In a more comprehensive study, Preston-Whyte *et al*. (2021) found slightly higher microplastics densities although there was large variation between nine sites in Durban harbour, with the highest densities found close to point sources such as sewage overflows, stormwater drains and river mouths. Most items were PE (47%) although it is unclear why such a high proportion of fibres in sediment were made of a buoyant polymer (density of PE = 0.88 - 0.96 g/cm^{-3}). Interestingly, 21% of fibres were made of cellophane, which supports the findings of Suaria *et al*. (2020b) that a high proportion of microfibres collected from environmental samples are of natural origin. At the deep-sea sites, Woodall *et al*. (2014) found 1.4 - 4 fibres/50 mL^{-1} sediment, all of which were polyester (Woodall *et al*. 2014).

Chapter 3: Sources, transport, and fate of marine litter and microplastics in the WIO

3.1. Land-based sources

The published literature indicates that land-based sources account for most of the litter entering the WIO marine environment. For example, field surveys in South Africa (Gerber 2017; De Villiers 2018; Ryan *et al*. 2018; Ryan 2020b; Ryan & Perold 2021), Kenya (Okuku *et al*. 2020b; Ryan 2020a) and Tanzania (Mayoma *et al*. 2020) show that both micro- and macrolitter on shorelines are concentrated around large coastal urban centres or river mouths, suggesting that most litter enters the sea as part of urban and river run-off. Indeed, the national hotspotting assessments implemented in these countries and Mozambique indicate that low waste collection rates coupled with high rates of improperly disposed waste (due to a lack of official sanitary landfills and incineration facilities in these continental countries) are major drivers of the plastic waste leakage into rivers and consequently to the ocean (IUCN-EA-QUANTIS 2020a,b,c,d). This is further supported by brand audits in South Africa (Madzena & Lasiak 1997; Ryan & Perold 2021; Ryan *et al*. 2021) and Kenya (Okuku *et al*. 2020b, 2021b; Ryan 2020a), which show that most beach litter is locally manufactured. However, as suggested by a higher proportion of foreign brands on a Kenyan beach during the southeast monsoon over the northeast monsoon, some litter also arrives from the ocean and the proportion varies seasonally (Okuku *et al*. 2021b). On remote beaches, the proportion of foreign bottles increases to more than 50% due to inputs from shipping and long-distance drift (Ryan 2020a; Ryan *et al*. 2021). The most important land-based sources are described in detail below.

3.1.1. Illegal dumping, tourism and beachgoers

For most WIO countries, beaches are one of the main tourist attractions and beachgoers contribute significantly to local and national economies. However, tourists and beachgoers can also negatively affect local marine environments by littering, which is supported by several studies that show higher densities of beach litter on popular tourist beaches (e.g., Gjerdseth 2017; Okuku *et al*. 2020b). Most of the litter left by beachgoers is packaging, particularly single-use food-packaging items (e.g., Okuku *et al*. 2020b). Local residents can also contribute significant amounts of litter, especially in areas with poor waste management and service delivery. For example, Gjerdseth (2017) noted that a common practice in northern Madagascar is for residents to leave their rubbish on the edge of their property where it can easily be blown onto the beach, resulting in high litter densities on the backshore.

3.1.2. Industries, sewage, and wastewater effluent

Industries may also act as significant sources of litter into the environment. Beach surveys around the coast of South Africa showed that industrial pellets were concentrated around urban centres, which is where industry tends to be concentrated, suggesting that at least historically many pellets were released into the environment from manufacturing plants that did not dispose of their waste properly (Ryan *et al*. 2018). This was supported by a more recent study in Cape Town, South Africa, which found industrial pellets being released into the Diep River via urban runoff from storm drains (Weideman *et al*. 2020d). However, as noted earlier, the density of industrial pellets on many South African beaches (Ryan *et al*. 2018) and the proportion ingested by seabirds (Ryan 2008) have been significantly reduced since the implementation of Operation Clean Sweep (https://www.opcleansweep.org/), showing that proper waste management is key to reduce the amount of litter released into the environment. No research has been conducted on the level of contamination of treated wastewater and sewage sludge in the WIO region, thus highlighting a major knowledge gap in our understanding of the sources of microplastics and microfibres. However, given the high proportions and densities of microfibres on sandy beaches and estuaries, some studies have suggested that wastewater is likely an important source of microfibres and other microplastics (Gerber 2017; De Villiers 2018; Jost 2019).

3.1.3. Rivers and urban run-off

Urban run-off has been suggested as one of the main land-based sources of litter in some WIO countries, given the "haloes" of litter seen around urban centres in South Africa (Ryan *et al*. 2018; Ryan 2020b; Figure 7), Kenya (Okuku *et al*. 2020b; Ryan 2020a) and Tanzania (Mayoma *et al*. 2020) and the high proportion of locally manufactured goods found on urban beaches (Ryan 2020a; Ryan *et al*. 2021). Similarly, Jost (2019) inferred that most litter seen on beaches in Mayotte is washed into the sea and onto beaches via urban run-off. Additionally, several studies in South Africa have shown that significant amounts of street litter are washed into the sea via storm drains, with the highest litter loads found in industrial and low-income residential areas with poor service delivery (Armitage & Rooseboom 2000; Marais *et al*. 2004; Weideman *et al*. 2020d; Appendix III Table S4). However, no data are available on the amount of litter in stormwater and other drainage systems in any of the other WIO countries, making it difficult to quantify how much litter is released into the sea as part of urban run-off.

Urban run-off and rivers go hand in hand because many stormwater systems drain directly into canals and rivers that can then transport litter to the sea. In the WIO region, no field studies have quantified the amount of litter washing into the sea from rivers for any countries except South Africa (Weideman *et al*. 2020c; Moss *et al*. 2021; Appendix III Table S4 and Table S9). These show that litter loads tend to be highest in rivers whose catchments are highly urbanised or industrialised (Swanepoel 1995; Moss *et al*. 2021) with significantly lower amounts of litter seen in rural rivers such as at the mouth of the rural and relatively pristine Orange River (Weideman *et al*. 2020c). Further inland, Weideman *et al*. (2020c) found the highest densities of meso- and macro-litter in the Vaal River downstream of the Johannesburg-Pretoria urban conurbation, but this litter was not transported far downstream, suggesting that river sediments and riparian vegetation are significant sinks for litter (Verster & Bouwman 2020; Weideman *et al*. 2020c). The litter that is transported is washed into mangroves, the sea and onto beaches by seasonal rains, as was validated by the higher litter loads on South African urban beaches at the beginning of the rainy season (Chitaka & von Blottnitz 2019; Weideman *et al*. 2020a,b). Ryan & Perold (2021) showed that the movement of litter between estuaries, the sea and beaches can be complex with rain and tides playing a significant role in determining how litter is transported and where it is retained (see Section 2.1.1a above). However, this has not been studied in other areas of the WIO and is an important knowledge gap, especially given that studies in other parts of the world show that litter can become trapped in estuaries for long periods of time (e.g., Tramoy *et al*. 2020).

3.2. Sea-based sources

While most litter enters the sea from land-based sources, a significant amount still originates at-sea, for example from fishing and shipping activities or via long-distance drift (which could originate from either land- or sea-based littering). These different sea-based sources are summarised below.

3.2.1. Fishing and shipping

Discarded fishing gear is commonly found across the WIO region (e.g., Burt *et al*. 2020; Okuku *et al*. 2020b), although the proportion of fishing gear versus other types of litter varies regionally and temporally. For example, fishing gear and other shipping-related gear tend to make up a larger proportion of litter mass on remote beaches (Ryan 2020b) and islands (Burt *et al*. 2020) than on beaches close to land-based source areas. Similarly, fishing gear was by far the most common type of litter at deep-sea sites south of Madagascar (Woodall *et al*. 2015), suggesting the deep-sea is a sink for debris from pelagic fisheries. In contrast, trawl surveys along the continental

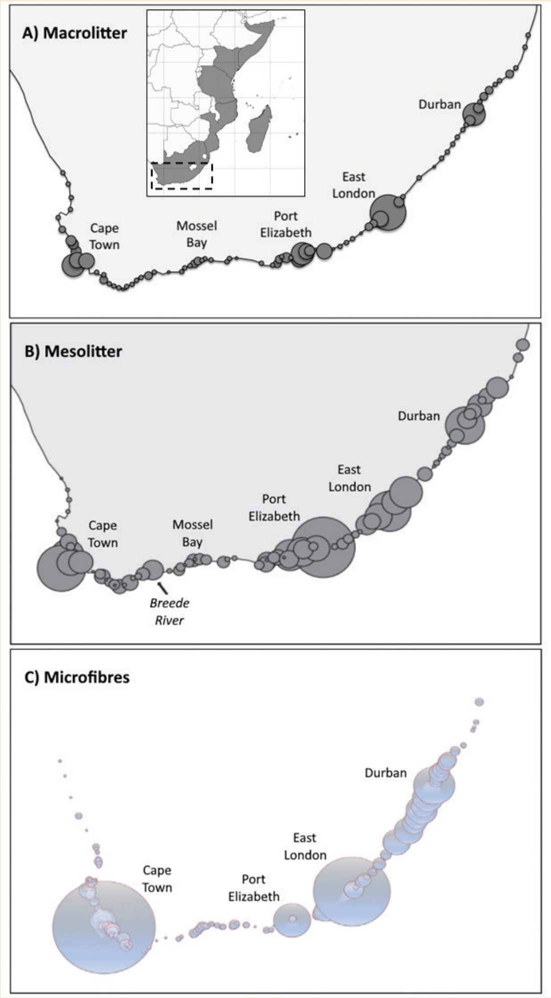


Figure 7: Maps showing how (A) macrolitter, (B) mesolitter, and (C) microfibres sampled on sandy beaches are concentrated close to large coastal urban centres in South Africa (study area shown in the dashed square inside insert in A). Densities of macrolitter, mesolitter and microfibres are represented by the circles, increasing with circle size. Panels were modified after Ryan (2020b), Ryan et al. (2018), and De Villiers (2018), respectively.

shelf of South Africa found a mix of fishing gear and other types of litter, suggesting litter originates from both at-sea and land-based sources (Ryan *et al*. 2020c). The abundance of fishing gear can also vary temporally; for example, the proportion of fishing-related litter regurgitated by seabirds on Marion Island decreased dramatically after the collapse of the Patagonian toothfish fishery around the islands (Perold *et al*. 2020).

Litter can also be dumped or lost from shipping activities. For example, date stamps on many of the foreign bottles that wash up along the coast of South Africa show that bottles were manufactured within a few months of manufacture, which is too short a period for them to have drifted from their country of origin. Rather, these bottles are likely illegally dumped from ships (Ryan *et al*. 2019, Ryan *et al*. 2021). There have also been several accidental industrial pellet spills when containers full of pellets were lost from ships off the coast of South Africa, releasing tens of tonnes of pellets into the sea (e.g., Schumann *et al*. 2019).

3.2.2. Long-distance drift

East Africa is downstream of southeast Asia, which is estimated to be the world's largest contributor to land-based plastic into the sea (Jambeck *et al*. 2015; Lebreton *et al*. 2017). Lagrangian drift simulations predict that ~1-5% of litter released from Southeast Asia is transported by surface currents to the southern Indian Ocean (see Section 3.3.2 for details), where much of it strands on WIO island states and along the east coast of Africa (Van der Mheen *et al*. 2020). This is supported by heavily fouled Asian branded litter items which have been found on shorelines in South Africa (Ryan & Perold 2021; Ryan *et al*. 2021), Kenya (Ryan 2020a) and on Alphonse Island in the Seychelles (Duhec *et al*. 2015). However, given that >80% of litter in Kenya and South Africa is locally manufactured, the contribution of litter via long-distance drift is likely low compared to local sources, at least for continental countries on the African east coast. This highlights the need for local solutions to the marine debris problem (see Chapter 7 below). In contrast, a high proportion of litter stranded on the remote islands of the WIO clearly originates from offshore sources (e.g., Duhec *et al*. 2015; Burt *et al*. 2020), most of which likely comes for southeast Asia, and the cost of removing this litter is extreme (Burt *et al*. 2020). There is therefore also a need for stricter international regulations to be put in place to limit land-based leakage of litter, and potentially to provide mechanisms for severely impacted countries to seek support from polluting nations in tackling local litter issues.

3.3. Transport and fate of marine litter

3.3.1. Beaches are major sinks for marine litter

In the WIO region, oceanographic models predict that most buoyant litter entering the sea strands on local shorelines close to source (Collins & Hermes 2019; Van der Mheen *et al*. 2020; Chenillat *et al*. 2021). This is supported by the concentration of macro- (Ryan 2020b), meso- (Ryan *et al*. 2018) and microlitter (De Villiers 2018) around coastal urban centres in South Africa (De Villiers 2018; Ryan *et al*. 2018; Ryan 2020b; Figure 7), Kenya (Okuku *et al*. 2020b; Ryan 2020a) and Tanzania (Mayoma *et al*. 2020) and close to estuaries and river mouths in South Africa (Gerber 2017; Ryan & Perold 2021). This is further supported by experimental releases of marked plastic and wood blocks in South African rivers which show that at least 80% of litter strands within a few kilometres of the river mouth (Maclean 2020; Ryan & Perold 2021). Together, these studies suggest that shorelines in the WIO region are major sinks for litter.

The stranding rate and turnover of marine litter on shorelines does, however, depend on several factors. For example, items made from polymers that are more dense than seawater are more likely to be transported offshore in undertow currents, while less dense polymers with high windage such as expanded polystyrene or sealed empty bottles that float well above the water surface are more easily blown onto the shore (Maclean 2020; Ryan 2020b). However, it is difficult to predict the fate of windblown marine litter: it can be blown inland and become trapped in coastal vegetation during periods of strong onshore winds but might also be blown back into the surf zone by offshore winds (Brennan *et al*. 2018). This is particularly true for light-weight items such as expanded polystyrene, which have particularly high turnover rates on beaches (Ryan *et al*. 2014a). Once litter re-enters the surf zone, high density items are again more likely to be carried offshore, although these can be washed back onto shorelines during upwelling events (Spencer 2020; Weideman *et al*. 2020a,b). Low density items may once again be blown onto the shore where they can be buried, trapped in coastal vegetation, or return into the surf zone (Ryan 2020b). Stranded litter can also be picked up by beachgoers, although the impact of cleaning depends on the frequency of cleaning programmes and the number of cleaners (Ryan 2020b). Beach cleaners also often target larger items and cleaning efforts thus have a greater impact on the mass of litter on beaches rather than the number of items (Ryan *et al*. 2009; Ryan 2020b).

The type of habitat and its physical characteristics also influence the turnover rate of stranded litter. Rocky shores may act as sinks for high-density items (Weideman *et al*. 2020b), while the turnover rate of litter is higher on coarse or pebbly beaches with steep slopes (from which litter is easily washed back into the surf zone) than on gently sloping sandy beaches (Ryan 2020b) or beaches with back-vegetation that trap litter items (Ryan *et al*. 2014a; Okuku *et al*. 2020a). On sandy beaches, litter can become buried under the sand, but few beach surveys sample for buried litter, making it difficult to determine the turnover rate of buried litter for much of the WIO region (Ryan *et al*. 2020a; see Section 2.1.1a above).

3.3.2. Dispersal of floating litter that does not strand on beaches

While much land-based litter strands on shorelines close to where it was washed into the sea, a small proportion may also be transported offshore (Duhec *et al*. 2015; Collins & Hermes 2019; Van der Mheen *et al*. 2020; Chenillat *et al*. 2021). For example, Lagrangian drift simulations predict that ~5-10% of litter released from east African rivers will be transported to the open ocean (Van der Mheen *et al*. 2020), where it is predicted to accumulate either along salinity fronts (as reviewed by Pattiaratchi *et al*. 2021), particularly where rivers enter the sea (e.g., Acha *et al*. 2003; Ryan 2020b), or be retained within the Indian Ocean gyre (Cózar *et al*. 2014; Eriksen *et al*. 2014; Van der Mheen *et al*. 2019, 2020; Chenillat *et al*. 2021). However, more at-sea surveys are needed to determine the extent of these accumulation zones in the WIO region (Connan *et al*. 2021; Pattiaratchi *et al*. 2021). It is not surprising that such a small proportion of litter is predicted to be transported offshore given that east Africa is a western boundary current. Here, strong onshore currents wash debris back onto beaches (Chenillat *et al*. 2021), compared to eastern boundary currents where upwelling carries floating litter offshore (Ryan 2020a). In support of this, ocean circulation models predict that >90% of litter released off the east coast of South Africa strands on local beaches, compared to only 19% of litter released from Cape Town on the southwest coast (Collins & Hermes 2019). However, the models assumed all litter from Cape Town was released into Table Bay, but litter released into False Bay is much more likely to strand due to the semi-enclosed nature of the bay (Ryan 2020b). Furthermore, the models did not account for near-shore conditions and assumed all litter was released 8 - 10 km offshore and it is therefore unclear how accurate they are (Ryan 2020b).

Lagrangian drift simulations predict that litter entering the northern Indian Ocean during the northeast and southwest monsoons will be transported back and forth between the Bay of Bengal and the Arabian Sea by seasonal surface currents (Figure 8; Van der Mheen *et al*. 2020; Pattiaratchi *et al*. 2021). Almost all of this litter is predicted to beach along the north Indian Ocean coastline within a few years of being washed into the sea, although a small proportion may be transported south by the Somali Current where it is predicted to beach in Somalia (Van der Mheen *et al*. 2020; Pattiaratchi *et al*. 2021). However, in the inter-monsoon period, following the southwest monsoon (September to November), up to 5% of litter released into the northern Indian Ocean is predicted to be transported eastwards along the equator by semi-annual Wyrtki Jets (dashed grey line in Figure 8) where it is picked up by the South Java Current and transported southeast across the equator (Van der Mheen *et al*. 2020). The South Java Current then feeds into the South Equatorial Current, which transports the litter southwest into the southern Indian Ocean. This litter can then be transported south along the east coast of Madagascar by the Southeast Madagascar Current, north along the coasts of Tanzania, Kenya, and Somalia by the Northeast Madagascar, East African Coastal and Somali Currents, or south along the coast of South Africa by the Agulhas Current (Figure 8; Van der Mheen *et al*. 2020).

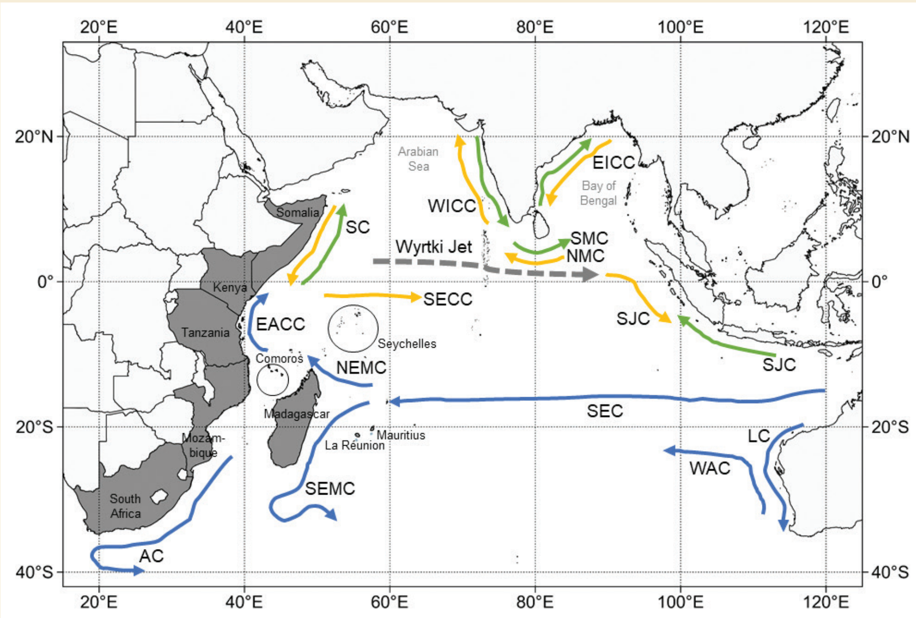


Figure 8: Map showing the major ocean currents of the Indian Ocean during the northeast (yellow arrows) and southwest (green arrows) monsoon. Annual currents not affected by the monsoon are shown by the blue arrows and the semi-annual, inter-monsoon Wyrtki Jet is shown by the dashed grey line. Currents are: AC = Agulhas Current, SEMC = Southeast Madagascar Current, NEMC = Northeast Madagascar Current, EACC = East African Coastal Current, SC = Somali Current, WICC = West Indian Coastal Current, SMC = Southwest Monsoon Current, NMC = Northeast Monsoon Current, EICC = East Indian Coastal Current, SJC = South Java Current, SEC = South Equatorial Current, SECC = South Equatorial Counter Current, WAC = West Australian Current, and LC = Leeuwin Current. Western Indian Ocean countries included in this review are shown in dark grey and ocean currents are based on Wijeratne et al. (2018), Rahaman et al. (2020) and Van der Mheen et al. (2020).

Much of this litter is expected to beach on WIO island states and along the east African coast, and field surveys in Seychelles (Duhec *et al*. 2015), Mauritius (Bouwman *et al*. 2016), South Africa (Ryan & Perold 2021; Ryan *et al*. 2021) and Kenya (Okuku *et al*. 2020b; Ryan 2020a) have indeed found Asian branded packaging covered in epibionts or with fish bite marks, which is indicative of long periods spent floating at sea.

Litter entering the Southern Indian Ocean from the west coast of Australia can also cross the Indian Ocean and eventually beach in east Africa (Trinanes *et al*. 2016; Pearce *et al*. 2019). Several modelling studies using a variety of data predict that litter released off the Australian west coast is transported in three phases: litter first becomes entrained in the Leeuwin Current eddy system where it can be retained for up to a year; it then enters the westward flowing South Equatorial Current, which transports it across the southern Indian Ocean; it is then picked up by the western boundary current system off southern Africa where it can be transported along the east African coast and eventually strands on shorelines in the WIO region (Figure 8; Trinanes *et al*. 2016; Van der Mheen *et al*. 2019, 2020; Pearce *et al*. 2019). However, Australian bottles are rare (<1% of foreign bottles) along the coasts of Kenya (Ryan 2020a) and South Africa (Ryan *et al*. 2021), which is likely due to Australia's effective waste management system (Jambeck *et al*. 2015) or because ships docking in Australia manage their waste well (given that most foreign PET bottles probably are discarded illegally from ships; Ryan 2020a).

3.3.3. Transport by marine animals

Animals may act as transport vectors of marine litter onto land. For example, birds often incorporate marine litter into their nests (Nel & Nel 1999; Witteveen *et al*. 2017; Perold *et al*. 2020; Ryan 2020c; Tavares *et al*. 2020; see Section 4.1.4 below for details) and marine predators such as seabirds and seals may transport litter onto land when they haul out to moult, either by regurgitating or excreting ingested litter (Ryan 2020b; Perold *et al*. 2020). Any ingested litter will also be retained on land when an individual dies (Nel & Nel 1999). However, despite the large populations of many of these marine predators, this behaviour probably only accounts for a small amount of marine litter in the WIO region due to the low ingestion rates for seals (Ryan *et al*. 2016b) and low plastic loads for most species of seabirds (Ryan 2020b).

3.3.4. The seabed as a long-term sink for marine litter

Several studies have suggested that the seabed is a long-term sink for marine litter (e.g., Woodall *et al*. 2014), especially for materials that have a higher density than seawater or items that have become less buoyant due to fouling by marine organisms. This has been supported by surveys on South African beaches, which showed that buoyant items dominate stranded litter on beaches farther from source areas (Fazey & Ryan 2016b) and that most items collected in trawls off the coast of South Africa floated after being cleaned (Ryan *et al*. 2020c). However, the limited data on the characteristics and densities of litter on the seafloor of the WIO region (see Section 2.4 above) make it difficult to ascertain to what degree the seafloor acts as the ultimate sink for marine litter.

Floating marine litter can also sink to the seafloor when it becomes colonised by epibionts, decreasing its buoyancy. For example, experiments conducted in shallow coastal waters of South Africa showed that small, tethered items with large surface area to volume ratios tended to sink within 2-3 weeks, while fouling rates were much slower on larger items with small surface area to volume ratios, which only sank after >2 months (Fazey & Ryan 2016a). However, it remains unclear whether fouling rates vary seasonally, how tethering affects fouling rates and whether fouling rates differ between inshore versus offshore waters (Ryan 2020b). The fate of items that sink in this way also remains unclear. In shallower waters, litter probably sinks to the seafloor where it can quickly become fouled by benthic organisms and retained in sediment. In contrast, litter that sinks in deeper waters may move up and down the water column because epibionts will die and fall off as the item sinks below the photic zone (thus increasing its buoyancy) but recolonise the litter (and again decrease its buoyancy) as it moves back up to shallower waters (Ye & Andrady 1991; Kooi *et al*. 2017). However, if the item reaches the seafloor before surface epibionts fall off, it will likely be further fouled by benthic organisms or become weighed down by sediment and thus retained on the seafloor.

Chapter 4: Ecological and human health impacts of marine debris

4.1. The ecological impacts of marine debris

More than one third of the 136 reviewed studies (38%) reported interactions between organisms and marine litter or microplastics (summarised in detail below). Interactions have been documented in all countries except mainland Comoros (excluding Mayotte) and Somalia (Figure 5), and the most commonly documented interactions were ingestion and entanglement (Figure 9, Table 2, Table 3). However, it should be noted that we did not include entanglement in active fishing gear, although it is often hard to differentiate entanglement in ghost gear from bycatch in active gear (Ryan 2018). Entanglement in active gear appears to be a significant problem for whales, which often become entangled in the buoy lines attached to crayfish or octopus traps (e.g., Best *et al*. 2001; Meÿer *et al*. 2011), and sharks and sea turtles, which easily become entangled in drifting FADs (Filmalter *et al*. 2013; Poisson *et al*. 2014; Balderson & Martin 2015; Filmalter *et al*. 2015; Forget *et al*. 2015; Maufroy *et al*. 2015; Bonnin *et al*. 2020).

4.1.1. Ingestion

Plastic ingestion has been most well studied in seabirds and 94% of all seabird species studied so far in the WIO region have been shown to ingest plastic litter (Table 2). Studies of seabirds ingesting marine litter have largely focused on those species that forage widely across the south-west Indian, Atlantic, and Southern Oceans and breed at sub-Antarctic islands (Appendix III Table S10). Thorough reviews of plastic ingestion by these seabirds include Ryan (1987b), who recorded plastic ingestion in 36 out of 60 species and showed that ingestion was most frequent in Procellariiformes, and Ryan (2008), who reported a decrease of 44-79% in the proportion of ingested virgin pellets in five species of seabirds from the 1980s to 2006. Interestingly, Ryan *et al*. (2016b) analysed the ingestion of plastics >0.5 mm in seven species of albatrosses off South Africa and only found plastics in the stomachs of one species (shy albatross *Thalassarche cauta* sensu lato), highlighting the importance of also reporting negative records. Albatrosses and giant petrels breeding on Marion Island regularly regurgitate fishing gear and other plastic items at their nests, but litter loads tend to be low (Nel & Nel 1999; Perold *et al*. 2020), especially compared to burrow-nesting species (Ryan 1987b). On La Réunion and Juan de Nova islands, the most common types of litter ingested by seabirds were fibres and fragments, which were found in the stomach contents of nine species of seabirds, of which tropical shearwaters (*Puffinus bailloni*) and Barau's petrels (*Pterodroma baraui*) were the most affected (Cartraud *et al*. 2019).

Plastic ingestion has been studied in four species of sea turtle, with samples collected in South Africa (Hughes 1973; Ryan *et al*. 2016a), Mayotte (Comoros Archipelago; Claro & Hubert 2011; Chebani 2020), La Réunion (Claro & Hubert 2011), and in oceanic waters around La Réunion and Madagascar (Hoarau *et al*. 2014; Barret *et al*. 2018). All four species were found to have ingested plastic debris (Table 2, Appendix III Table S13), with the first records dating back almost 50 years, when plastic bags, strips, sheets, and beads were found in the stomach contents of loggerhead turtles (*Caretta caretta*) in South Africa (Hughes 1973). Overall, loggerheads have been the most studied sea turtle species (Hughes 1973; Ryan *et al*. 2016a; Hoarau *et al*. 2014; Barret *et al*. 2018) and are also the species with the highest proportion of individuals with ingested litter (Claro & Hubert 2011). Hard-backed turtles (Cheloniidae) switch from pelagic to benthic foraging as they mature and pelagic hatchlings are therefore most likely at risk given the prevalence of plastics floating on the sea surface (Ryan *et al*. 2016a). Indeed, all individuals sampled around La Réunion and Madagascar were juveniles foraging on pelagic prey (Hoarau *et al*. 2014). In contrast, leatherback turtles (*Dermochelys coriacea*) feed on jellyfish at the sea surface and the water column and are thus at risk of ingesting marine debris throughout their lives.

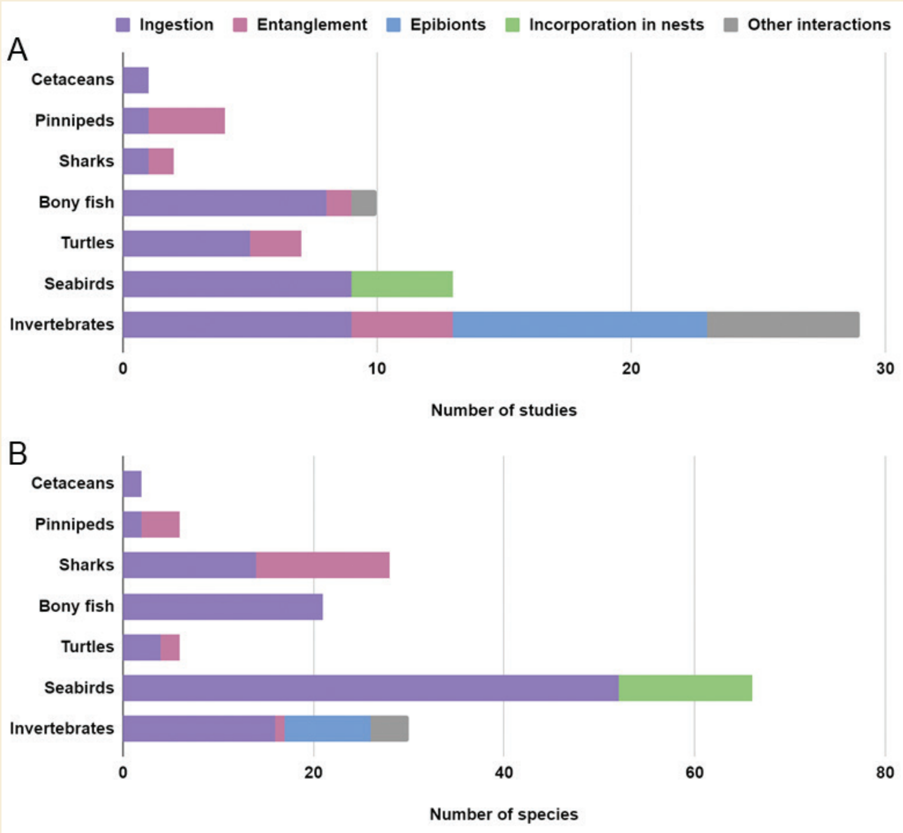


Figure 9: (A) The number of studies reporting on interactions between biota and marine litter or microplastics per studied taxon and type of interaction (total n = 51 studies); some studies report data on more than one taxon and/or more than one type of interaction, and are thus included in all the respective categories. (B) The number of studied species per taxon and type of interaction; only organisms identified to the species level were included, as well as non-identified organisms when only one individual was sampled/recorded within a taxonomic group (for other non-identified organisms interacting with marine litter via ingestion or entanglement see footnotes below Tables 2 and 3). "Other interactions" include the incorporation of microplastics in the tube structure of polychaetes, the use of marine litter as sunshades, its use as decoration, and its use as habitat.

Table 2: Number of species which have been sampled for ingested marine litter or microplastics. The percentage of species found to have ingested marine debris or microplastics is shown in brackets. No studies on debris ingestion were available for Mauritius, Seychelles, Mozambique and Somalia.

	Forage widely across south-west Indian, Atlantic and Southern Oceans	Deep-sea sites in international waters	Kenya *	Madagascar, La Réunion, Mayotte (Comoros Archipelago)	South Africa	Tanzania	All countries/ regions combined
Bony fish	0	0	0	1 (100%)	20 (100%)	0	21 (100%)
Invertebrates	0	4 (75%)	4 (100%)	2 (100%)	5 (100%)	1 (100%)	16 (94%)
Pinnipeds	0	0	0	0	2 (0%)	0	2 (0%)
Cetaceans	0	0	0	2 (100%)	0	0	2 (100%)
Seabirds	42 (93%)	0	0	10 (100%)	0	0	52 (94%)
Charadriiformes	5 (100%)	0	0	4 (100%)	0	0	9 (100%)
Phaethontiformes	0	0	0	1 (100%)	0	0	1 (100%)
Procellariiformes	35 (91%)	0	0	4 (100%)	0	0	39 (92%)
Sphenisciformes	1 (100%)	0	0	0	0	0	1 (100%)
Suliformes	1 (100%)	0	0	1 (100%)	0	0	2 (100%)
Sharks	0	0	0	0	14 (71%)	0	14 (71%)
Sea turtles	0	0	0	4 (100%)	1 (100%)	0	4 (100%)
All species combined	42	4	4	19	42	1	111

** Kosore et al. (2018) showed that four groups of zooplankton (Amphipoda, Chaetognatha, Copepoda, fish larvae) ingested microplastics but did not identify the zooplankton to species-level, and Awuor (2020) reported ingestion of microplastics (mostly microfibres) by jellyfish of the genus **Crambionella**, but did not specify the species and whether the sampled individuals belonged to one or more species.*

In the WIO region, 21 species of bony fishes and 14 shark species have been sampled for ingested marine litter, most of them in South Africa (Table 2, Appendix III Table S12). Microlitter was found in the stomachs of all species of bony fishes that have been sampled (Table 2) and the most common types of microlitter were microfibres and fragments (Appendix III Table S12; Naidoo *et al*. 2016; Naidoo *et al*. 2017; Ross 2017; Bakir *et al*. 2020; Chebani 2020; McGregor & Strydom 2020; Naidoo *et al*. 2020a; Sparks & Immelman 2020; Appendix III Table S12). Plastic ingestion was much less prevalent in shark species, at least in the 1980s and 1990s: Cliff *et al*. (2002) sampled sharks killed in shark nets off the coast of South Africa for 23 years and showed that 71% of species (Table 2) but only 0.4% of individuals had ingested plastic litter. However, cartilaginous fishes tend to regurgitate and even evert their stomachs to remove indigestible materials, parasites or mucus and maintain a healthy digestive tract (Sims *et al*. 2000; Brunnschweiler *et al*. 2005), which might explain the very low percentage reported by Cliff *et al*. (2002). Notably, one study reported bite marks presumably caused by fish on HDPE bottles stranded on Kenyan beaches, which were more frequent on bottles inferred to come from foreign sources than on those originating in Kenya, due to the time spent at sea (Ryan 2020a). Similar bite marks are regular on foreign HDPE bottles and lids washing ashore in South Africa (Ryan *et al*. 2021).

Very little is known about plastic ingestion by marine mammals in the WIO region (Table 2). Plastic ingestion seems to be uncommon for seals; for example, no plastic was found in 8066 fur seal scats collected from 1989 to 2014 on Marion Island (Appendix III Table S14; Ryan *et al*. 2016b), although plastic ingestion may be higher in seals living close to urban centres. Ingestion of macrolitter also seems to be uncommon in whales and dolphins; for example, no litter was found in the digestive tracts of two individuals belonging to two species of cetaceans in Mayotte (Comoros Archipelago, Appendix III Table S14; Chebani 2020) and of 40 smaller whales and dolphins washed up between Cape Agulhas and the Groot Brak River in South Africa (Department of Forestry, Fisheries and the Environment, unpubl. data). Similarly, among 8 cetaceans stranded in La Réunion and necropsied by the organization GLOBICE, none had ingested macrolitter (GLOBICE, unpubl. data), even though in other regions whales and dolphins have been found with ingested plastics (Unger *et al*. 2016; Alexiadou *et al*. 2019). Regardless of the scarcity of studies, however, it is inevitable that most individuals have likely ingested microplastics, especially for filter-feeding species.

Ingestion of marine litter and microplastics has also been recorded in several species of invertebrates and zooplankton (Appendix III Table S11), although most species probably ingest microplastics and microfibres given the high densities of litter at the sea surface and on the seafloor (see Sections 2.2.2 and 2.4 above). While the impact of this ingestion remains unknown for WIO species, it is likely negligible given that many of these species have evolved to ingest indigestible items and excrete them. Across all these species, 60-100% of ingested microplastics were microfibres (Gerber 2017; Awuor 2020; Awuor *et al*. 2020; Chebani 2020; Mayoma *et al*. 2020; Sparks 2020; Appendix III Table S11), which were also found to be ingested by other benthic organisms sampled at deep-sea sites off the coast of Madagascar (i.e., one hermit crab, one seapen and one zoanthid; Taylor *et al*. 2016). Likewise, fibres/filaments dominated the microplastics ingested by zooplankton in the central part of Kenya's EEZ (Kosore *et al*. 2018). Among macroinvertebrates, filter feeders such as oysters were shown to ingest more microfibres than deposit feeders (three species of brachyuran crabs), which the authors mainly attributed to the capacity of filter feeders to sieve large volumes of water and to concentrate materials in the process, including microplastics (Awuor *et al*. 2020). Ingestion of macrolitter has been documented in only one invertebrate species, the sandy sea anemone (*Bunodactis reynaudi*), which was studied at an urban beach in False Bay, South Africa (Weideman *et al*. 2020a). More than 99% of the ingested litter was plastic, and mostly comprised flexible plastic such as bags and food packaging (Weideman *et al*. 2020a). Ingested plastic was normally regurgitated within a few hours of ingestions, and it is unclear whether this had any impact on the animals (Weideman *et al*. 2020a).

4.1.2. Entanglement

Most data about entanglement in marine debris is anecdotal, given the infrequent nature of most entanglement events. Entanglement studies from the WIO region are only available for South Africa and the Seychelles. Using Google Images and unpublished records, Ryan (2018) found evidence of 28 species of seabirds and 15 of freshwater and coastal birds in South Africa being entangled in debris. However, the author noted that it was difficult to differentiate entanglement in marine debris from bycatch in active fishing gear (Ryan 2018) and no other records are available on seabird entanglement for the rest of the WIO region. Similarly, hawksbill (*Eretmochelys imbricata*) and olive ridley (*Lepidochelys olivacea*) turtles have been found entangled in FADs in the outer islands of Seychelles, but it is unclear whether this was active or ghost fishing gear (Balderson & Martin 2015). As is the case with ingestion, individuals of most WIO species have likely become entangled in marine debris, but this is unlikely to affect species at a population level.

Records of sharks entangled in marine debris are only available for South Africa and the incidence rate was low (Table 3; Cliff *et al*. 2002). Given this low incidence, it has been suggested that entanglement in marine debris poses little threat to sharks at the population level (Cliff *et al*. 2002). Similarly, while entanglement has been found to affect four species of seal in South Africa, the number of individuals seen entangled was low at all study sites (Shaughnessy 1980; Hofmeyr *et al*. 2002; Hofmeyr & Bester 2002; Appendix III Table S15). However, these studies of shark and seal entanglement were conducted ~20 years ago and more research is needed to quantify how often and to what extent sharks and marine mammals become entangled in marine litter in other regions of the WIO. In La Réunion, the organization GLOBICE registered 13 cases of cetaceans entangled in fishing lines between 2007 and 2019 (i.e., long-beaked dolphin, humpback whales, and bottlenose dolphins of the Indo-Pacific), but this information has not been published (GLOBICE, unpubl. data).

Only a few records of invertebrates being entangled in marine debris are available for the WIO region. Rundgren (1992) noted the sea fan (*Lophogorgia flamea*) entangled in fishing line in False Bay, South Africa, while Schleyer & Tomalin (2000) found fishing line entangled around corals and tunicates in Sodwana Bay, South Africa, although the species were not specified. At deep-sea sites south of Madagascar, Woodall *et al*. (2014, 2015) found fibres entangled around octocorals, sponges, fish and crustacea, but did not identify the species or note the frequency of occurrence (Table S15).

Table 3: Number of species in which entanglement has been studied. The percentage of species which have been found entangled in debris is shown in brackets. No studies on debris entanglement were available for Comoros (including Mayotte), Kenya, Madagascar, Mauritius, Mozambique, La Réunion, Somalia and Tanzania.

	Seychelles	South Africa	All countries combined
Invertebrates	0	1 (100%)	1 (100%)
Pinnipeds	0	4 (100%)	4 (100%)
Sharks	0	14 (57%)	14 (57%)
Sea turtles	2 (100%)	0	2 (100%)
All species combined	2	19	21

4.1.3. Epibionts

Ten studies have found epibionts on marine litter, seven of which were conducted in South Africa (Appendix III Table S16). In general, most studies did not identify the organisms to the species level, but rather reported the broader taxa (Figure 9A, 9B). Rundgren (1992) found encrusting coralline alga, barnacles (*Balanus* sp.), a mussel (*Choromytilus meridionalis*) and an anemone (*Bunodosoma capensis*) growing on litter collected from the seafloor of False Bay, South Africa, while Woodall *et al*. (2015) saw corals and hydroids encrusting marine litter at deep-sea sites south of Madagascar. Ryan *et al*. (2020c) found that 77% of benthic litter trawled up from the continental shelf of South Africa had been colonised by epibionts, and most of this litter was buoyant once the epibionts had been removed, suggesting it has been colonised while floating on the sea surface, and perhaps retained on the seabed after being colonised by benthic epibionts.

Six species of barnacles were found growing on litter collected from 22 sites along the east, south, and south-west coasts of South Africa (Whitehead *et al*. 2011). Interestingly, on the east coast, most goose barnacles were found growing on pieces of plastic and rubber, while goose barnacles were mostly found on natural flotsam such as kelp on the south and south-west coasts. This is likely due to the absence of kelp on the east coast and also to the prevalence of rubber and plastic debris arriving on the east coast of South Africa from other east African countries via the Mozambique and Agulhas Currents (Whitehead *et al*. 2011) and is consistent with the higher stranding rates of litter in western boundary current systems (c.f. eastern boundary currents where upwelling carries floating litter offshore, Ryan 2020a). In support of this, epibionts were uncommon on stranded litter items collected along the west coast of South Africa (<1% of litter colonised in Table Bay, Swanepoel 1995), with much higher fouling rates seen along the South African southeast coast (Ryan *et al*. 2021), in Kenya (Ryan 2020a), in Mozambique (Barnes 2004) and in the Seychelles (Barnes *et al*. 2009). Furthermore, foreign bottles on beaches in Kenya and South Africa also had more bite marks and were more frequently colonised by epibionts than locally manufactured bottles, which is indicative of longer periods spent floating at sea (Ryan 2020a; Ryan *et al*. 2021). These high rates of colonisation raise concerns about the role of floating anthropogenic litter in facilitating the spread of alien and potentially invasive species across the Indian Ocean (Barnes 2004), which has been reported and reviewed in other oceans (Póvoa *et al*. 2021).

4.1.4. Marine debris in seabird nests

Plastic and other marine debris has been recorded at or in the nests of 14 seabird species in the WIO region. This litter may either have been regurgitated by birds while sitting on the nest (e.g., Perold *et al*. 2020) or have been incorporated into the nest as building material (e.g., Witteveen *et al*. 2017; Appendix III Table S17). On Marion Island, the proportion of fishing-related debris found in the nests of albatrosses and giant petrels decreased dramatically after the fishery for Patagonian toothfish around the island collapsed, and seabirds on Marion Island now ingest mostly rigid pieces of plastic such as fragments from larger items and bottle lids (Perold *et al*. 2020). In coastal dunes of the Western

Cape, South Africa, plastic packaging and ropes/strapping were the most common types of litter found in kelp gull (*Larus dominicanus*) nests. Litter was more common in nests located in open areas as opposed to vegetated areas, suggesting that kelp gulls tend to use more plastic items for nest construction where natural nest construction material is scarce (Witteveen *et al*. 2017). Marine debris use tends to be much less common in other species of seabirds; for example, litter was found much less frequently in nests built by Hartlaub's gulls (*Chroicocephalus hartlaubii*), African penguins (*Spheniscus demersus*), great white pelicans (*Pelecanus onocrotalus*), and white-breasted cormorants (*Phalacrocorax lucidus*; Ryan 2020c; Tavares *et al*. 2020; Appendix III Table S17). However, rope and other litter is often used to build nests of Cape cormorants (*Phalacrocorax capensis*) that nest in harbours, where there is little other nesting material.

4.1.5. Other interactions between marine debris and organisms

Five studies have reported on other interactions between organisms and marine litter in the WIO. In False Bay, South Africa, Rundgren (1992) observed 43 sea urchins (*Parechinus angulosus*) with plastic fragments attached to their spines, suggesting that the species uses plastic fragments as sunshades and camouflage although it is unclear how common this behaviour is given that the author did not state how many urchins were checked for plastics. Decades later, Spencer (2020) and Weideman *et al*. (2020b) reported the same behaviour in *P. angulosus* on the rocky shore of False Bay, and also observed sandy anemones (*Bunodactis reynaudi*) and cask sea cucumbers (*Pentacta doliolum*) with plastic fragments adhered to their sides. At deep-sea sites south of Madagascar, Woodall *et al*. (2015) observed several species of benthic invertebrates (including crinoids, anemones, sea urchins and brittle stars) and fish using marine macrolitter as a habitat. Microplastics have been found and quantified in the tube structures of the Cape reef worm (*Gunnarea gaimardi*) along the west and southeast coasts of South Africa, although it remains unclear whether *G. gaimardi* deliberately incorporates microplastics into its tube structures and whether this interaction has any detrimental ecological effects (Nel & Froneman 2018). Together, these studies and observations highlight the variety of ways in which organisms interact with marine debris and it is important that the ecological costs of these interactions are quantified, especially in WIO countries where little data are available.

4.2. Potential impacts of marine debris on human health

The 2008 UNEP-WIOMSA report highlighted how little research has been done on the impact of marine litter on human health. This remains a severely understudied aspect of marine litter globally, with only a few studies having subsequently been published for the WIO region (Figure 5, Table 6). The most comprehensive study was conducted in Zanzibar, Tanzania and found high concentrations of human pathogens and multi-drug resistant bacteria growing on waste plastics, including *Vibrio cholerae*, the bacteria which causes cholera in humans (Rasool *et al*. 2021). Inadequate waste management combined with poor sanitation may therefore lead to the spread of disease-causing bacteria and antimicrobial resistance and may have played a role in the recent outbreaks of cholera on the island (Rasool *et al*. 2021).

Humans can also ingest microplastics, although there is still debate about how this might affect human health (Barboza *et al*. 2018; Naidoo *et al*. 2020b; Vethaak & Legler 2021). Microplastics have been found in a brand of South African table salt (Karami *et al*. 2017), but the authors suggest that ingestion of microplastics via table salt should have negligible impacts on human health given the low prevalence of particles (Karami *et al*. 2017). Microplastics have also been identified in different edible marine organisms along the South African, Kenyan and Tanzanian coastlines, including estuarine fish (Naidoo *et al*. 2020a), mussels (Gerber 2017; Sparks 2020), oysters (Awuor *et al*. 2020), and cockles (Mayoma *et al*. 2020). However, it is unclear what proportion of these microplastics are ingested by humans. Naidoo *et al*. (2020b) argue that this is likely negligible for species that are gutted before being consumed, but any microplastics in mussels or cockles might be eaten by humans as these species are consumed whole. However, most seafood dealers will keep bivalves in clean seawater so that they can defecate before being sold and the likelihood of ingesting plastics is therefore low. This is a severely understudied topic in the WIO region, and more research is needed to determine how much microplastic is ingested by humans, how long it is retained in the human gut and what effects it can have on human health (Naidoo *et al*. 2020b).

As reviewed elsewhere (Vethaak & Leslie 2016; Vethaak & Legler 2021), the ingestion of microplastics is potentially harmful to humans because of the toxicity of plastic additives, but also due to the sorption of other pollutants present in the environment, such as persistent organic pollutants (POPs). In the WIO region, POPs have been detected on the surfaces of polyethylene pellets beached in Mozambique and South Africa (Ogata *et al*. 2009; Ryan *et al*. 2012). While the concentrations of three types of POPs showed a decreasing trend in South Africa between the 1980s and early 2000s (Ryan *et al*. 2012), that of hexachlorocyclohexanes (HCHs) remained higher than in most other regions of the world, suggesting that the pesticide Lindane was still being used illegally after its ban in 2009 (Ryan *et al*. 2012). These results highlight the importance of considering the interactions between different socio-environmental issues to better understand the potential threat of plastic litter to human health. Surprisingly, contrasting results have been reported regarding the level of transference of POPs and other chemicals from microplastics to tissues of marine biota upon ingestion of the microplastics (Teuten *et al*. 2009; Herzke *et al*. 2016), and it remains unclear whether they can be transferred to human tissue (Vethaak & Legler 2021). However, given that nano-sized microplastics are able to cross cell membranes, it has been hypothesized that this may increase the bioavailability of the sorbed micropollutants (Vethaak & Leslie 2016; Vethaak & Legler 2021), but this has not been studied in the WIO region.

Marine litter poses a myriad of other threats to human health, but most have not been adequately studied in the WIO region, such as the physical harm that litter can cause to humans, a problem which has been highlighted in other parts of the world (e.g., Kiessling *et al*. 2019). Discarded fishing nets may also pose a navigational threat to ships, fishing fleets and the people on board them, if nets become entangled around the ships' propellers (Hong *et al*. 2017), but studies assessing this are non-existent in the WIO region.

The date stamp on a plastic canister found on a South African beach showing it was made in December 1974. @ Peter Ryan

Chapter 5: Information gathered through consultations with local stakeholders

We conducted 19 interviews, one each from Somalia, Kenya, Mauritius and Madagascar, two from Tanzania, Mozambique, Seychelles, La Réunion and Comoros (including Mayotte) and five from South Africa. Most interviews were conducted via Zoom, except for the interview from Mauritius, one from Seychelles and one from Mozambique, which were received in written format. While we could have conducted more interviews with stakeholders from South Africa, this country is already well represented in the literature and adding any more interviews would further bias South Africa in the review.

Ten stakeholders were researchers, four worked for NGOs and one for a public trust organisation, one was a park ranger, one was in industry, and two were citizens with interest in marine litter. Nine stakeholders had been observing or monitoring litter for less than five years, four for 5-10 years and six for more than 10 years. Almost all stakeholders (18) perceived litter as a moderate to high threat to the environment (i.e., ranked it between 5 and 10, on a 1-10 scale), but only four perceived it as worse of a threat than heavy metals and other persistent marine pollutants, and two perceived it as a more significant threat than climate change; five rated it worse than overfishing (Table 4). We present the stakeholder responses and perceptions in the following sections; however, we have not included responses on interactions between marine litter and organisms, given that few stakeholders felt confident in their answers to this section.

5.1. Monitoring programmes

Stakeholders indicated that monitoring programmes have been set up in all countries except Comoros and Somalia. Most programmes currently focus on standing stock and accumulation surveys of macrolitter on sandy beaches, which are also the methods that most stakeholders rated as the most practical and think should be prioritised in their countries (Figure 10). Some programmes are also conducting litter surveys in mangroves and sampling for mesoplastics with sieve transects on sandy beaches. Importantly, one stakeholder from Tanzania mentioned that the monitoring programme provides only a small spatial coverage of the entire Tanzanian coastline, highlighting a major gap for improvement.

5.2. Composition, sources, transport, and fate of litter

Plastic was consistently ranked as the most abundant type of material in all habitats (Figure 11A). This largely agrees with the literature that identified plastics to make up at least 50% of litter in most habitats (see Chapter 2 above). Stakeholders also included glass, metal, and cloth in the top three most abundant materials in most habitats (Figure 11B, Table 4). When asked about the types of plastic found in their local environment, most stakeholders ranked packaging (e.g., food packaging, bottles, and packing straps), user items (e.g., toys, shoes, and clothing) or fishing gear (e.g., ropes, nets, fishing lines, and FADs) as the most numerous type of litter across different habitats (Figure 12A). One stakeholder stated that the proportion of fishing gear is higher on rural than on urban beaches because the latter present higher densities of land-based litter originating from urban and river run-off, while another stakeholder from South Africa stated that the density of fishing gear washing up on beaches in Algoa Bay peaks during the squid fishery season.

Table 4: Summary of answers provided by stakeholders from continental countries (South Africa, Tanzania, Mozambique, Kenya and Somalia) and WIO island nations (Seychelles, Mauritius, La Réunion, Comoros Archipelago and Madagascar) for selected questions and statements from virtual and written interviews.

	Continental countries (n=11)	Island states (n=8)
Litter as a threat to the environment		
Average ranking of how stakeholders perceive litter as a threat to their environment, lower score is no threat, 1 to 10	8.1	8.5
Number of stakeholders that ranked marine litter as (a) less, (b) same, and (c) more of a threat than heavy metals and other pollutants	1, 8, 1*	0, 5, 3
Number of stakeholders that ranked marine litter as (a) less, (b) same, and (c) more of a threat than climate change	6, 4, 1	3, 4, 1
Number of stakeholders that ranked marine litter as (a) less, (b) same, and (c) more of a threat than overfishing	6, 3, 2	4, 1, 3
Composition and sources of litter		
Number of times each litter material was ranked as one of the top three most abundant materials (across all habitats): **		
Plastic	30	24
Glass	13	6
Metal	3	8
Cloth/material	13	10
Cigarette butts	5	3
Paper/card	2	4
Rubber	3	1
Worked wood	1	2
Main types of litter identified by stakeholders in any habitat:		
Number of times each type of litter was ranked as one of the top three most abundant litter types (across all habitats): **		
Packaging	30	18

	Continental countries (n=11)	Island states (n=8)
User items	11	17
Fishing gear	13	12
Miscellaneous fragments	7	4
Industrial pellets	6	0
Main sources of litter identified by stakeholders in any habitat:		
Number of times that land-based source(s) were ranked in the top three main sources of litter (across all habitats) **	36	27
Number of times that sea-based source(s) were ranked in the top three main sources of litter (across all habitats) **	10	26
Drivers of seasonal changes in the abundances of litter in any habitat according to stakeholders:		
Number of stakeholders that mentioned the following as a major driver of seasonal changes:		
Seasonal rains	6	1
Holiday season (or the amount of people)	3	2
Tidal variations	2	0
Fishery season	1	0
Monsoon season (and/or associated oceanographic/climatic conditions)	1	5

**One stakeholder chose not to answer this question.*

***For each litter material/type/source, the numbers do not add to the total number of interviews (n=19) because stakeholders were asked to rank the three most abundant materials/types/sources in each habitat, and therefore each stakeholder might have mentioned each material/type/source more than once. For example, a stakeholder might have ranked plastic as the most abundant material in urban sandy beaches, remote sandy beaches, and coral reefs, and this would add "3 times" for "plastic" in the table. The same stakeholder might have ranked glass as the second most abundant material in urban sandy beaches and third in coral reefs, but not included it in the three most abundant materials in remote sandy beaches, and this would reflect as an addition of "2 times" for "glass" in the table. It is also worth noting that not all stakeholders answered for all habitats, and not all stakeholders ranked three materials/types/sources (i.e., some ranked only the most abundant one, or the two most abundant).*

Table 5: Summary of the responses provided by the interviewed stakeholders (n=19 interviews) regarding the perceived impact of marine litter and microplastics on human health in the WIO region. Stakeholders were asked whether they perceive litter to be a threat to the health of people living in their area and had to rank this threat on a scale from 1 to 10 where 1 indicates no threat and 10 high threat. They were then asked to explain what kinds of threats litter poses to human health (stakeholders often listed more than one threat so the total does not add to 19).

Country and number of stakeholders	Average ranking of how stakeholders perceive litter as a threat to human health, lower score is no threat, 1 to 10	Number of stakeholders that identified the following types of threats			
		Disease	Physical harm	Ingestion	Other
South Africa (n=5)	4.7	2	1	2	Aesthetics and economic impacts
Mozambique (n=2)	6	1	1	0	-
Tanzania (n=2)	9	2	0	1	-
Kenya (n=1, but with 3 participants answering the same interview)	6	0	0	0	Impact on food security because ingested litter can harm fish stocks
Somalia (n=1)	10	1	0	0	-
La Réunion (n=2)	5.5	0	0	1	Burning of litter releases toxic chemicals
Mauritius (n=1)	3	0	0	0	Detracts from aesthetics of beaches
Madagascar (n=1)	9	0	0	0	Burning of litter releases toxic chemicals
Comoros (including Mayotte; n=2)	7.5	2	1	0	-
Seychelles (n=2)	8.5	0	0	2	-
All countries combined	6.5	8	3	6	

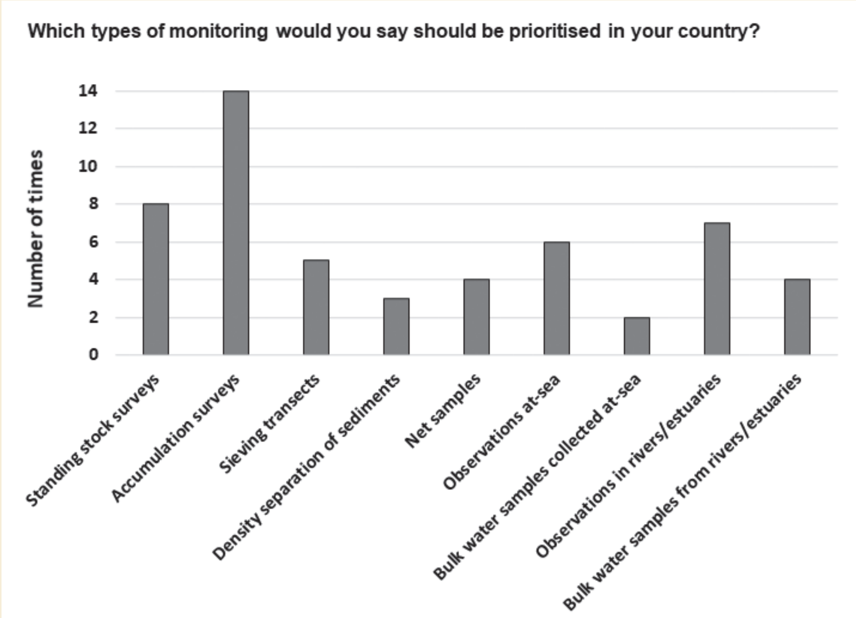


Figure 10: Bar plots showing the number of times that each type of monitoring was mentioned among the types that should be prioritised in the countries of the respective stakeholders, according to their perception (n = 19 interviews).

The stakeholder consultations also largely supported the reviewed literature regarding the main sources of litter: stakeholders consistently ranked land-based sources such as urban runoff, rivers and beachgoers as the most important sources of litter on urban sandy beaches, but sea-based sources (fishing, shipping activity and long-distance drift) were ranked as more important on remote beaches (Figures 13A, 13B). Furthermore, stakeholders from continental countries identified land-based sources most often as the main sources of litter, while stakeholders from island countries mostly ranked sea-based activities in the top three sources (Table 4). For example, stakeholders from Mozambique, Kenya, South Africa and Tanzania stated that rivers are one of the top three sources of litter into the sea and indicated that most litter is dumped into rivers or onto riverbanks by people living in areas with poor service delivery and waste management. Furthermore, when asked about the main drivers of seasonal changes in the abundances of marine litter, stakeholders from continental countries mostly mentioned drivers related to land-based sources such as seasonal rains flushing litter from land to the coast through waterways, and the holiday season, when the number of people visiting coastal areas increases (Table 4). In contrast, most stakeholders from island states identified seasonal monsoons as the major driver of seasonal changes in litter loads (Table 4) and stakeholders from the Seychelles explained that higher densities of litter are found on the north coasts of the Seychelles islands during the northwest monsoon, whereas higher densities are found on the south coasts during the southeast monsoon.

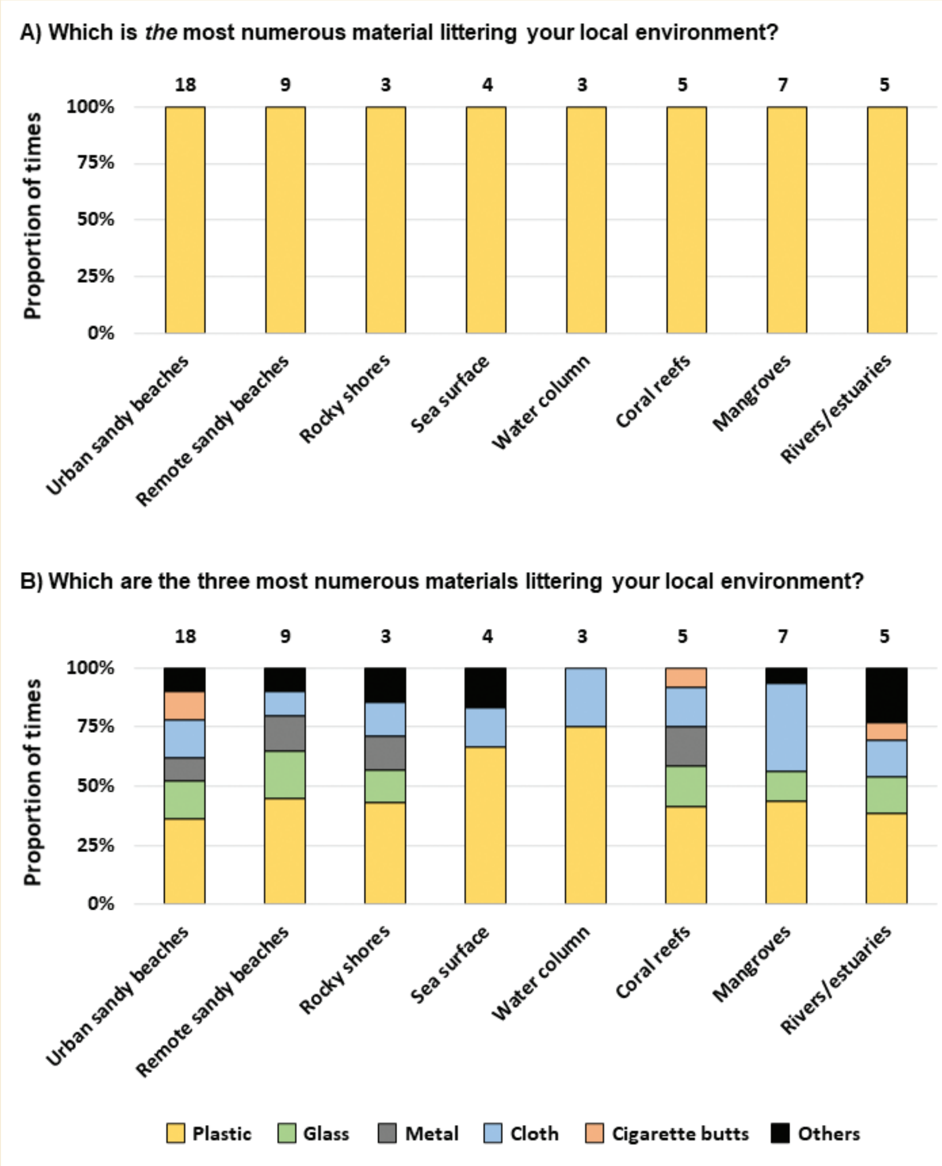


Figure 11: Stacked bar plots showing the proportion of times that stakeholders (n = 19 interviews) ranked each litter material (A) as the most abundant material in each habitat, and (B) as any of the top three most abundant materials. The category "others" includes paper/cardboard, rubber and worked wood. Numbers above the bars indicate the number of stakeholders that responded for the respective habitat.

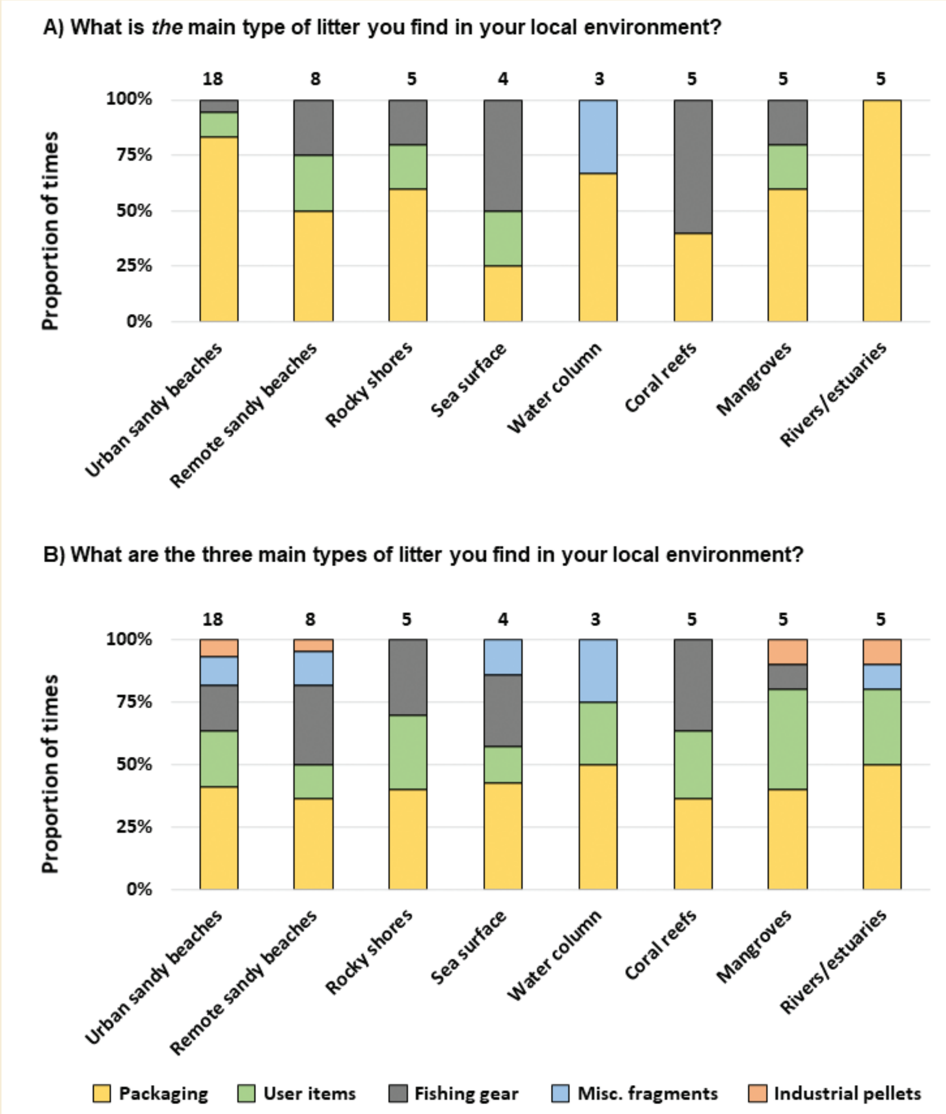


Figure 12: Stacked bar plots showing the proportion of times that stakeholders (n = 19 interviews) ranked each litter type (A) as the most abundant type in each habitat, and (B) as any of the top three most abundant litter types. Numbers above the bars indicate the number of stakeholders that responded for the respective habitat. Packaging includes items such as food packaging, bottles, and packing straps; user items includes e.g., toys, shoes, and clothing; fishing gear includes ropes, nets, fishing lines, and FADs.

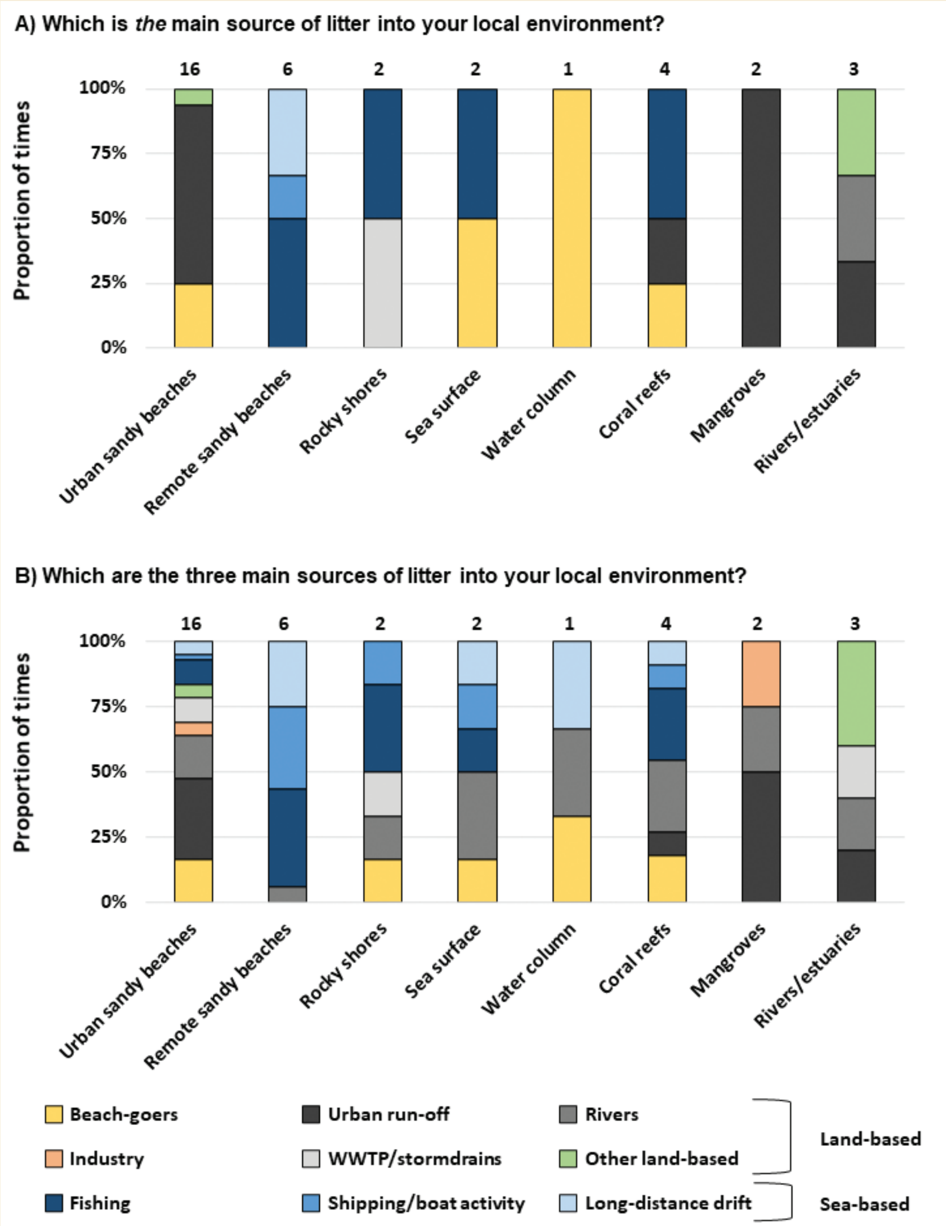


Figure 13: Stacked bar plots showing the proportion of times that stakeholders (n = 19 interviews) ranked each litter source (A) as the main source in each habitat, and (B) as any of the top three most important sources. Numbers above the bars indicate the number of stakeholders that responded for the respective habitat. Note: two stakeholders did indicate three most important sources but did not specify the habitat(s), and thus they are not included in the charts.

When assessing the results of the stakeholder consultations, it is important to note that few stakeholders felt confident or knowledgeable enough to respond about some habitats, such as the rocky shores, the sea surface and the water column (Figures 11, 12, 13), which was even more evident for the identification of the main litter sources, where only sandy beaches received more than five responses (Figure 13). This suggests that there is not only little information published about litter in the other habitats, but they are also scarcely known by people in the field, being thus a major knowledge gap in the WIO region. Interestingly, the three least known habitats (i.e., rocky shores, the sea surface, and the water column) coincided with the habitats less perceived as threatened by marine litter by the interviewed stakeholders, while the opposite was true for the most studied and known habitat (i.e., urban sandy beaches; Figure 14). However, one stakeholder indicated that they perceived the water column and the seafloor ("Other habitat" in Figure 14) as most threatened precisely because we know so little about the amounts and types of litter in them.

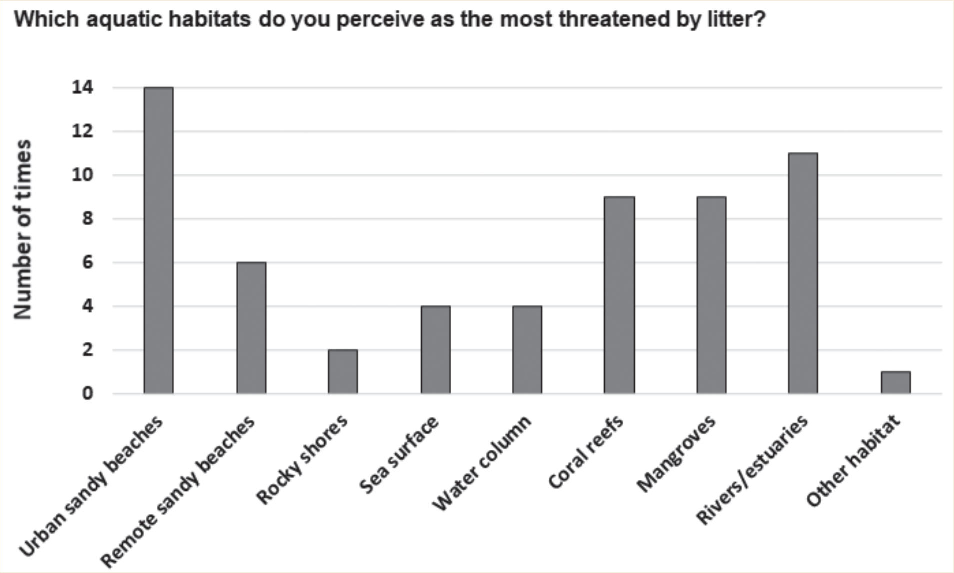


Figure 14: Bar plots showing the number of times that each habitat was mentioned among the habitats perceived as the most threatened by the interviewed stakeholders (n = 19 interviews). The question asked for the three most threatened habitats; however, one stakeholder preferred to mention only one habitat, one stakeholder mentioned two, four stakeholders mentioned four habitats, while one mentioned five. "Other habitat" was mentioned by one stakeholder, who referred to the seafloor.

5.3. Perceived impacts of marine debris on human health

Interestingly, when asked to indicate the potential impacts of marine litter and microplastics on human health, most stakeholders mentioned that this has not been studied in the WIO region (see their responses summarised in Table 5) and would thus be important to investigate. For example, stakeholders from the Comoros Archipelago, Mozambique and Tanzania stated that litter could promote the spread of malaria because mosquitoes lay their eggs in water that has accumulated in discarded containers (e.g., bottles and tyres; Table 5), a potential impact reported in the global literature (Vethaak & Leslie 2016), but which has not been studied in the WIO region. Stakeholders from both La Réunion and Madagascar mentioned that burning of litter in the open air, be it accidental or intentional, is common due to poor waste management, and this likely releases harmful chemicals into the air that can be inhaled by people nearby, while stakeholders from South Africa and the Comoros Archipelago mentioned that certain litter items can lead to physical injuries, such as stepping on broken glass (Table 5). It is also important to assess the potential role of medical waste in spreading diseases, as mentioned by a stakeholder from Mozambique (Table 5), which is especially relevant during a worldwide pandemic such as that of COVID-19.

Plastic bottles and shoes dominate macro litter on an uncleaned beach in Kenya. @ Peter Ryan

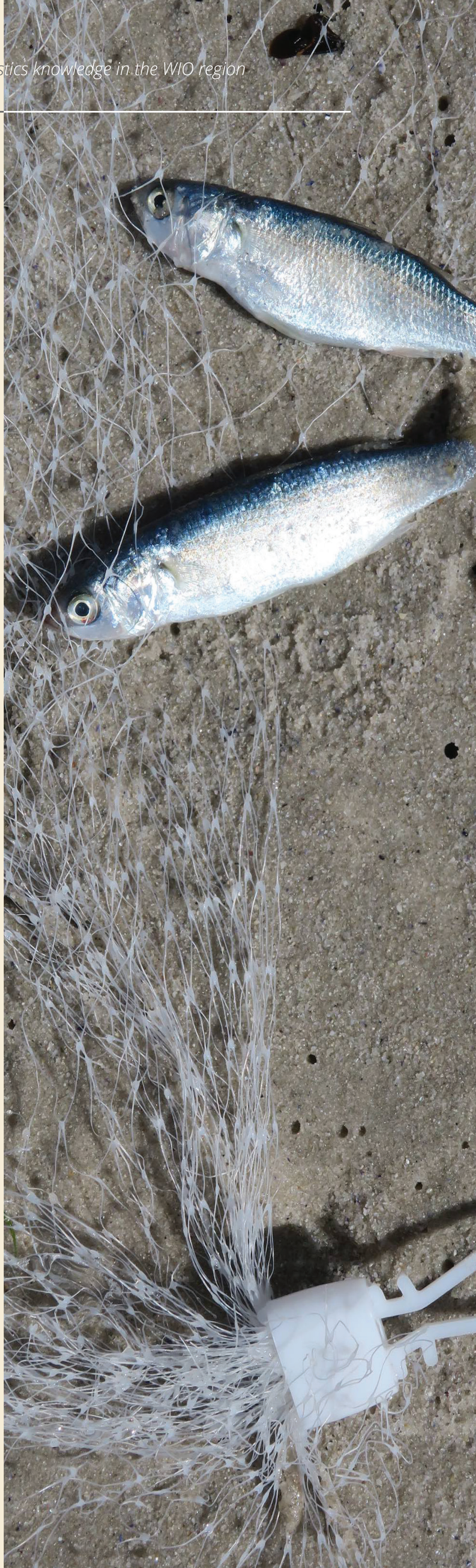
Chapter 6: Identification of knowledge gaps and future research priorities

While there have been vast improvements in our understanding of the characteristics, sources, transport, and fate of marine litter since the 2008 UNEP/WIOMSA report, there are still large knowledge gaps that urgently need to be addressed. However, we certainly know enough to start implementing action plans (see Chapter 7 below) and this should not be delayed while further research is conducted, as it has also been underlined by the national hotspotting assessments implemented in Kenya, Mozambique, South Africa and Tanzania (IUCN-EA-QUANTIS 2020a,b,c,d). The main knowledge gaps for the WIO region are summarized below and in Table 6, although recent reviews for South Africa by Naidoo *et al*. (2020b), Ryan (2020b), Ryan *et al*. (2020b) and Verster & Bouwman (2020) also highlight important evidence gaps that are applicable to most other WIO countries and should be read in conjunction with this report.

The most important research priorities are those focusing on improving our understanding of the main sources of litter and on testing the effectiveness of different mitigation measures. While it is clear from the literature and stakeholder interviews that most litter in the WIO region comes from land-based sources (Section 3.1, Figure 13), particularly in continental east Africa (e.g., IUCN-EA-QUANTIS 2020a,b,c,d), more research is needed to quantify the amounts of litter being released from specific land-based sources. For example, no studies have quantified how effectively wastewater treatment plants (WWTPs) in the WIO region remove microplastics from wastewater or what proportion of microplastics is retained in sewage sludge (Verster & Bouwman 2020). Furthermore, data on the quantity of litter washing out of rivers or stormwater outlets is only available for some parts of South Africa, and it remains unclear what proportion of litter is trapped in riverine sediments or riparian vegetation (Verster & Bouwman 2020; Weideman *et al*. 2020c). This makes it difficult to assess the accuracy of global models that attempt to predict the amounts of litter washing out of land-based sources (Jambeck *et al*. 2015; Lebreton *et al*. 2017). Field surveys in South Africa suggests that these global models are overestimating litter loads by several orders of magnitude (Ryan 2020b; Verster & Bouwman 2020; Weideman *et al*. 2020d), but this needs to be assessed for other WIO countries. It is also unclear how the proportion of litter originating on land versus that released from offshore, sea-based sources differs spatially and temporally and this needs to be addressed so that effective mitigation measures can be implemented. However, before mitigation measures are implemented across large spatial scales, it is vitally important to first assess their effectiveness and practicality. For example, research is needed on the retention rate of litter by river booms and stormwater traps, the effectiveness of beach, river, and street cleanup programs and how these can be improved, and to determine where waste management is lacking and what resources are needed to improve this.

More research on the fate of litter is also required as this will help focus cleanup efforts. For instance, while modelling studies have predicted the proportion of land-based litter that is transported offshore, this has largely not been verified in the field. The lack of data on the types of litter stranding on rocky shores and in mangroves also makes it difficult to determine to what extent these habitats act as sinks for litter, and it remains unknown how much and what types of litter are found in the water column or on the seafloor for most of the WIO region. This is particularly true for microplastics and much more research is needed to determine the sources, fates, sinks and impacts of microplastics in all habitats in the WIO region. Additionally, future studies should identify microplastic polymers using Raman or FTIR spectroscopy as this information can be used to improve our understanding of microplastic sources and transport mechanisms. Furthermore, the WIO region lies between ~12°N and 35°S, which has high incident solar radiation. This may result in high fragmentation rates of stranded macrolitter, but the conversion rate of macrolitter to microplastics has not been quantified anywhere in the WIO region. Importantly, all research on marine litter and microplastics in the environment should be conducted following harmonised methodologies, size classes and reporting units, to allow for comparability among studies and for determining spatial and temporal trends (GESAMP 2019; Galgani *et al*. 2021).

While extensive research has been conducted on ingestion of marine litter by seabirds around South Africa, little is known about their potential impacts on most other organisms, such as bony fish, sharks, sea turtles, marine mammals, and invertebrates, both in South Africa and the rest of the WIO region. However, given the prevalence of debris in most marine habitats, systematic studies will inevitably find individuals of almost all species ingesting (especially microplastics) or entangled in debris. Future studies should therefore focus on quantifying the effects of these interactions rather than just documenting them. For example, studies are needed to assess to what extent chemicals within different plastic polymers and adhered to the surfaces of plastics are leached into the guts of organisms



and how this affects them on a physiological level. It has also been shown that plastics are associated with diseases on coral reefs (e.g., Lamb *et al*. 2018) and plastics entangled around benthic organisms, corals or kelp may increase their drag and make them more susceptible to breaking, but this has not been studied in the WIO region.

Globally, we know little about how marine litter affects human health, and this kind of data is virtually non-existent for the WIO region (Naidoo *et al*. 2020b). The most important research priority in this regard is to determine what role litter plays in aiding the spread of diseases such as cholera and malaria (by providing mosquito breeding sites), as well as the health implications of burning litter in communal, open-air areas. While it is inevitable that humans are ingesting microplastics, the retention rate and health implications of this remains unclear and need to be addressed. The effect of marine litter such as discarded fishing nets on ships has also not been studied in the WIO region, but may pose a significant threat and economic cost to navies, fishing fleets and shipping companies, as well as a hazard to people on board the vessels, if nets regularly become entangled around propellers. The presence of hazardous litter items on the seashore, such as broken glass, hygiene products (e.g., condoms, disposable nappies, face masks) and wood with nails, can constitute a direct risk to people, the degree of which should also be evaluated.

Small pelagic fish caught in a mesh bag used to package toys, washed ashore on a South African beach. @ Peter Ryan

Table 6: Level of knowledge in the WIO region for different sizes of marine litter on ecological and social impacts using colour codes.

Level of knowledge or evidence	Major knowledge or evidence gap	Weak knowledge	Fair knowledge	Good knowledge

Characteristics and density of marine litter			
	Micro <5 mm	Meso 5-25 mm	Macro >25 mm
Seashore	Substantial amount of data available for South African sandy beaches, but very little data available for other WIO countries.	Substantial amount of data available on spatial and temporal variation for South Africa, one study available for Kenya. Stakeholders are conducting sieve transects in some WIO countries, but most data have not been published.	Substantial amount of data available for South African sandy beaches and some data for rocky shores. Surveys have been conducted on sandy beaches in Kenya, Mayotte (Comoros Archipelago), Madagascar, Mauritius, Mozambique and Seychelles. Stakeholders are undertaking beach macrolitter surveys in all WIO countries except Comoros and Somalia, but most data still need to be published. All stakeholders indicated that standing stock and accumulation surveys for macrolitter should be prioritised in their countries.
Sea surface	Moderate amount of data available for South Africa, but almost no data available for the rest of the WIO region.	Moderate amount of data available for South Africa, but almost no data available for the rest of the WIO region.	Three studies have been conducted around South Africa but should be updated, one study available for Kenya. Nothing available for other WIO countries.
Water column	One study collected bulk water samples from 5m below the surface on a transect from Cape Town to the Prince Edward Islands, but no other information available.	No data available for the WIO region.	No data available for the WIO region.
Seafloor	Data available for only one site in South Africa (Durban harbour) and at three deep-sea sites in international waters. Nothing available for rest of WIO region.	No data available for the WIO region.	Some data available for sites along the continental slope and shelf of South Africa, from coral reefs around Mayotte (Comoros Archipelago), and from deep-sea sites in international waters, but data not comprehensive and covers small spatial scales. Nothing available for rest of WIO region.
Rivers and estuaries	Some data available for South African rivers but no information available for other WIO countries.	Some data available for South African rivers but not spatially comprehensive. Some sampling being conducted in other WIO countries but has not been published.	Some data available for South African rivers but not spatially comprehensive. Some sampling being conducted in other WIO countries but has not been published.
Mangroves	No data available for the WIO region.	No data available for the WIO region.	Only one study available for Mauritius, but several stakeholders are conducting surveys in mangroves using funding from WIOMSA.

Sources, transport, and fate of marine litter			
	Micro <5 mm	**Meso 5-25 mm**	**Macro >25 mm**
Sources	Some research available for South Africa, Kenya, Mozambique and Tanzania, but more research urgently required for other WIO countries.	Some research available for South Africa, Kenya, Mozambique and Tanzania, but more research urgently required for other WIO countries.	Substantial amount of research has been published for South Africa; some research available for Kenya, Mozambique and Tanzania, but more research for other WIO countries still urgently needed.
Transport	Modelling studies available for South Africa, but not for other WIO countries.	Modelling studies available for South Africa, but not for other WIO countries.	Several modelling studies have been published but field studies needed across the WIO region.
Fate	A few modelling studies available but more research needed across the WIO region.	A few modelling/field studies available but more research needed across the WIO region.	Good evidence that most litter from land-based sources strands close to source, but more research needed on what happens to litter that is released at-sea or transported off-shore.
Ecological and human interactions with marine litter			
	Micro <5 mm	Meso 5-25 mm	Macro >25 mm
Seabirds	Some information available for birds that breed on sub-Antarctic islands and which forage across the Atlantic, south-western Indian and Southern Oceans. No data available for other regions.	Substantial amount of information available for birds that breed on sub-Antarctic islands and which forage across the Atlantic, south-western Indian and Southern Oceans. Some data available for birds from La Réunion and Juan de Nova islands, but no data available for other regions.	Well known that birds can become entangled in macrolitter, but frequency of occurrence and effect at a species-level not well established. Some data available on birds incorporating litter into their nests in South Africa but has not been studied in other WIO countries.
Bony fish	Ingestion has been recorded in several species of bony fish in South Africa, but consequences of ingestion poorly understood and has not been studied in other WIO countries.	No data available for the WIO region.	No data available for the WIO region.
Sharks	No information available for WIO region.	No data available for the WIO region.	Ingestion and entanglement have been recorded in several shark species in South Africa, but little is known about the rest of the WIO region.
Sea turtles	No data available for the WIO region.	Some data on ingested plastics available for La Réunion, Madagascar, Mayotte (Comoros Archipelago) and South Africa, but more research needed on types, amounts and effects of ingested litter.	Well known that sea turtles become entangled in macrolitter and that they struggle to lay eggs when stranded litter densities are high, but little data published.
Marine mammals (seals, dolphins, whales)	No data available for the WIO region.	No data available for the WIO region.	Entanglement has been recorded in three species of fur seals and in elephant seals in South Africa, but research is needed on other species and other WIO countries.
Marine invertebrates	Some data available for zooplankton in Kenya and for mussels in South Africa, but no research available for other WIO countries.	No data available for the WIO region.	Ingestion only recorded in a sandy anemone in South Africa. Data on entanglement of macrolitter around corals has been published in South Africa and Mayotte (Comoros Archipelago), but more research needed to determine the extent and severity of entanglement.
Human health	No data available for the WIO region.	No data available for the WIO region.	Only one study conducted in Zanzibar, Tanzania.

Chapter 7: Recommendations for action

The information gathered in the present review about the marine litter situation in the WIO region, coupled with the results and recommendations of the hotspotting assessments implemented in four continental WIO countries (i.e., Kenya, Mozambique, South Africa and Tanzania; IUCN-EA-QUANTIS 2020a,b,c,d), highlight the need to address the marine litter problem by means of locally driven measures and a life cycle intervention approach, however emphasising actions on the source and the end-of-life. Based on this, we recommend a series of actions mostly focused on monitoring/research, prevention, and management that can be implemented at the regional, national and local level in the WIO region (recommendations summarised in Table 7).

One major need relating to the mitigation of marine litter in the WIO region is the continuation of the regional monitoring programme that has recently been established (Barnardo & Ribbink 2020). Ongoing litter monitoring is vitally important to (i) help identify the major sources of litter, as well as new sources not previously identified, and (ii) provide information to evaluate whether measures and policies aimed at reducing marine litter are effective or not. Thus, policy-making and litter monitoring need to go hand in hand as integral parts in any life cycle intervention approach implemented to curb the release of litter to the environment. Even though monitoring activities are currently being conducted under the supervision of WIOMSA in most WIO countries, it is important that these efforts are extended within countries, in order to cover a more representative extent of coastline and litter sources. We additionally recommend that such monitoring activities are coordinated and harmonised in terms of protocols and reporting units (in coordination with other global and regional programmes, such as GESAMP 2019). It is also fundamental that all data generated by the activities conducted under the regional monitoring programme are readily available, most particularly for decision-makers, so they can serve as input for the elaboration of policies, but also to measure the effectiveness of such policies after they have been implemented (see above).

While several major knowledge gaps still need to be addressed (see Chapter 6), we certainly know enough to start implementing action plans to reduce the amounts of waste plastic entering the sea, and this should not be delayed while further research is conducted. Given that most marine litter in the WIO region comes from local, land-based sources, and most especially from the packaging sector (see also IUCN-EA-QUANTIS 2020a,b,c,d), the most effective way to reduce current levels of plastic pollution is to stop littering at the sources. The main recommendation is thus to modify local production and to convert the current production of single-use plastics to reusable materials (which could also be reusable plastics). For this, promoting designs of alternative materials or processes that favour reuse will be essential, as it has been particularly recommended for South Africa (IUCN-EA-QUANTIS 2020c). Governments should also approve, implement, and enforce Extended Producer Responsibility (EPR), including take back schemes, given that EPR constitutes a fundamental and integral policy tool covering the entire production-consumption-disposal cycle, and involves all sectors of society: governments, policymakers, producers, consumers, recycling facilities, and waste pickers. Importantly, these types of policies should always be accompanied and supported by educative campaigns directed towards citizens, to teach them about the negative effects of litter, most particularly plastic litter, and about the value of choosing reusable or returnable products over single-use plastics.

At the end-of-life step of the cycle, emphasis should be placed on improving waste management (e.g., collection and infrastructure) at the municipal level, most importantly in coastal areas where it is lacking or poor. This is a key issue, given that the national hotspotting assessments revealed very low rates of collection and proper disposal of waste, which translates to very high rates of mismanaged waste (IUCN-EA-QUANTIS 2020a,b,c,d). This is particularly relevant in Kenya, Mozambique and Tanzania, where 92% to 99% of the generated waste is mismanaged (IUCN-EA-QUANTIS 2020a,b,d). To improve waste collection and infrastructure, one of the most pressing needs is to reduce dumpsites and unsanitary landfills, along with ensuring an appropriate waste collection and increasing the capacity for proper disposal (e.g., official sanitary landfills). Additionally, as urban runoff is a major source of marine litter in the WIO region, the national hotspotting assessments have recommended implementing more frequent waste collection in areas prone to plastic leakage and prior to rainy events (IUCN-EA-QUANTIS 2020a,b,c). Increasing the number of waste bins, most particularly in areas prone to plastic leakage (IUCN-EA-QUANTIS 2020b,c), is also an important measure. In this context, anti-littering campaigns could help reduce the incidence of littering behaviour by citizens and reinforce their use of waste bins and of the pickup service. Given that most litter strands on local beaches, coastal clean-up programmes could be helpful mitigation strategies until effective prevention and management measures are put in place to stop the release of litter from land-based sources.

Table 7: Recommendations on actions to address the marine litter and microplastics problem in the WIO region, based on the information gathered in the present review and the recommendations provided by the national hotspotting assessments implemented in Kenya, Mozambique, South Africa and Tanzania (IUCN-EA-QUANTIS 2020a,b,c,d)

Research and monitoring	Actions for addressing land-based sources			Actions for addressing sea-based sources
	Prevention	Disposal/management	Clean-up	
• Extend regional monitoring programme within all WIO countries • Coordinate and harmonise protocols and reporting units within WIO and among other regional programmes • Include understudied habitats (e.g., water column, seafloor) • Strengthen research of understudied topics (e.g., ecological impacts and on human health) • Ensure data are readily available to decision-makers	• Reduce production and consumption of single-use plastics • Promote design, production and consumption of reusable/ returnable alternatives • Implement and enforce Extended Producer Responsibility (EPR), including take back schemes • Tax imported plastic products (especially in island states) • Promote and carry out education campaigns to support measures	• Ensure appropriate waste collection • More frequent waste collection in areas prone to plastic leakage and prior to rainy events • Reduce dumpsites and unsanitary landfills • Increase capacity for proper waste disposal (e.g., official sanitary landfills) • Increase number of waste bins • Promote and conduct anti-littering campaigns • Increase recycling capacity (for plastics more difficult to avoid and reduce) • Increase waste segregation at households and in public spaces • Ensure plastic waste has enough value to cover collection costs • Reduce open burning of waste	• Promote and strengthen clean-up efforts near source points (e.g., river mouths)	• Implement and enforce stricter international regulations (to e.g., reduce litter released from land-based activities, and ensure adhesion of ships to MARPOL) • Require that waste audits are conducted on board ships upon departure and docking • Adopt a coordinated regional approach for litter reception facilities in ports, based on a general fee

In the case of remote beaches and most particularly small island states, an important fraction of litter originates from offshore sources, coming from fishing, shipping, and long-distance drift mostly from southeast Asia. In addition to implementing local solutions, stricter international regulations therefore also need to be put in place and enforced, such as policies aimed at reducing the amounts of litter released from land-based activities carried out on other continents and ensuring that shipping and fishing companies adhere to MARPOL and improve waste management on board ships. For instance, waste audits may be conducted before departure and upon docking at destination, and a coordinated approach regarding rates at litter reception facilities in harbours may be adopted across the WIO region and more broadly given most shipping is simply passing through the region, not calling at ports. It is also important that major polluters such as Indonesia and other southeast Asian countries pledge their support for small island nations by implementing local measures to curb the release of litter into the sea.

In conclusion, the aim of this review was to collate the available information on marine debris in the WIO region with a specific focus on the sources, transport, and fate of litter as well as the ecological and human health impacts. While our knowledge has greatly improved since the last review for the region was published in 2008, there are still large knowledge gaps that need to be filled. However, while further research is needed, there is sufficient information to recommend and take actions. It is clear from the available literature that most litter comes from land-based sources, especially in the case of continental countries (although this needs to be verified with more field data in countries such as Tanzania and Somalia where little research has been conducted), and urgent action is needed to curb the release of this litter into the sea. This can be achieved by promoting the use of reusable items such as reusable plastics, by improving waste management at the municipal level and by educating citizens about the negative effects of litter on the marine environment. While some litter is also released from land-based sources in WIO island states, a significant proportion originates offshore, either from fisheries or boating activity, or via long-distance drift from foreign nations, which is especially relevant on remote coasts and islands that receive little or no local input of litter. International measures are therefore also needed to address this problem. Given that waste generation in all WIO countries is expected to increase in the future – especially in the continental countries – these action plans should be made a priority by WIO governments and municipalities and monitoring programmes should continue in order to assess how effective these mitigation measures are.

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Appendices

Appendix I: Interview and questionnaire for marine litter stakeholders in the Western Indian Ocean (WIO) region

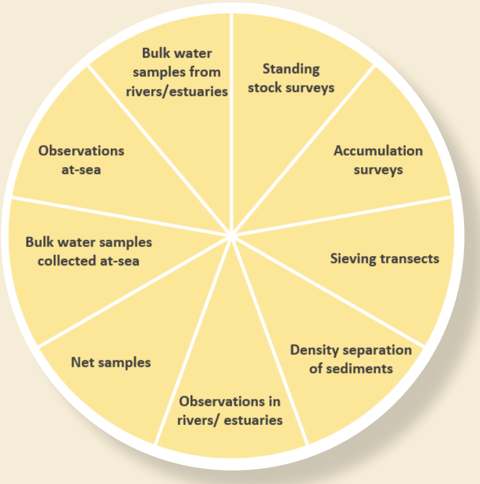
Section A: Experience of interviewee

A.1.	How long have you been observing/monitoring litter?
A.2.	In which function/role are you currently observing/monitoring litter? For example, as a citizen, NGO, administrator, scientist, extractive user (fisherman/ aquaculture), tourist operator, field ranger etc. Have you observed/studied litter in other capacities in the past?
A.3.	In which region(s)/country(s) have you observed/monitored litter?
A.4.	In which habitats have you observed/monitored litter? For example, sandy beaches, rocky shores, mangroves, estuaries/rivers, sea surface, water column, seafloor, organisms.
A.5.1.	Do you have experience with scientific sampling of litter or microplastics?
A.5.2.	If yes, please provide more detail of the kinds of sampling you have been involved in; for example, have you participated in litter surveys on beaches, in rivers, at-sea, or as part of coastal clean-ups?

Section B: Monitoring programs in your country

B.1.1.	Are you involved in any monitoring programs in your area/country/region?
B.1.2.	If yes, please provide more information on these monitoring programs; for example, what is being monitored, how long has the program been running, who has access to the data and is the data freely available, who funds the project?
B.1.3.	If you are not involved in any monitoring programs, do you know of any such program in your country/ region? If so, please provide some details on the program.
B.1.4.	If you are not involved in and do not know of any monitoring programs in your country, what factors have prevented the establishment of such a program? For example, financial constraints, lack of expertise, lack of organization to lead the program, lack of dedicated work force, etc.
B.2.1.	Do you think it is important to monitor marine litter? If so, why? If not, why not?
B.2.2.	Of the types of monitoring in the pie chart below, which would you say should be prioritized in your country?

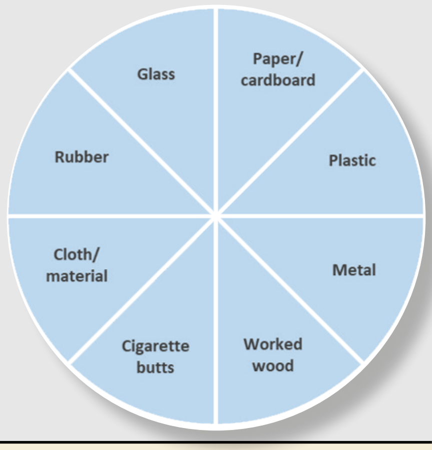
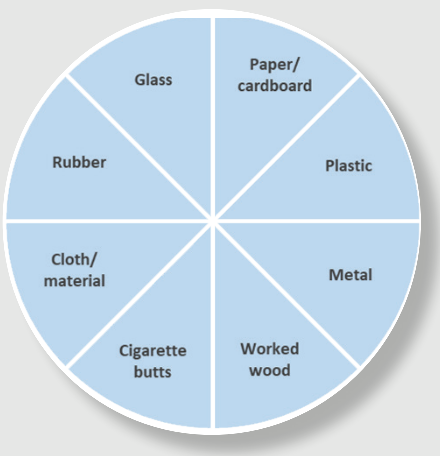
B.2.3.	Of the types of monitoring in the pie chart below, which would you say are the most practical in your country?



Section C: Marine litter as a threat to your local environment

C.1.1.	Do you perceive litter to be a threat to your local environment? Please mark your answer on the below scale, where 1 refers to no threat and 10 refers to serious threat.									
	1	2	3	4	5	6	7	8	9	10
C.1.2.	How do you perceive litter as a threat to your local environment in relation to heavy metals and other persistent marine pollutants?									
	Less of a threat			Same level of threat			Worse of a threat			
C.1.3.	How do you perceive litter as a threat to your local environment in relation to climate change?									
	Less of a threat			Same level of threat			Worse of a threat			
C.1.4.	How do you perceive litter as a threat to your local environment in relation to overfishing?									
	Less of a threat			Same level of threat			Worse of a threat			
C.1.5.	Which three of the following aquatic habitats do you perceive as the most threatened by litter?									
	Coral reefs Rivers/estuaries Mangroves Remote sandy beaches Rocky shores Sea surface Urban sandy beaches Water column Other, please specify:									

Section D: Composition of litter in your local environment

<table>
<tr><td rowspan="2">D.1.1.</td><td colspan="2">Of the materials in the pie chart below, which are the three most numerous materials littering your local environment? Please do this ranking for any of the habitats listed below that you have knowledge of. You do not have to answer for habitats which you do not feel confident about.</td></tr>
<tr><td>
</td><td>Habitats:
Coral reefs
Rivers/estuaries
Mangroves
Remote sandy beaches
Rocky shores
Sea surface
Urban sandy beaches
Water column
Other, please specify:</td></tr>
<tr><td rowspan="2">D.1.2.</td><td colspan="2">If you were to rank the same litter materials by their weight instead of number, would your rankings change?</td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td rowspan="2">D.1.3.</td><td colspan="2">If yes, please state the three most abundant materials by mass for each of the habitats which you chose in question D.1.1.</td></tr>
<tr><td>
</td><td>Habitats:
Coral reefs
Rivers/estuaries
Mangroves
Remote sandy beaches
Rocky shores
Sea surface
Urban sandy beaches
Water column
Other, please specify:</td></tr>
</table>

D.2.	Of the litter types in the pie chart below, what are the main types of items you find in your local environment? Please do this ranking for any of the habitats on the right that you have knowledge of. You do not have to answer for habitats which you do not feel confident about.	
		Habitats: Coral reefs Rivers/estuaries Mangroves Remote sandy beaches Rocky shores Sea surface Urban sandy beaches Water column Other, please specify:

Section E: Sources, transport and fate of litter in your local environment

E.1.1.	For any of the habitats listed below for which you have knowledge, have you observed any seasonal variation in the amount of litter?	
	Yes	No
E.1.2.	If yes, in which seasons or months of the year do you observe the highest densities of litter in these different habitats? Please only reply for habitats that you feel confident about.	
	Habitats: Coral reefs Rivers/estuaries Mangroves Remote sandy beaches Rocky shores Sea surface Urban sandy beaches Water column	

<table>
<tr><td rowspan="2">E.1.3.</td><td colspan="2">What do you think is driving these seasonal changes?</td></tr>
<tr><td colspan="2">* OPEN QUESTION</td></tr>
<tr><td rowspan="2">E.2.1.</td><td colspan="2">Have you observed any long-term (decadal) changes in the density of litter in any of the habitats listed below?</td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td rowspan="3">E.2.2.</td><td colspan="2">If yes, has the density of litter increased or decreased? Please only reply for habitats that you feel confident about.</td></tr>
<tr><td>Increased</td><td>Decreased</td></tr>
<tr><td colspan="2">Habitats:
Coral reefs
Rivers/estuaries
Mangroves
Remote sandy beaches
Rocky shores
Sea surface
Urban sandy beaches
Water column</td></tr>
<tr><td rowspan="2">E.2.3.</td><td colspan="2">What do you think is driving these long-term changes?</td></tr>
<tr><td colspan="2">* OPEN QUESTION</td></tr>
<tr><td rowspan="2">E.3.</td><td colspan="2">Which of the sources in the pie chart below would you say are the top three main sources of litter into your local environment? Please only reply for habitats that you have knowledge of.</td></tr>
<tr><td>
</td><td>Habitats:
Coral reefs
Rivers/estuaries
Mangroves
Remote sandy beaches
Rocky shores
Sea surface
Urban sandy beaches
Water column
Other, please specify:</td></tr>
</table>

Section F: Impacts of litter on local ecosystems and human health

F.1.1.	Have you noticed interactions between litter and living organisms in your local area?									
	Yes			No						
F.1.2.	If yes, please indicate which organisms are most affected by the types of interactions listed in the table below. Only reply for organisms that you have knowledge of and please mention any other interactions which you have seen.									
	Ingestion	Entanglement	Nesting material	Other, please specify:						
	Birds Bony fish Invertebrates Seals/sea lions Sharks Sea turtles Whales/dolphins Other, please specify:									
F.1.3.	Are there any specific species which you think are particularly threatened by marine litter?									
	* OPEN QUESTION									
F.2.	How often do you see these interactions occur? Please reply according to the table below and provide the group of organisms you are referring to for any specific type of interaction.									
	Ingestion	Entanglement	Nesting material	Other, please specify:						
	Seldom Regularly Seasonally									
F.3.1.	Do you perceive litter to be a threat to the health of people living in your area? Indicate the level of threat on the scale below where 1 indicates no threat, 5 moderate threat and 10 high threat.									
	1	2	3	4	5	6	7	8	9	10
F.3.2.	If you perceive marine debris to pose a threat to human health, please elaborate on the kinds of threats you think it poses.									
	* OPEN QUESTION									

Section G: Knowledge gaps and research priorities

G.1.	Do you think we need more research, or do we have enough science-based knowledge to implement action plans aimed at stopping the release of litter into the marine environment?
G.2.	In terms of research, what types of primary information is required and what are the knowledge gaps concerning marine litter in your country?
G.3.	In terms of action, what are the main mitigation measures needed to curb the release of litter into the environment?
G.4.	Please mention any queries, concerns or things that came to your mind during this interview.

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Appendix III: Summaries of the reviewed literature, sorted by compartment/habitat, size of analysed litter, and type of interaction with marine organisms

Table S1. Summary of the densities, types, materials, and inferred sources of macrolitter (>25 mm) and mesoplastics (5-25 mm, collected without sieving) collected from the seashore of countries in the Western Indian Ocean. NA = data not available, nr = studies that did not report a range. Values indicated with an asterisk (*) were extracted from paper using metaDigitise.

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Comoros (including Mayotte)											
Sandy beach	M'Tzamboro	2017-2019	Beach transects, quarterly monitoring	>5 mm	NA	387.16 ± 749.86 (nr)	Items 100m^{-1} (mean for 5 non-anthropized sites)	90% plastic, 3% metal, 3% textiles, 1% paper, 1% glass, <1% wood, 3% other	NA	NA	Jost (2019)
Sandy beach	Handrema	2017-2019	Beach transects, quarterly monitoring	>5 mm	NA	387.16 ± 749.86 (nr)	Items 100m^{-1} (mean for 5 non-anthropized sites)	96% plastic, 2% metal, <1% each textiles, glass, wood, paper, 1.4% other	NA	NA	Jost (2019)
Sandy beach	Bambo	2017-2019	Beach transects, quarterly monitoring	>5 mm	NA	387.16 ± 749.86 (nr)	Items 100m^{-1} (mean for 5 non-anthropized sites)	95% plastic, 2% metal, <1% each textiles, glass, paper, wood, rubber, 1.8% other	NA	NA	Jost (2019)
Sandy beach	Ilot de Sable Blanc	2017-2019	Beach transects, quarterly monitoring	>5 mm	NA	387.16 ± 749.86 (nr)	Items 100m^{-1} (mean for 5 non-anthropized sites)	96% plastic, 2% metal, 1% textiles, <1% each glass, paper, wood, 2% other	NA	NA	Jost (2019)
Sandy beach	Saziley	2017-2019	Beach transects, quarterly monitoring	>5 mm	NA	387.16 ± 749.86 (nr)	Items 100m^{-1} (mean for 5 non-anthropized sites)	96% plastic, 3% metal, <1% each textiles, wood, paper, glass, rubber, 2% other	NA	NA	Jost (2019)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Iloni	2019	Beach transects	>5 mm	NA	NA	NA	55% plastic, 18% paper, 17% metal, 5% glass, 2% textiles, <1% rubber	NA	Tourism, urban areas	Jost (2019)
Sandy beach	Badamiers	2019	Beach transects	>5 mm	NA	NA	NA	74% plastic, 19% paper, 3% metal, 1% glass, 1% textiles, <1% each rubber, wood	NA	Tourism, urban areas	Jost (2019)
Sandy beach	Sohoa	2019	Beach transects	>5 mm	NA	NA	NA	74% plastic, 17% metal, 5% textiles, 3% paper, <1% each glass, wood, other	NA	Tourism, urban areas	Jost (2019)
Kenya											
Sandy beach	Baobab	2019	Beach transects, daily accumulation	>25 mm	NA	1270 ± 1250 * / 4 ± 2 * (nr)	Items 100m^{-1} day^{-1} / g 100m^{-1} day^{-1}	Plastics and foams had highest accumulation rates; across all beaches from study, 91% of items were food packaging, 6% personal care products, 2% household products	Of the branded products, 39% were multiple layer, 33% single layer, 16% PET, 3% HDPE, 3% PP, <1% PVC, 5% other	Local sources (tourism/ recreational beach use/ surface run-off), but also some inputs from fisheries, shipping, long-distance drift	Okuku *et al.* (2020b)
Sandy beach	Kenyatta	2019	Beach transects, daily accumulation	>25 mm	NA	1820 ± 1360 * / 12 ± 8 * (nr)	Items 100m^{-1} day^{-1} / g 100m^{-1} day^{-1}	Plastics and foams had highest accumulation rates; across all beaches from study, 91% of items were food packaging, 6% personal care products, 2% household products	Of the branded products, 39% were multiple layer, 33% single layer, 16% PET, 3% HDPE, 3% PP, <1% PVC, 5% other	Local sources (tourism/ recreational beach use/ surface run-off), but also some inputs from fisheries, shipping, long-distance drift	Okuku *et al.* (2020b)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Mkomani	2019	Beach transects, daily accumulation	>25 mm	NA	1650 ± 1250 * / 31 ± 20 * (nr)	Items $100m^{-1}$ day^{-1} / g $100m^{-1}$ day^{-1}	Plastics and foams had highest accumulation rates; across all beaches from study, 91% of items were food packaging, 6% personal care products, 2% household products	Of the branded products, 39% were multiple layer, 33% single layer, 16% PET, 3% HDPE, 3% PP, <1% PVC, 5% other	Local sources (tourism/ recreational beach use/ surface run-off), but also some inputs from fisheries, shipping, long-distance drift	Okuku *et al.* (2020b)
Sandy beach	Pirates	2019	Beach transects, daily accumulation	>25 mm	NA	2490 ± 1910 * / 16 ± 6 * (nr)	Items $100m^{-1}$ day^{-1} / g $100m^{-1}$ day^{-1}	Plastics and foams had highest accumulation rates; across all beaches from study, 91% of items were food packaging, 6% personal care products, 2% household products	Of the branded products, 39% were multiple layer, 33% single layer, 16% PET, 3% HDPE, 3% PP, <1% PVC, 5% other	Local sources (tourism/ recreational beach use/ surface run-off), but also some inputs from fisheries, shipping, long-distance drift	Okuku *et al.* (2020b)
Sandy beach	Tradewinds 1	2019	Beach transects, daily accumulation	>25 mm	NA	380 ± 310 * / 4 ± 2 * (nr)	Items $100m^{-1}$ day^{-1} / g $100m^{-1}$ day^{-1}	Plastics and foams had highest accumulation rates; across all beaches from study, 91% of items were food packaging, 6% personal care products, 2% household products	Of the branded products, 39% were multiple layer, 33% single layer, 16% PET, 3% HDPE, 3% PP, <1% PVC, 5% other	Local sources (tourism/ recreational beach use/ surface run-off), but also some inputs from fisheries, shipping, long-distance drift	Okuku *et al.* (2020b)
Sandy beach	Tradewinds 2	2019	Beach transects, daily accumulation	>25 mm	NA	900 ± 780 * / 8 ± 5 * (nr)	Items $100m^{-1}$ day^{-1} / g $100m^{-1}$ day^{-1}	Plastics and foams had highest accumulation rates; across all beaches from study, 91% of items were food packaging, 6% personal care products, 2% household products	Of the branded products, 39% were multiple layer, 33% single layer, 16% PET, 3% HDPE, 3% PP, <1% PVC, 5% other	Local sources (tourism/ recreational beach use/ surface run-off), but also some inputs from fisheries, shipping, long-distance drift	Okuku *et al.* (2020b)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	25 beaches along Kenyan coastline	2020	Standing stock surveys	>25 mm	NA	NA	NA	0.43% of total litter items were COVID-19 related items	NA	NA	Okuku *et al.* (2021a)
Sandy beach	Mkomani	2019-2020	Standing stock surveys	>25 mm	NA	Overall: 0.383 ± 0.260 (0.091-0.736) SE monsoon: 0.339 ± 0.215 (0.091-0.464) NE monsoon: 0.449 ± 0.329 (0.162-0.736)	Items m^{-2}	Overall: Mostly plastics (49.9% by count) and foam SE monsoon: Plastics dominated NE monsoon: Hygiene products dominated	Overall: Of the branded items, 48.2% were PET, 21.7% multi-layered, 17.5% single-layered, 5.6% HDPE, 2.4% PP, 4.2% PVC SE monsoon: Of the branded items, 53.6% were PET NE monsoon: Of the branded items, 42.4% were multi-layered, 26.2% single-layered, 20.2% PET	Mostly local sources, but also some long-distance drift, especially during SE monsoon	Okuku *et al.* (2021b)
Sandy beach	Mombasa beach	2019	Beach transects	>25 mm	NA	147.3 (nr)	Bottles $100m^{-1}$	NA	88% PET (Mombasa, Bamburi and Malindi combined)	Urban areas, shipping, long-distance drift	Ryan (2020a)
Sandy beach	Bamburi beach	2019	Beach transects	>25 mm	NA	22.9 (nr)	Bottles $100m^{-1}$	NA	88% PET (Mombasa, Bamburi and Malindi combined)	Urban areas, shipping, long-distance drift	Ryan (2020a)
Sandy beach	Malindi beach	2019	Beach transects	>25 mm	NA	52.7 (nr)	Bottles $100m^{-1}$	NA	88% PET (Mombasa, Bamburi and Malindi combined)	Urban areas, shipping, long-distance drift	Ryan (2020a)
Sandy beach	Diani beach	2019	Beach transects	>25 mm	NA	19.0 (nr)	Bottles $100m^{-1}$	NA	45% PET (Diani, Watamu and Coco combined)	Urban areas, shipping, long-distance drift	Ryan (2020a)
Sandy beach	Watamu beach	2019	Beach transects	>25 mm	NA	34.4 (nr)	Bottles $100m^{-1}$	NA	45% PET (Diani, Watamu and Coco combined)	Urban areas, shipping, long-distance drift	Ryan (2020a)
Sandy beach	Coco beach	2019	Beach transects	>25 mm	NA	3.1 (nr)	Bottles $100m^{-1}$	NA	45% PET (Diani, Watamu and Coco combined)	Urban areas, shipping, long-distance drift	Ryan (2020a)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Uvombo beach	2019	Beach transects	>25 mm	NA	82.0 (nr)	PET bottles 100m^{-1}	NA	52% PET (Uvombo, Ngomeni and Mareneni combined)	Urban areas, shipping, long-distance drift	Ryan (2020a)
Sandy beach	Ngomeni beach	2019	Beach transects	>25 mm	NA	25.7 (nr)	Bottles 100m^{-1}	NA	52% PET (Uvombo, Ngomeni and Mareneni combined)	Urban areas, shipping, long-distance drift	Ryan (2020a)
Sandy beach	Mareneni beach	2019	Beach transects	>25 mm	NA	36.4 (nr)	Bottles 100m^{-1}	NA	52% PET (Uvombo, Ngomeni and Mareneni combined)	Urban areas, shipping, long-distance drift	Ryan (2020a)
Madagascar											
Sandy beach	Nosy Ve	1996-2002	Beach transects, yearly accumulation	>1 cm^2	NA	0.1085 (nr)	Items 100m^{-1} yr^{-1}	Mostly persistent plastics	NA	NA	Barnes (2004)
Sandy beach	Ampasindava	2015	Beach transects	>1 cm^2	372 items	0.157 (nr)	Items m^{-2}	69% plastic, 14% cloth, 4% metal, 4% paper, 3% glass, 3% foam, 2% other, 1% cigarette butts	NA	Poor rural waste management	Gjerdseth (2017)
Sandy beach	Ramena	2015	Beach transects	>1 cm^2	626 items	0.23 (nr)	Items m^{-2}	47% plastic, 27% paper, 11% metal, 5% glass, 4% cigarette butts, 2% cloth, 2% other, 1% foam	NA	Tourism, restaurants, beach-goers	Gjerdseth (2017)
Sandy beach	Baïe de Sakalava	2015	Beach transects	>1 cm^2	218 items	0.088 (nr)	Items m^{-2}	95% plastic, 2% foam, <1% paper, <1% metal, <1% cloth, <1% cigarette butts	NA	Poor rural waste management, long-distance drift	Gjerdseth (2017)
Sandy beach, mangroves	Nosy Be (close to village)	2019	Beach transects, weekly accumulation	>25 mm	2908 items	267 ± 33 * (nr)	Items	46 % plastic	NA	Direct local inputs	Stokes & Manning (2019)
Sandy beach, mangroves	Nosy Be (control transect away from village)	2019	Beach transects, weekly accumulation	>25 mm	757 items	73 ± 16 * (nr)	Items	55% plastic	NA	Direct local inputs	Stokes & Manning (2019)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Mauritius											
Sandy beach	Rodrigues Island	1996-2002	Beach transects, yearly accumulation	>1 cm^2	NA	0.441 (nr)	Items $100m^{-1}$ yr^{-1}	Mostly persistent plastics	NA	NA	Barnes (2004)
Isolated coral atoll	St Brandon's Rock - 15 islets and sandbars	2010	Beach transects	>5 mm	28948 items	76 (12-164)	Items $100m^{-1}$	79% plastic	NA	Long-distance drift	Bouwman *et al.* (2016)
Mangrove	Mahebourg	2018	Monthly surveys	>25 mm	2127 items, 150.07 kg	0.5 ± 0.2 (1.4 ± 0.04 to 3.5 ± 0.1) / 33.9 ± 13.3 (19.0 ± 3.6 to 59.3 ± 12.6)	Items m^{-2} / g m^{-2}	By number: 43% plastic, 13% metal, 10% foam, 9% glass, 6% paper, 5% cloth, <5% each rubber, wood, other By mass: 41% plastic, 14% wood, 11% foam, 11% rubber, 9% glass, 5% cloth, 4% metal, 3% paper, 2% other	NA	Mostly from shoreline and recreational activities	Seeruttun *et al.* (2021)
Mangrove	Ferney	2018	Monthly surveys	>25 mm	1098 items, 43.71kg	0.2 ± 0.2 (2.1 ± 0.01 to 3.1 ± 0.02) / 87.9 ± 7.5 (1.8 ± 0.3 to 22.8 ± 2.4)	Items m^{-2} / g m^{-2}	By number: 44% plastic, 15% metal, 10% glass, 8% foam, 7% paper, 7% rubber, 5 % cloth, <5% each paper, wood, other By mass: 32% plastic, 25% glass, 14% metal,10% rubber, 8% cloth, 5% wood,4% foam, 1% paper, 1% other	NA	Mostly from shoreline and recreational activities	Seeruttun *et al.* (2021)
Mozambique											
Sandy beach	Quirimba Island	1996-2002	Beach transects, yearly accumulation	>1 cm^2	NA	0.212 (nr)	Items $100m^{-1}$ yr^{-1}	Mostly persistent plastics	NA	NA	Barnes (2004)
Sandy beach	Inhaca Island	1996-2002	Beach transects, yearly accumulation	>1 cm^2	NA	0.101 (nr)	Items $100m^{-1}$ yr^{-1}	Mostly persistent plastics	NA	NA	Barnes (2004)
Sandy beach	Ponta Malongane - Malongane Sul	Not specified	Beach transects	>25 mm	NA	21.8 (nr)	Items $100m^{-2}$	94% plastic, 4% rubber, 2% glass, <1% wood	NA	Tourism	Pereira *et al.* (2001)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Ponta Malongane - Parque de Campismo	Not specified	Beach transects	>25 mm	NA	70.8 (nr)	Items 100m^{-2}	81% plastic, 7% tar, 3% wood, 2% cigarette butts, 2% metal, 1% rubber, 1% cloth, 1% paper, <1% glass, <1% sponge	NA	Tourism	Pereira *et al.* (2001)
Sandy beach	Ponta Malongane - Parque de Campismo	Not specified	Random sampling	>25 mm	NA	NA	NA	84% plastic, 4% metal, 3% paper, 2% rubber, 1% tar, 1% cigarette butts, 1% wood, 1% glass, <1% cloth	NA	Tourism	Pereira *et al.* (2001)
Sandy beach	Ponta Malongane - Casas Verdes	Not specified	Beach transects	>25 mm	NA	31 (nr)	Items 100m^{-2}	86% plastic, 7% cigarette butts, 3% tar, 3% wood, 1% paper	NA	Tourism	Pereira *et al.* (2001)
Sandy beach	Ponta Malongane - Malongane Norte	Not specified	Beach transects	>25 mm	NA	135 (nr)	Items 100m^{-2}	68% plastic, 30% wood, <1% tar, <1% rubber, <1% sponge, <1% cloth	NA	Tourism, but also transport by winds coming from south-southwest, currents and tides	Pereira *et al.* (2001)
Seychelles											
Sandy beach	Aldabra Atoll (sampled at Dune d'Messe, Dune Jean-Louis, Cinq Cases)	2019	Beach transects	>10 mm	26.4 tonnes (513.4 tonnes [95% CI 212-814 tonnes] extrapolated across whole island)	0.44 (extrapolated across whole island) (nr)	kg m^{-2}	By mass: 60% fishing-related items, 24% plastic shoes	NA	Mostly fisheries, some from long-distance drift	Burt *et al.* (2020)
Sandy beach	Alphonse Island	2013	Beach transects, weekly accumulation	>5 mm	4743 items / 142 kg	470 / 14.2 (nr)	Items 100m^{-1} / kg 100m^{-1}	By number: 96% plastic, 2% fishing gear; By mass: 23% beach sandals, 21% glass bottles, 15% other (comprising three heavy large items), 9% plastic beverage bottles, 8% hard plastic, 7% fishing items, 6% foam sheets, 5% domestic items, 6% smaller categories	NA	Long-distance drift, tourism, industry, wastewater, shipping	Duhec *et al.* (2015)
Sandy beach	Cousine Island	2003-2019	Beach transects, daily accumulation	>10 mm	9119 items	0.82 ± 0.77 (0.10-4.15) / 299.3	Items 100m^{-1} day^{-1} / items 100m^{-1} yr^{-1}	All plastics contributed >80%; mostly polystyrene fragments/ pieces, plastic items, plastic bottle	NA	NA	Dunlop *et al.* (2020)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Desroches Island	2006	Strandline surveys	>10 mm	NA	5.4	Plastic items m^{-1} yr^{-1}	NA	NA	NA	Barnes *et al.* (2009)
Sandy beach	Mahe Island	2006, 2007, 2008	Strandline surveys	>10 mm	NA	12.9 [mean of three years]	Plastic items m^{-1} yr^{-1}	NA	NA	NA	Barnes *et al.* (2009)
Sandy beach	Sillouette Island	2006, 2007	Strandline surveys	>10 mm	NA	6.7 [mean of two years]	Plastic items m^{-1} yr^{-1}	NA	NA	NA	Barnes *et al.* (2009)
Sandy beach	Curieuse Island	2008	Strandline surveys	>10 mm	NA	7.2	Plastic items m^{-1} yr^{-1}	NA	NA	NA	Barnes *et al.* (2009)
South Africa											
Sandy beach adjacent to river mouth	Zandvlei, False Bay	2020	Beach transect, daily accumulation	>1 cm	6554	1.65 (IQR: 0.95-3.14)	Median items $100m^{-1}$ day^{-1}, inter-quartile range	85% lids, 8% bottles, 6% ice lolly packets, 1% light sticks, 1% cigarette lighters – but only collected sub-set of items	NA	Mostly from local land-based sources, some foreign items dumped from ships or via long-distance drift	Ryan & Perold (2021)
Sandy beach	Milnerton beach, Cape Town	2019	Beach transects, daily accumulation	>10 mm	24641 items / 91.1 kg	329 ± 410 / 1214.5 ± 1520.6 (nr)	Items $100m^{-1}$ day^{-1} / g $100m^{-1}$ day^{-1}	98% plastic by number, 45% plastic by mass, 38% wood by mass	NA	Urban areas, rivers	Opie (2020)
Sandy beach	Koeberg beach, Cape Town	2019	Beach transects, daily accumulation	>10 mm	14960 items / 25.5 kg	100 ± 85 / 170.1 ± 93 (nr)	Items $100m^{-1}$ day^{-1} / g $100m^{-1}$ day^{-1}	99% plastic by number, 59% plastic by mass, 38% wood by mass	NA	Urban areas, rivers	Opie (2020)
Rocky shore	Muizenberg, False Bay	2018-2019	Beach transects, monthly accumulation	>25 mm	1191 items / 207 200 g	240 ± 170 (53-910) / 4360 ± 4270 (441-23670)	Items $100m^{-1}$ $month^{-1}$ / g $100m^{-1}$ $month^{-1}$ (range is min and max number/mass per month)	By number: 74% plastic (mostly packaging), 19% glass, 3% cloth/leather; By mass: 31% plastic, 25% glass, 23% rubber, 11% cloth/leather, 4% metal, 3% brick/ceramic, 3% wood	NA	Mostly from urban run-off, some from beachgoers or at-sea activities	Weideman *et al.* (2020b)
Sandy beach	Muizenberg, False Bay	2019	Beach transect, monthly accumulation	>25 mm	2793 items / 10189 g	230 ± 30 (813-991) / 850 ± 880 (1230-7451)	Items $100m^{-1}$ $month^{-1}$ / g $100m^{-1}$ $month^{-1}$ (range is min and max number/mass per month)	By number: 96% plastic (78% plastic packaging), 3% cloth/leather; By mass: 78% plastic (18% packaging, 60% disposable user items), 13% wood, 5% glass, 3% metal	NA	Mostly from urban run-off, some from beachgoers or at-sea activities	Weideman *et al.* (2020b)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Hout Bay	2017	Beach transects, daily accumulation	>20 mm	36 620 items / 52.9 kg (across all five beaches)	594 ± 494 [SE] / 1294 ± 732 [SE] (nr)	Items $100m^{-1}$ day^{-1} / g $100m^{-1}$ day^{-1}	By number: 96% plastic (mostly food and beverage packaging); By mass: 76% plastic	NA	NA	Chitaka & von Blottnitz (2019)
Sandy beach	Milnerton	2017	Beach transects, daily accumulation	>20 mm	36 620 items / 52.9 kg (across all five beaches)	521 ± 364 [SE] / 827 ± 871 [SE] (nr)	Items $100m^{-1}$ day^{-1} / g $100m^{-1}$ day^{-1}	By number: 97% plastic (mostly food and beverage packaging); By mass: 67% plastic	NA	NA	Chitaka & von Blottnitz (2019)
Sandy beach	Muizenberg	2017	Beach transects, daily accumulation	>20 mm	36 620 items / 52.9 kg (across all five beaches)	36 ± 28 [SE] / 134 ± 134 [SE] (nr)	Items $100m^{-1}$ day^{-1} / g $100m^{-1}$ day^{-1}	By number: 95% plastic (mostly especially food and beverage items); By mass: 57% plastic	NA	NA	Chitaka & von Blottnitz (2019)
Sandy beach	Paarden Eiland	2017	Beach transects, daily accumulation	>20 mm	36 620 items / 52.9 kg (across all five beaches)	2961 ± 2386 [SE] / 4421 ± 3329 [SE] (nr)	Items $100m^{-1}$ day^{-1} / g $100m^{-1}$ day^{-1}	By number: 99% plastic (mostly food and beverage packaging); By mass: 83% plastic	NA	NA	Chitaka & von Blottnitz (2019)
Sandy beach	Wolfgat	2017	Beach transects, daily accumulation	>20 mm	36 620 items / 52.9 kg (across all five beaches)	2197 ± 825 [SE] / 2340 ± 1181 [SE] (nr)	Items $100m^{-1}$ day^{-1} / g $100m^{-1}$ day^{-1}	By number: 97% plastic (mostly food and beverage packaging); By mass: 83.4% plastic	NA	NA	Chitaka & von Blottnitz (2019)
Sandy beach	Milnerton, Table Bay	2014	Beach transects, only freshly stranded litter on wet sand	>5 mm	256 items	73 (nr)	Items $100m^{-1}$	Plastic made up >96% of litter at all sites; mostly plastic packaging, but fishery-related items made up bigger proportion by mass	NA	NA	Fazey & Ryan (2016)
Sandy beach	Muizenberg, False Bay	2014	Beach transects, only freshly stranded litter on wet sand	>5 mm	279 items	37 (nr)	Items $100m^{-1}$	Plastic made up >96% of litter at all sites; mostly plastic packaging, but fishery-related items made up bigger proportion by mass	NA	NA	Fazey & Ryan (2016)
Sandy beach	16 Mile beach, West Coast Park	2014	Beach transects, only freshly stranded litter on wet sand	>5 mm	520 items	104 (nr)	Items $100m^{-1}$	Plastic made up >96% of litter at all sites; mostly plastic packaging, but fishery-related items made up bigger proportion by mass	NA	NA	Fazey & Ryan (2016)
Sandy beach	Die Plaat, Walker Bay	2014	Beach transects, only freshly stranded litter on wet sand	>5 mm	186 items	4 (nr)	Items $100m^{-1}$	Plastic made up >96% of litter at all sites; mostly plastic packaging, but fishery-related items made up bigger proportion by mass	NA	NA	Fazey & Ryan (2016)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Rocherpan Nature Reserve	2014	Beach transects, only freshly stranded litter on wet sand	>5 mm	180 items	4 (nr)	Items 100m^{-1}	Plastic made up >96% of litter at all sites; mostly plastic packaging, but fishery-related items made up bigger proportion by mass	NA	NA	Fazey & Ryan (2016)
Sandy beach	De Mond Nature Reserve	2014	Beach transects, only freshly stranded litter on wet sand	>5 mm	198 items	4 (nr)	Items 100m^{-1}	Plastic made up >96% of litter at all sites; mostly plastic packaging, but fishery-related items made up bigger proportion by mass	NA	NA	Fazey & Ryan (2016)
Sandy beach	Milnerton beach, Cape Town	2012	Beach transects, daily accumulation	>10 mm	124 646 items / 147 kg (across both study sites)	1458 ± 273 (nr)	Items 100m^{-1} day^{-1}	Both study sites combined, by number: 93% plastic; By mass: 59% plastic, 22% wood, 13% glass, 2% cloth	NA	Urban areas	Lamprecht (2013), Ryan *et al.* (2014a)
Sandy beach	Koeberg beach, Cape Town	2012	Beach transects, daily accumulation	>10 mm	124 646 items / 147 kg (across both study sites)	102 ± 43 (nr)	Items 100m^{-1} day^{-1}	Both study sites combined, by number: 93% plastic; By mass: 59% plastic, 22% wood, 13% glass, 2% cloth	NA	Urban areas	Lamprecht (2013), Ryan *et al.* (2014a)
Sandy beach	16 Mile Beach	2010	Beach transects	>10 mm	NA	10 060 / 133 110 (nr)	Items 100m^{-1} / g 100m^{-1}	99% plastic	NA	Urban areas, fisheries, shipping	Ryan *et al.* (2020a)
Sandy beach	Agate Terrace	1994	Beach transects	<1, 1-10, 11-100, 101-1000, >1000 cm^2	6053 items / 16275 g (all six beaches combined)	NA	NA	95% plastic, 1% metal, 1% styrofoam, 1% glass, 1% clothes, 1% other	NA	Rivers	Madzena & Lasiak (1997)
Sandy beach	Agate Terrace	1994-1995	Beach transects, monthly accumulation	<1, 1-10, 11-100, 101-1000, >1000 cm^2	7015 items / 20033 g (all six beaches combined)	140 / 340 (nr)	Items 100m^{-1} month^{-1} / g 100m^{-1} month^{-1}	89% plastic, 5% paper, 3% styrofoam, 3% other	NA	Rivers	Madzena & Lasiak (1997)
Sandy beach	Second Beach	1994-1995	Beach transects, monthly accumulation	<1, 1-10, 11-100, 101-1000, >1000 cm^2	7015 items / 20033 g (all six beaches combined)	860 (nr)	Items 100m^{-1} month^{-1}	56% styrofoam, 31% plastic, 1% metal, 1% glass, 1% paper, 10% other	NA	Tourism	Madzena & Lasiak (1997)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Mngazi	1994-1995	Beach transects, monthly accumulation	<1, 1-10, 11-100, 101-1000, >1000 cm^2	7015 items / 20033 g (all six beaches combined)	870 (nr)	Items $100m^{-1}$ $month^{-1}$	96% plastic, 2% glass, 2% other	NA	NA	Madzena & Lasiak (1997)
Sandy beach	Mdumbi	1994-1995	Beach transects, monthly accumulation	<1, 1-10, 11-100, 101-1000, >1000 cm^2	7015 items / 20033 g (all six beaches combined)	980 (nr)	Items $100m^{-1}$ $month^{-1}$	92% plastic, 5% styrofoam, 3% other	NA	NA	Madzena & Lasiak (1997)
Sandy beach	Umtata Mouth	1994-1995	Beach transects, monthly accumulation	<1, 1-10, 11-100, 101-1000, >1000 cm^2	7015 items / 20033 g (all six beaches combined)	NA	NA	96% plastic, 4% other	NA	NA	Madzena & Lasiak (1997)
Sandy beach	Coffee Bay	1994-1995	Beach transects, monthly accumulation	<1, 1-10, 11-100, 101-1000, >1000 cm^2	7015 items / 20033 g (all six beaches combined)	2500 (nr)	g $100m^{-1}$ $month^{-1}$	53% plastic, 28% styrofoam, 4% glass, 4% metal, 3% clothes, 1% paper, 1% wood, 6% other	NA	Tourism	Madzena & Lasiak (1997)
Sandy beach	Second Beach	1994	Beach transects	<1, 1-10, 11-100, 101-1000, >1000 cm^2	6053 items / 16275 g (all six beaches combined)	7250 / 7220 (nr)	Items $100m^{-1}$ / g $100m^{-1}$	84% plastic, 9% styrofoam, 2% glass, 4% other	NA	Tourism	Madzena & Lasiak (1997)
Sandy beach	Mngazi	1994	Beach transects	<1, 1-10, 11-100, 101-1000, >1000 cm^2	6053 items / 16275 g (all six beaches combined)	4950 (nr)	Items $100m^{-1}$	88% plastic, 8% styrofoam, 3% glass	NA	NA	Madzena & Lasiak (1997)
Sandy beach	Mdumbi	1994	Beach transects	<1, 1-10, 11-100, 101-1000, >1000 cm^2	6053 items / 16275 g (all six beaches combined)	1960 / 4280 (nr)	Items $100m^{-1}$ / g $100m^{-1}$	97% plastic, 1% metal, 2% other	NA	NA	Madzena & Lasiak (1997)
Sandy beach	Umtata Mouth	1994	Beach transects	<1, 1-10, 11-100, 101-1000, >1000 cm^2	6053 items / 16275 g (all six beaches combined)	NA	NA	94% plastic, 2% styrofoam, 4% other	NA	NA	Madzena & Lasiak (1997)
Sandy beach	Coffee Bay	1994	Beach transects	<1, 1-10, 11-100, 101-1000, >1000 cm^2	6053 items / 16275 g (all six beaches combined)	16410 (nr)	g $100m^{-1}$	40% plastic, 30% styrofoam, 19% glass, 4% paper, 2% metal, 1% wood, 1% clothes, 3% other	NA	Tourism	Madzena & Lasiak (1997)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Milnerton beach, Cape Town	1994	Beach transects, daily accumulation	>10 mm	21739 items / 64.68 kg	157 ± 70 (nr)	Items $100m^{-1}$ day^{-1}	Styrofoam, plastics, miscellaneous	NA	Tourism, urban areas, shipping	Swanepoel (1995), Ryan *et al.* (2014a)
Sandy beach	Koeberg beach, Cape Town	1994	Beach transects, daily accumulation	>10 mm	4771	35 ± 3 (nr)	Items $100m^{-1}$ day^{-1}	Styrofoam, plastics, miscellaneous	NA	Tourism, urban areas, shipping	Swanepoel (1995), Ryan *et al.* (2014a)
Sandy beach	52 beaches along the coastline from Saldanha Bay to Kei River mouth	1989	Beach transects	>20 mm	NA	299 (nr)	Items $100m^{-1}$	88% plastic (both years combined); 69% packaging and other disposable items (only year 1989)	NA	Urban areas (96% of macroplastics were produced in South Africa)	Ryan & Moloney (1990)
Sandy beach	50 beaches along South African coast	1984	Beach transects	>20 mm	NA	Urban beaches = 66, Rural beaches = 53 (nr)	Packaging items $100m^{-1}$	>90% plastic, of which 57% packaging, 31% fishing gear	NA	Urban areas, fisheries	Ryan (1990)
Sandy beach	52 beaches along the coastline from Saldanha Bay to Kei River mouth	1984	Beach transects	>20 mm	NA	109 (nr)	Items $100m^{-1}$	88% plastic (both years combined); 65% packaging and other disposable items (only year 1984)	NA	Urban areas (96% of macroplastics were produced in South Africa)	Ryan & Moloney (1990)
Island	Marion Island	1984	Surveys for stranded litter	>10 mm	109 items	2.83 (nr)	Items $100m^{-1}$	94% plastic (mostly expanded polystyrene and bags), 6% metal	NA	Local meteorological station, fisheries, shipping, long-distance drift	Ryan (1987a)
Island	Prince Edward Island	1984	Surveys for stranded litter	>10 mm	46 items	4.38 (nr)	Items $100m^{-1}$	76% plastic (mostly fishery floats and expanded polystyrene), 24% metal	NA	Local meteorological station, fisheries, shipping, long-distance drift	Ryan (1987a)
Sandy beach	Several beaches	Several years	Summary of published and unpublished data	Not specified, but it is macrolitter	NA	4120 (480-30000)	Items km^{-1}	93% plastic, 3% glass, 2% metal, 2% paper; 25-40% are fishing related items	NA	NA	Gregory & Ryan (1997)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Fence line	Fence line next to Milnerton beach, Cape Town	1994	Fence survey	>10 mm	NA	20.7 (nr)	g $100m^{-1}$ day^{-1}	NA	NA	NA	Swanepoel (1995)
Fence line	Fence line next to Koeberg beach, Cape Town	1994	Fence survey	>10 mm	NA	1.1 (nr)	g $100m^{-1}$ day^{-1}	NA	NA	NA	Swanepoel (1995)
Sandy beaches and rocky shores	32 sites along South African coast	2019-2020	Beach transects	NA	13 240 bottles	NA (8-450)	Bottles km^{-1}	95% plastic, 3% glass, 2% metal and composites (Tetra Paks)	59% PET, 27% HDPE, 9% PP, <1% other polymers (LDPE, PVC, PS and SAN, styrene acrylonitrile)	Local land-based sources, illegal dumping from ships, long-distance drift	Ryan *et al.* (2021)
Tanzania											
Sandy beach	Pemba Island	1996-2002	Beach transects, yearly accumulation	>1 cm^2	NA	0.2 (nr)	Items $100m^{-1}yr^{-1}$	Mostly persistent plastics	NA	NA	Barnes (2004)

Table S2. Summary of the densities, types, materials, and inferred sources of macrolitter (>25 mm) and mesolitter (5-25 mm, collected without nets) in surface waters of the Western Indian Ocean. NA = data not available, nr = studies that did not report a range.

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Kenya											
Coastal water surface	Coastal waters adjacent to Kilifi county	2020	Observations	>25 mm	NA	86	items km^{-2}	NA	NA	NA	Okuku *et al.* (2021a)
Coastal water surface	Coastal waters adjacent to Kwale county	2020	Observations	>25 mm	NA	66	items km^{-2}	NA	NA	NA	Okuku *et al.* (2021a)
South Africa											
Coastal and offshore water surface	Southwestern Cape Province from Cape Columbine to Cape Point	1985	At-sea aerial transects	>100 mm	NA	10km offshore = 19.64, 50km offshore = 1.64 (nr)	items km^{-2}	NA	NA	NA	Ryan (1988)
Coastal and offshore water surface	Agulhas retroflection region	1990	Observations	>25 mm	NA	0.04-0.09	items km^{-2}	NA	NA	NA	Ryan (1990)
Coastal and offshore water surface	Agulhas retroflection region	2013, 2014	Observations	>1 cm	NA	1.0	items km^{-2}	NA	>90% plastic, and mostly plastic packaging	NA	Ryan *et al.* (2014b)
Coastal and offshore water surface	Southwest of Cape Town	2013, 2014	Observations	>1 cm	NA	0.2	items km^{-2}	NA	>90% plastic, and mostly plastic packaging	NA	Ryan *et al.* (2014b)
International WIO											
Off-shore water surface	Transect from Cape Town to north of the Subtropical Front	2017	Observations	>25 mm	37	0.28-0.51	items km^{-2}	NA	NA	NA	Suaria *et al.* (2020a)
Off-shore water surface	Transect from Durban to Kerguelen and Crozet islands	2019-2020	Observations	>1 cm^2	1 623	12.66 (0-169)	items km^{-2}	99% plastic, 1% non-plastic	64% plastic fragments, 20% plastic packaging, 7% plastic fishing/boating debris, 7% plastic user items, 1% non-plastic, <1% other	Both local inputs (fishing-related items and other maritime litter) and long-distance transport	Connan *et al.* (2021)

Table S3. Summary of the densities, types, materials, and inferred sources of macrolitter (>25 mm) and mesoplastics (5-25 mm, collected without sieving) on the seafloor of the Western Indian Ocean. NA = data not available, nr = studies that did not report a range.

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Comoros (including Mayotte)											
Fringing reef	Mayotte	2018, 2019	Reef transects	>5 cm^2	Winter: 172 items / Summer: 167 items	Winter: 3.9 ± 1.3 (0-41.5) Summer: 3.8 ± 1.1 (0-36.5)	items 500m^{-2} (max is the average items 500m^{-2} at the site with the highest density of litter)	Winter: 95% plastic (62% fishing gear, 15% bags, 14% bottles, 6% textiles, 2% rubber/boat plastic), 4% metal, 1% glass and ceramic; Summer: 89% plastic (69% fishing gear, 10% bags and sacks, 9% textiles, 6% rubber/boat plastic, 4% bottles), 11% metal, <1% glass and ceramic	NA	Urban areas, runoff from rivers, fisheries	Mulochau *et al.* (2020)
South Africa											
Seafloor	South African continental shelf	2019	Underwater transects	>35 mm	65 items / 39.5 kg	3.4 / 2.1 (nr)	items km^{-2} / kg km^{-2}	88% plastics by number, 14% by mass; overall types by number: 48% packaging, 19% fishing gear, 23% disposable plastics, 10% user items; overall by mass: 91% user items, 7% fishing gear, 2% packaging, <1% disposable plastics	38% LDPE, 34% polypropylene, 12% polyamide, 3% each of HDPE and PET bottles; 10% of plastic items could not be identified to polymer type	Urban areas, fisheries, shipping	Ryan *et al.* (2020c)
Seafloor within bay	False Bay, several sites	1991	Underwater transects	>20 mm	557 items of plastic packaging [Kalk Bay = 95 pieces in March, 220 in September; Monwabisi = 73 pieces in March, 60 in September] / Total mass at Kalk Bay = 660 g, total mass at Monwabisi = 1350 g	NA	NA	By number: 83% plastic packaging, of which 65% were plastic bags, 21% bottles/jars, 12% food wrapping, 1% packing straps, <1% polystyrene fragments	NA	Local tourism, local residents	Rundgren (1992)
Seafloor within bay	False Bay	NA	Underwater photographs	NA	0	0	No litter was seen in 421 images	NA	NA	NA	Ryan (2020b)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
International WIO											
Deepsea floor	Coral Seamount	2011, 2013	Remotely Operated Vehicle transects	Not specified, smallest category was <20 cm	NA	1.47 (nr)	items ha^{-1}	Mostly fishing gear	NA	Fisheries	Woodall *et al.* (2015)
Deepsea floor	Melville Bank	2011, 2013	Remotely Operated Vehicle transects	Not specified, smallest category was <20 cm	NA	13.33 (nr)	items ha^{-1}	Mostly fishing gear	NA	Fisheries	Woodall *et al.* (2015)
Deepsea floor	Middle of What Seamount	2011, 2013	Remotely Operated Vehicle transects	Not specified, smallest category was <20 cm	NA	2.44 (nr)	items ha^{-1}	Mostly fishing gear	NA	Fisheries	Woodall *et al.* (2015)
Deepsea floor	Sapmer Seamount	2011, 2013	Remotely Operated Vehicle transects	Not specified, smallest category was <20 cm	NA	17.39 (nr)	items ha^{-1}	Mostly fishing gear	NA	Fisheries	Woodall *et al.* (2015)
Deepsea floor	Atlantis Bank	2011, 2013	Remotely Operated Vehicle transects	Not specified, smallest category was <20 cm	NA	0.75 (nr)	items ha^{-1}	Mostly fishing gear	NA	Fisheries	Woodall *et al.* (2015)

Table S4. Summary of the densities, types, materials, and inferred sources of macrolitter (>25 mm) and mesoplastics (5-25 mm, collected without nets) in rivers, estuaries and stormwater drains of the Western Indian Ocean. NA = data not available, nr = studies that did not report a range.

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
South Africa											
Stormwater catchment	Capel Sloot, Cape Town, drains into Duncan Docks	Not specified	Trap over stormwater outlet	>75 mm	NA	0.33 / 31 (nr)	$m^3\ ha^{-1}\ yr^{-1}$ / $kg\ ha^{-1}\ yr^{-1}$	NA	NA	Urban areas, industry, wastewater	Armitage & Rooseboom (2000)
Stormwater outlet	Imizamo Yethu, Cape Town	2000-2002	Trap over stormwater outlet	>25 mm, although mesh size not reported	NA	45 (nr)	$kg\ ha^{-1}\ yr^{-1}$	Plastic dominant when miscellaneous excluded	NA	NA	Marais *et al.* (2004)
Stormwater outlet	Ocean View, Cape Town	2000-2002	Trap over stormwater outlet	>25 mm, although mesh size not reported	NA	41 (nr)	$kg\ ha^{-1}\ yr^{-1}$	Plastic dominant when miscellaneous excluded	NA	NA	Marais *et al.* (2004)
Stormwater outlet	Central Business District (Section C), Cape Town	2000-2002	Trap over stormwater outlet	>25 mm, although mesh size not reported	NA	23 (nr)	$kg\ ha^{-1}\ yr^{-1}$	Plastic dominant when miscellaneous excluded	NA	NA	Marais *et al.* (2004)
Stormwater outlet	Central Business District (Section D), Cape Town	2000-2002	Trap over stormwater outlet	>25 mm, although mesh size not reported	NA	22 (nr)	$kg\ ha^{-1}\ yr^{-1}$	Plastic dominant when miscellaneous excluded	NA	NA	Marais *et al.* (2004)
Stormwater outlet	Central Business District (Section E), Cape Town	2000-2002	Trap over stormwater outlet	>25 mm, although mesh size not reported	NA	59 (nr)	$kg\ ha^{-1}\ yr^{-1}$	Plastic dominant when miscellaneous excluded	NA	NA	Marais *et al.* (2004)
Stormwater outlet	Fresnaye, Cape Town	2000-2002	Trap over stormwater outlet	>25 mm, although mesh size not reported	NA	0 (nr)	$kg\ ha^{-1}\ yr^{-1}$	NA	NA	NA	Marais *et al.* (2004)
Stormwater outlet	Summer Greens, Cape Town	2000-2002	Trap over stormwater outlet	>25 mm, although mesh size not reported	NA	6 (nr)	$kg\ ha^{-1}\ yr^{-1}$	Paper dominant when miscellaneous excluded	NA	NA	Marais *et al.* (2004)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Stormwater outlet	Montague Gardens, Cape Town	2000-2002	Trap over stormwater outlet	>25 mm, although mesh size not reported	NA	28 (nr)	kg ha^{-1} yr^{-1}	Plastic dominant when miscellaneous excluded	NA	NA	Marais *et al.* (2004)
Stormwater outlet	Welgemoed, Cape Town	2000-2002	Trap over stormwater outlet	>25 mm, although mesh size not reported	NA	0 (nr)	kg ha^{-1} yr^{-1}	Paper dominant when miscellaneous excluded	NA	NA	Marais *et al.* (2004)
Stormwater outlet	Stormwater outlet, Cape Town harbour	1994	Trap over stormwater outlet	>10 mm	NA	679.7 / 2.1 (nr)	items m^{-2} day^{-1} / kg m^{-2} day^{-1}	NA	NA	NA	Swanepoel (1995)
Stormwater outlet	Sea Point, Cape Town	2018, 2019	Trap over stormwater outlet	>10 mm	NA	203 / 115 (nr)	items ha^{-1} day^{-1} / g ha^{-1} day^{-1}	By number: plastic 49%, cigarette butts 37%; by mass: plastic 52%, cigarette butts 13%; most plastic was food packaging	NA	Street litter	Weideman *et al.* (2020d)
Stormwater outlet	Paarden Eiland, Cape Town	2018, 2019	Trap over stormwater outlet	>10 mm	NA	576 / 377 (nr)	items ha^{-1} day^{-1} / g ha^{-1} day^{-1}	Plastic 78% by number, 52% by mass; most plastic was food packaging	NA	Street litter	Weideman *et al.* (2020d)
Stormwater outlet	Milnerton, Cape Town	2018, 2019	Trap over stormwater outlet	>10 mm	NA	5 / 2.4 (nr)	items ha^{-1} day^{-1} / g ha^{-1} day^{-1}	By number: plastic 40%, cigarette butts 42%, by mass: plastic 64%, cigarette butts 19%; most plastic was food packaging	NA	Street litter	Weideman *et al.* (2020d)
River surface water	Black River, Cape Town	1994	Observations	>10 mm	NA	2888 / 8.8 (nr)	Items discharged day^{-1} / kg discharged day^{-1}	NA	NA	NA	Swanepoel (1995)
River surface water	Orange River Mouth, Alexander Bay, Northern Cape	2018, 2020	Observations	>25 mm	1 item / <5 g	NA	NA	Sweet wrapper	NA	NA	Weideman *et al.* (2020c)
River surface water	Swartkops River, Algoa Bay	2019	Observations	>25 mm	3440.6 items without cleaning upstream of the river's mouth, 959 with cleaning	NA	Estimated number of plastics transported per day	36% plastic particles, 19% foam/polystyrene, 15% food packaging, 11% plastic bags, 11% plastic films/sheets, 3% synthetic ropes, 3% plastic bottles, 3% other (incld. cigarette butts)	NA	NA	Moss *et al.* (2021)
River surface water	Baakens River, Algoa Bay	2019	Observations	>25 mm	1504	NA	Estimated number of plastics transported per day	28% plastic films/sheets, 21% plastic particles, 8% foam/polystyrene, 5% other (incld. cigarette butts), 2% plastic bags, 1% food packaging, 1% synthetic ropes/fibres	NA	NA	Moss *et al.* (2021)
River surface water	Sundays River, Algoa Bay	2019	Observations	>25 mm	22	NA	Estimated number of plastics transported per day	87% plastic particles, 5% food packaging, 5% plastic films/sheets, 3% plastic bags	NA	NA	Moss *et al.* (2021)

Table S5. Summary of the densities, types, materials, and inferred sources of micro- (<5 mm) and mesoplastics (5-25 mm, collected with cores or sieving) from the seashore of countries in the Western Indian Ocean. NA = data not available, nr = studies that did not report a range. Values indicated with an asterisk (*) were extracted from paper using metaDigitise.

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Comoros (including Mayotte)											
Sandy beach	M'Tzamboro	2019	Sieve transects	0.25-5 mm	NA	NA	NA	94% fibres, 6% fragments, <1% microbeads, <1% films	NA	Wastewater	Jost (2019)
Sandy beach	Handrema	2019	Sieve transects	o.25-5 mm	NA	NA	NA	96% fibres, 4% fragments, <1% films	NA	Wastewater	Jost (2019)
Sandy beach	Bambo	2019	Sieve transects	0.25-5 mm	NA	533.4 ± 261.3 (nr)	Items kg^{-1}	94% fibres, 6% fragments, <1% foam	NA	Wastewater	Jost (2019)
Sandy beach	Ilot de Sable Blanc	2019	Sieve transects	0.25-5 mm	NA	172.3 ± 119.7 (nr)	Items kg^{-1}	90% fibres, 10% fragments	NA	Wastewater	Jost (2019)
Sandy beach	Saziley	2019	Sieve transects	0.25-5 mm	NA	377.1 (nr)	Items kg^{-1}	93% fibres, 6% fragments, <1% films	NA	Wastewater	Jost (2019)
Kenya											
Sandy beach	6 beaches near populated areas	2019	Sieve transects	5-25 mm	NA	2572.7 ± 1320.0 (nr)	Items m^{-2}	Plastic contributed >60% of litter at all beaches, except Mkomani which had 71% metal	NA	Tourism, rivers, boat repair, fisheries	Okuku *et al.* (2020a)
Sandy beach	14 beaches near semi populated areas	2019	Sieve transects	5-25 mm	NA	328.6 ± 94.1 (nr)	Items m^{-2}	Plastic contributed from 90% to 100% of litter at most beaches, except three beaches where it ranged from 30% to 70%	NA	Tourism, rivers, boat repair, fisheries	Okuku *et al.* (2020a)
Sandy beach	3 beaches in remote areas	2019	Sieve transects	5-25 mm	NA	122.7 ± 20.7 (nr)	Items m^{-2}	Plastic contributed from 70% to 90% of litter at all beaches	NA	Tourism, rivers, boat repair, fisheries	Okuku *et al.* (2020a)
Mozambique											
Sandy beach	Pemba	Not specified	Sediment cores	<1 mm (lower limit not specified)	NA	Somewhere between 21 and 30	Items $250mL^{-1}$	Apparently mostly fibres, since authors usually refer to microplastics as fibres	Data not available for specific site, but overall results for 18 beaches around the world: polyester (56%), acrylic (23%), polypropylene (7%), polyethylene (6%), and polyamide fibers (3%)	Urban areas, wastewater	Browne *et al.* (2011)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
South Africa											
Sandy beach	Western Cape	Not specified	Sieve transects	<1 mm (lower limit not specified)	NA	Somewhere between 21 and 30	Items $250mL^{-1}$	Apparently mostly fibres, since authors usually refer to microplastics as fibres	Data not available for specific site, but overall results for 18 beaches around the world: polyester (56%), acrylic (23%), polypropylene (7%), polyethylene (6%), and polyamide fibers (3%)	Urban areas, wastewater	Browne *et al.* (2011)
Sandy beach	West Coast	2016, 2017	Sediment cores	0.04-1 mm	NA	Feb-March 2017 = 33 ± 21 (3-87), Nov 2016 = 47 ± 30 (3-120), May-June 2016 = 48 ± 20 (8-132)	Fibres dm^{-3}	NA	NA	Wastewater, rivers	De Villiers (2018)
Sandy beach	Cape Peninsula	2017	Sediment cores	0.04-1 mm	NA	Feb-March 2017 = 101 ± 147 (17-797)	Fibres dm^{-3}	NA	NA	Wastewater, rivers	De Villiers (2018)
Sandy beach	South Coast	2016, 2017	Sediment cores	0.04-1 mm	NA	Feb-March 2017 = 41 ± 23 (0-108), May-June 2016 = 57 ± 20 (4-124)	Fibres dm^{-3}	NA	NA	Wastewater, rivers	De Villiers (2018)
Sandy beach	South-East Coast	2016, 2017	Sediment cores	0.04-1 mm	NA	Feb-March 2017 = 97 ± 122 (4-520), May-June 2016 = 101 ± 87 (4-772)	Fibres dm^{-3}	NA	NA	Wastewater, rivers	De Villiers (2018)
Sandy beach	East Coast	2016, 2017	Sediment cores	0.04-1 mm	NA	Feb-March 2017 = 127 ± 96 (20-512), May-June 2016 = 125 ± 42 (16-284)	Fibres dm^{-3}	NA	NA	Wastewater, rivers	De Villiers (2018)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Mhlangeni Estuary, KZN	2017	Sediment cores	0.02-5 mm	2209 microplastics (all three estuaries and both water and beach samples combined)	13300 ± 1520 * (nr)	Items m^{-2}	Beach and water surface combined: 60% fibres, 23% fragments, followed by films, microbeads and foam	NA	Wastewater, rivers, fisheries	Gerber (2017)
Sandy beach	Kongweni Estuary, KZN	2017	Sediment cores	0.02-5 mm	2209 microplastics (all three estuaries and both water and beach samples combined)	18900 ± 2310 * (nr)	Items m^{-2}	Beach and water surface combined: 64% fibres, 22% fragments, followed by films, microbeads, foam and twine	NA	Wastewater, rivers, fisheries	Gerber (2017)
Sandy beach	Bilanhlolo Estuary, KZN	2017	Sediment cores	0.02-5 mm	2209 microplastics (all three estuaries and both water and beach samples combined)	42200 ± 2170 * (nr)	Items m^{-2}	Beach and water surface combined: 58% fibres, 23% fragments, followed by films, microbeads, twine and foam	NA	Wastewater, rivers, fisheries, possibly overflow from nearby landfill	Gerber (2017)
Sandy beach	2000m north of Mhlangeni Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	5210.9 ± 781.6 * (nr)	Items m^{-2}	Mhlangeni: 79% fibres, 6% films, 3% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	1000m north of Mhlangeni Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	6687.3 ± 1042.2 * (nr)	Items m^{-2}	Mhlangeni: 79% fibres, 6% films, 3% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	500m north of Mhlangeni Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	9466.5 ± 955.3 * (nr)	Items m^{-2}	Mhlangeni: 79% fibres, 6% films, 3% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	500m south of Mhlangeni Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	10161.3 ± 1042.2 * (nr)	Items m^{-2}	Mhlangeni: 79% fibres, 6% films, 3% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	1000m south of Mhlangeni Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	9900.7 ± 1389.6 * (nr)	Items m^{-2}	Mhlangeni: 79% fibres, 6% films, 3% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	2000m south of Mhlangeni Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	11377.2 ± 1389.6 * (nr)	Items m^{-2}	Mhlangeni: 79% fibres, 6% films, 3% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	2000m north of Kongweni Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	9466.5 ± 347.4 * (nr)	Items m^{-2}	Kongweni: 88% fibres, 6% films, <1% microbeads	NA	Rivers, estuary	Gerber (2017)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	1000m north of Kongweni Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	10161.3 ± 1215.9 * (nr)	Items m^{-2}	Kongweni: 88% fibres, 6% films, <1% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	500m north of Kongweni Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	10248.1 ± 1129 * (nr)	Items m^{-2}	Kongweni: 88% fibres, 6% films, <1% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	500m south of Kongweni Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	16848.6 ± 2258.1 * (nr)	Items m^{-2}	Kongweni: 88% fibres, 6% films, <1% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	1000m south of Kongweni Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	13635.2 ± 2518.6 * (nr)	Items m^{-2}	Kongweni: 88% fibres, 6% films, <1% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	2000m south of Kongweni Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	11985.1 ± 1737 * (nr)	Items m^{-2}	Kongweni: 88% fibres, 6% films, <1% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	2000m north of Bilanhlolo Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	13722.1 ± 434.2 * (nr)	Items m^{-2}	Bilanhlolo: 75% fibres, 12% films, <1% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	1000m north of Bilanhlolo Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	14503.7 ± 955.3 * (nr)	Items m^{-2}	Bilanhlolo: 75% fibres, 12% films, <1% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	500m north of Bilanhlolo Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	20756.8 ± 1997.5 * (nr)	Items m^{-2}	Bilanhlolo: 75% fibres, 12% films, <1% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	500m south of Bilanhlolo Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	30223.3 ± 955.3 * (nr)	Items m^{-2}	Bilanhlolo: 75% fibres, 12% films, <1% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	1000m south of Bilanhlolo Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	26488.8 ± 607.9 * (nr)	Items m^{-2}	Bilanhlolo: 75% fibres, 12% films, <1% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	2000m south of Bilanhlolo Estuary, KZN	2017	Sediment cores	0.02-5 mm	NA	15980.1 ± 1737 * (nr)	Items m^{-2}	Bilanhlolo: 75% fibres, 12% films, <1% microbeads	NA	Rivers, estuary	Gerber (2017)
Sandy beach	Milnerton beach, Cape Town	2012	Sediment cores	0.5-10 mm	NA	30.9 ± 17.2 (nr)	Items L^{-1}	All items were plastic; 39% virgin plastic pellets, 29% unidentified plastic pellets, 28% styrofoam	NA	NA	Lamprecht (2013)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Mdloti Estuary	Not specified	Sediment cores	0.02-5 mm	13680 microplastics (all five estuaries combined)	20.0 ± 7.5 (nr)	Items 500mL^{-1}	Mostly fibres (~75%), followed by fragments, films, polystyrene, and scrubber	NA	Wastewater, rivers	Naidoo *et al.* (2015)
Sandy beach	uMgeni Estuary	Not specified	Sediment cores	0.02-5 mm	13680 microplastics (all five estuaries combined)	38.5 ± 12.3 (nr)	Items 500mL^{-1}	Mostly fibres (~55%), followed by fragments, pellets, films, scrubber, polystyrene, and fishing lines	NA	Wastewater, rivers	Naidoo *et al.* (2015)
Sandy beach	Durban Harbour	Not specified	Sediment cores	0.02-5 mm	13680 microplastics (all five estuaries combined)	38.6 ± 20.9 (nr)	Items 500mL^{-1}	Mostly fibres (~60%), followed by fragments, polystyrene, films, scrubber, and pellets	NA	Urban areas, industry, wastewater, rivers, discarded and weathered angling gear, ship repairs	Naidoo *et al.* (2015)
Sandy beach	Isipingo Estuary	Not specified	Sediment cores	0.02-5 mm	13680 microplastics (all five estuaries combined)	46.0 ± 23.0 (nr)	Items 500mL^{-1}	Mostly fibres (~80%), followed by fragments, polystyrene, films, and scrubber	NA	Wastewater, rivers	Naidoo *et al.* (2015)
Sandy beach	iLovu Estuary	Not specified	Sediment cores	0.02-5 mm	13680 microplastics (all five estuaries combined)	20.4 ± 10.0 (nr)	Items 500mL^{-1}	Mostly fibres (~80%), followed by fragments, films, polystyrene, and twine	NA	Wastewater, rivers	Naidoo *et al.* (2015)
Sandy beach	Kenton-on-Sea	2014	Bulk sediment	0.065-5 mm	NA	1158 ± 344 [SE] (758-1833)	Items m^{-2}	90% blue/black fibres, 10% red fibres	NA	NA	Nel & Froneman (2015)
Sandy beach	Cannon rocks	2014	Bulk sediment	0.065-5 mm	NA	1592 ± 696 [SE] (825-2900)	Items m^{-2}	90% blue/black fibres, 8% red fibres, 1% yellow fibres, 1% fragments	NA	NA	Nel & Froneman (2015)
Sandy beach	Bluewater Bay	2014	Bulk sediment	0.065-5 mm	NA	2214 ± 834 [SE] (1867-2208)	Items m^{-2}	91% blue/black fibres, 4% red fibres, 3% yellow fibres, 1% green fibres	NA	NA	Nel & Froneman (2015)
Sandy beach	PE pier	2014	Bulk sediment	0.065-5 mm	NA	1542 ± 320 [SE] (1292-1958)	Items m^{-2}	83% blue/black fibres, 8% red fibres, 2% yellow fibres, 6% fragments	NA	NA	Nel & Froneman (2015)
Sandy beach	Summerstrand	2014	Bulk sediment	0.065-5 mm	NA	1347 ± 674 [SE] (650-2300)	Items m^{-2}	88% blue/black fibres, 7% yellow fibres, 4% red fibres, 1% fragments	NA	NA	Nel & Froneman (2015)
Sandy beach	Jeffrey's Bay	2014	Bulk sediment	0.065-5 mm	NA	1028 ± 375 [SE] (442-1467)	Items m^{-2}	85% blue/black fibres, 8% red fibres, 5% yellow fibres, 1% fragments, 1% polystyrene	NA	NA	Nel & Froneman (2015)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Aston Bay	2014	Bulk sediment	0.065-5 mm	NA	689 ± 348 [SE] (83-1258)	Items m^{-2}	90% blue/black fibres, 8% red fibres, <1% green fibres, <1% fragments, <1% polystyrene	NA	NA	Nel & Froneman (2015)
Sandy beach	St Francis	2014	Bulk sediment	0.065-5 mm	NA	1208 ± 182 [SE] (975-1375)	Items m^{-2}	89% blue/black fibres, 6% red fibres, 3% fragments, 1% yellow fibres, 1% polystyrene	NA	NA	Nel & Froneman (2015)
Sandy beach	Oyster Bay	2014	Bulk sediment	0.065-5 mm	NA	2636 ± 612 [SE] (1783-3783)	Items m^{-2}	91% blue/black fibres, 7% red fibres, 1% yellow fibres, 1% fragments	NA	NA	Nel & Froneman (2015)
Sandy beach	Skuitbaai	2014	Bulk sediment	0.065-5 mm	NA	2411 ± 298 [SE] (1942-2933)	Items m^{-2}	92% blue/black fibres, 6% red fibres, 1% yellow fibres	NA	NA	Nel & Froneman (2015)
Sandy beach	Nature's Valley	2014	Bulk sediment	0.065-5 mm	NA	1181 ± 485 [SE] (517-2050)	Items m^{-2}	92% blue/black fibres, 4% red fibres, 3% yellow fibres, 1% fragments	NA	NA	Nel & Froneman (2015)
Sandy beach	Keurbooms	2014	Bulk sediment	0.065-5 mm	NA	1644 ± 451 [SE] (983-2375)	Items m^{-2}	86% blue/black fibres, 12% red fibres, 1% yellow fibres, 1% fragments	NA	NA	Nel & Froneman (2015)
Sandy beach	Plett main	2014	Bulk sediment	0.065-5 mm	NA	1936 ± 270 [SE] (1550-2183)	Items m^{-2}	82% blue/black fibres, 15% red fibres, 1% yellow fibres, 1% green fibres, 1% fragments	NA	NA	Nel & Froneman (2015)
Sandy beach	Robberg	2014	Bulk sediment	0.065-5 mm	NA	1389 ± 379 [SE] (983-2100)	Items m^{-2}	89% blue/black fibres, 9% red fibres, 1% yellow fibres, 1% fragments	NA	NA	Nel & Froneman (2015)
Sandy beach	Buffels Bay	2014	Bulk sediment	0.065-5 mm	NA	1139 ± 385 [SE] (425-1692)	Items m^{-2}	90% blue/black fibres, 8% red fibres, 2% fragments, 1% yellow fibres	NA	NA	Nel & Froneman (2015)
Sandy beach	Sedgefield	2014	Bulk sediment	0.065-5 mm	NA	3308 ± 1449 [SE] (1867-2667)	Items m^{-2}	93% blue/black fibres, 4% red fibres, 3% yellow fibres	NA	NA	Nel & Froneman (2015)
Sandy beach	Hartenbos	2014	Bulk sediment	0.065-5 mm	NA	1708 ± 504 [SE] (825-1892)	Items m^{-2}	89% blue/black fibres, 7% red fibres, 3% yellow fibres, 1% fragments	NA	NA	Nel & Froneman (2015)
Sandy beach	Kleinbrak	2014	Bulk sediment	0.065-5 mm	NA	1294 ± 301 [SE] (825-1583)	Items m^{-2}	89% blue/black fibres, 5% red fibres, 4% yellow fibres, 1% green fibres, 1% fragments	NA	NA	Nel & Froneman (2015)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Diaz Strand	2014	Bulk sediment	0.065-5 mm	NA	1006 ± 431 [SE] (350-1767)	Items m^{-2}	79% blue/black fibres, 11% yellow fibres, 7% red fibres, 1% green fibres, 1% fragments, 1% polystyrene	NA	NA	Nel & Froneman (2015)
Sandy beach	Danabaai 1	2014	Bulk sediment	0.065-5 mm	NA	1406 ± 987 [SE] (117-3317)	Items m^{-2}	94% blue/black fibres, 6% red fibres	NA	NA	Nel & Froneman (2015)
Sandy beach	Danabaai 2	2014	Bulk sediment	0.065-5 mm	NA	1522 ± 518 [SE] (567-2175)	Items m^{-2}	88% blue/black fibres, 7% yellow fibres, 4% red fibres, 2% fragments	NA	NA	Nel & Froneman (2015)
Sandy beach	Cape Vidal	2016	Bulk sediment	0.063-5 mm	NA	103 ± 30 [SE] (52-156)	Items m^{-2}	91% fibres, 9% fragments	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	Richards Bay Harbour	2016	Bulk sediment	0.063-5 mm	NA	312 ± 27 [SE] (272-364)	Items m^{-2}	91% fibres, 9% fragments	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	Salt Rock	2016	Bulk sediment	0.063-5 mm	NA	357 ± 198 [SE] (132-752)	Items m^{-2}	93% fibres, 7% fragments	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	Vetchies	2016	Bulk sediment	0.063-5 mm	NA	675 ± 290 [SE] (104-1052)	Items m^{-2}	89% fibres, 8% fragments, 2% industrial pellets	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	Durban Harbour	2016	Bulk sediment	0.063-5 mm	NA	588 ± 124 [SE] (464-836)	Items m^{-2}	51% fragments, 48% fibres, <1% industrial pellets	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	Port Edward	2016	Bulk sediment	0.063-5 mm	NA	755 ± 393 [SE] (264-1532)	Items m^{-2}	99% fibres, 1% fragments, <1% industrial pellets	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Morgan's Bay	2016	Bulk sediment	0.063-5 mm	NA	252 ± 101 [SE] (96-440)	Items m^{-2}	95% fibres, 5% fragments	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	Kenton-on-Sea	2016	Bulk sediment	0.063-5 mm	NA	341 ± 50 [SE] (244-408)	Items m^{-2}	98% fibres, 2% fragments	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	St Francis	2016	Bulk sediment	0.063-5 mm	NA	205 ± 43 [SE] (136-284)	Items m^{-2}	99% fibres, 1% fragments	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	Brenton-on-Sea	2016	Bulk sediment	0.063-5 mm	NA	236 ± 29 [SE] (192-292)	Items m^{-2}	95% fibres, 3% fragments, 2% industrial pellets	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	Kommetjie	2016	Bulk sediment	0.063-5 mm	NA	87 ± 49 [SE] (36-184)	Items m^{-2}	82% fibres, 18% fragments	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	Paternoster	2016	Bulk sediment	0.063-5 mm	NA	751 ± 289 [SE] (244-1244)	Items m^{-2}	82% fibres, 18% fragments	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	Hondeklipbaai	2016	Bulk sediment	0.063-5 mm	NA	517 ± 90 [SE] (408-696)	Items m^{-2}	82% fibres, 18% fragments	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	Doringbaai	2016	Bulk sediment	0.063-5 mm	NA	449 ± 146 [SE] (244-732)	Items m^{-2}	99% fibres, 1% fragments	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Port Nolloth	2016	Bulk sediment	0.063-5 mm	NA	593 ± 220 [SE] (268-1012)	Items m^{-2}	100% fibres	NA	Urban areas, industry, rivers, near land-bases sources through water circulation	Nel *et al.* (2017)
Sandy beach	52 beaches along the coastline from Saldanha Bay to Kei River mouth	1984	Sieve transects	2-20 mm	NA	491 (nr)	Items m^{-1}	Plastics comprised 98% (both years combined); 80% virgin pellets (only year 1984)	NA	Urban areas, also mentions inshore currents	Ryan & Moloney (1990)
Sandy beach	52 beaches along the coastline from Saldanha Bay to Kei River mouth	1989	Sieve transects	2-20 mm	NA	678 (nr)	Items m^{-1}	Plastics comprised 98% (both years combined); 68% virgin pellets (only year 1989)	NA	Urban areas, also mentions inshore currents	Ryan & Moloney (1990)
Sandy beach	Blue Water Bay, Port Elizabeth	1989, 1999, 2008	Sieve transects	2-20 mm	NA	NA (1000-1800)	Pellets m^{-1}	NA	All three beaches and all years combined: 82% polyethylene, 11% polypropylene, 7% other polymers	NA	Ryan *et al.* (2012)
Sandy beach	16 Mile beach, Yzerfontein	1989, 1999, 2008	Sieve transects	2-20 mm	NA	NA (100-700)	Pellets m^{-1}	NA	All three beaches and all years combined: 82% polyethylene, 11% polypropylene, 7% other polymers	NA	Ryan *et al.* (2012)
Sandy beach	Woody Cape, Port Elizabeth	1984, 1994, 2005	Sieve transects	2-20 mm	NA	NA (1500-10000)	Pellets m^{-1}	NA	All three beaches and all years combined: 82% polyethylene, 11% polypropylene, 7% other polymers	NA	Ryan *et al.* (2012)
Sandy beach	82 beaches along 2000 km of southern coastline	2015	Sieve transects	2-25 mm	Year 2015 = 29034 items / 1029.6 g	708 (8 to >10000) / 25.1 (0.1-480)	Items m^{-1}/ g m^{-1}	99% plastic (95% by mass), of which 55% were pellets, 34% rigid plastics, and 8% foamed plastics; wax (<1%) and cigarette butts (<1%) were most common non-plastic items	NA	Urban areas, industry	Ryan *et al.* (2018)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	16 Mile Beach	2010, 2015, 2017	Sieve transects	2-10 mm	3437 items / 69.58 g	573 / 11.6 (nr)	Items m^{-1}/ g m^{-1}	>99% plastics by number; 64% were industrial pellets (70% by mass), 19% rigid fragments (20% by mass), 14% expanded polystyrene (7% by mass)	NA	Urban areas, industry, shipping	Ryan *et al.* (2020a)
Sandy beach	16 Mile Beach	2017	Sediment cores	0.025-2 mm	296 microfibres	188000 / 59.9 (nr)	Microfibres m^{-1} / mg m^{-1}	>99% microfibres, only 1 fragment found	NA	NA	Ryan *et al.* (2020a)
Sandy beach	Several beaches	Several years	Summary of published and unpublished data	<5 mm	NA	NA (20-12000)	Items m^{-1}	40-90% pellets (proportional decrease from 1984 to 1989)	NA	NA	Gregory & Ryan (1997)
Tanzania											
Sandy beach	Ruvula	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	15 ± 4 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by foam	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	Msimbati	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	101 ± 19 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by foam and fibres	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	Mtwara Fish Market	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	25 ± 6 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by foam	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	Mtwara Mikindani	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	25 ± 8 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by fibres and film	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	LindiFish Market	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	27 ± 6 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by fibres	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	Lindi Public Beach	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	77 ± 7 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by fibres	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Kilindoni West Beach	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	214 ± 28 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by fibres and foam	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	Juani Island East	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	103 ± 18 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by fibres and foam	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	Mtoni Kijichi Creek	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	2972 ± 238 (nr)	Items kg^{-1} dry sediment	Mostly pellets, followed by fragments and fibres	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	Industries and stormwater	Mayoma *et al.* (2020)
Sandy beach	Coco Beach	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	173 ± 13 (nr)	Items kg^{-1} dry sediment	Mostly fragments and foam	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	UDSM Kunduchi Campus	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	128 ± 11 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by film and fibres	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	Mbegani Fisheries Institute	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	85 ± 19 (nr)	Items kg^{-1} dry sediment	Mostly fragments and foam	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	Mission Cross Beach	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	589 ± 99 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by fibres, then foam and film	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	Pangani Beach	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	113 ± 24 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by fibres, pellets and foam	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	Tanga Deep Sea Fish Market	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	50 ± 16 (nr)	Items kg^{-1} dry sediment	Mostly fragments and film, followed by fibres	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sandy beach	Tanga Yacht Beach	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	36 ± 14 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by fibres	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	Wete Pwani	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	33 ± 7 (nr)	Items kg^{-1} dry sediment	Mostly fibres, followed by fragments	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)
Sandy beach	Kizingo Beach	2018	Sediment cores	0.5-5 mm	14681 items (all 18 study sites combined)	127 ± 15 (nr)	Items kg^{-1} dry sediment	Mostly fragments, followed by fibres	Only polyethylene and polypropylene among 15 microplastics representative of all 18 study sites	NA	Mayoma *et al.* (2020)

Table S6. Summary of the densities, types, materials, and inferred sources of micro- (<5 mm) and mesoplastics (5-25 mm, collected with buckets or nets) occurring in surface waters of the Western Indian Ocean. NA = data not available, nr = studies that did not report a range.

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Comoros (including Mayotte)											
Surface of coastal waters	M'Tzamboro	2019	Plankton net	0.25-5 mm	NA	1.59 ± 0.25 (nr)	Items m^{-3}	57% fibres, 30% fragments, 7% films, 3% microbeads, 3% foam	NA	Wastewater	Jost (2019)
Surface of coastal waters	Handrema	2019	Plankton net	0.25-5 mm	NA	3.11 ± 1.49 (nr)	Items m^{-3}	43% fibres, 47% fragments, 7% foam, 1% films, 1% microbeads	NA	Wastewater	Jost (2019)
Surface of coastal waters	Bambo	2019	Plankton net	0.25-5 mm	NA	2.50 ± 0.54 (nr)	Items m^{-3}	60% fibres, 34% fragments, 6% films	NA	Wastewater	Jost (2019)
Surface of coastal waters	Ilot de Sable Blanc	2019	Plankton net	0.25-5 mm	NA	1.76 ± 0.62 (nr)	Items m^{-3}	44% fragments, 28% fibres, 23% films, 5% microbeads	NA	Wastewater	Jost (2019)
Surface of coastal waters	Saziley	2019	Plankton net	0.25-5 mm	NA	1.48 ± 0.27 (nr)	Items m^{-3}	47% fibres, 44% fragments, 6% foam, 3% films	NA	Wastewater	Jost (2019)
Kenya											
Surface water in EEZ	Central part of Kenya's EEZ	2017	Bulk water	0.25-5 mm	149 items	110 (33.3-275)	Items m^{-3}	76% filaments, 12% fragments, 12% granules and foams	Only identified PP and LDPE; PP was more common	Urban areas, rivers	Kosore *et al.* (2018)
Nearshore surface water	Vanga, Mombasa, Malindi and Lamu	NA	Manta net	0.5-5 mm	NA	3 228 (83-8266 during NE monsoon; 126-12 256 during SE monsoon)	Items m^{-3}	NE monsoon: 48% fragments, 24% fibres, 19% films, 8% foam, <1% pellets; SE monsoon: 40% fragments, 36% films, 20% fibres, <1% foam	NA	Runoff, rivers	Kosore (2020)
Surface water	Tudor creek	2018	Bulk water (small microplastics), Manta net (large and medium)	0.02-0.25 mm (small), 0.25-0.5 mm (medium), 0.5-5 mm (large)	NA	S = 3161.3 ± 363.7 [SE] M = 2.6 ± 0.45 [SE] L = 0.5 ± 0.1 [SE]	Items m^{-3}	S = 93% fibres, 6% fragments, 1% films (across all creeks) M = 87% fibres, 10% fragments, 3% films (across all creeks) L = NA	NA	Urban areas, industry, rivers	Kerubo *et al.* (2020)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Surface water	Port-Reitz creek	2018	Bulk water (small microplastics), Manta net (large and medium)	0.02-0.25 mm (small), 0.25-0.5 mm (medium), 0.5-5 mm (large)	NA	S = 2883.3 ± 485.4 [SE] M = 2.7 ± 0.71 [SE] L = 0.6 ± 0.1 [SE]	Items m^{-3}	S = 93% fibres, 6% fragments, 1% films (across all creeks) M = 87% fibres, 10% fragments, 3% films (across all creeks) L = NA	NA	Urban areas	Kerubo *et al.* (2020)
Surface water	Mida creek	2018	Bulk water (small microplastics), Manta net (large and medium)	0.02-0.25 mm (small), 0.25-0.5 mm (medium), 0.5-5 mm (large)	NA	S = 2523.3 ± 211.8 [SE] M = 4.2 ± 0.58 [SE] L = 0.8 ± 0.1 [SE]	Items m^{-3}	S = 93% fibres, 6% fragments, 1% films (across all creeks) M = 87% fibres, 10% fragments, 3% films (across all creeks) L = NA	NA	Tourism, inhabitants	Kerubo *et al.* (2020)
Surface water	Kilifi county	2020	Manta net	0.3 mm	NA	289 698	Items km^{-2}	NA	NA	Athi-Galana-Sabaki river, strong surface currents during SE monsoon	Okuku *et al.* (2021a)
Surface water	Kwale county	2020	Manta net	0.3 mm	NA	75 922	Items km^{-2}	NA	NA	Athi-Galana-Sabaki river, strong surface currents during SE monsoon	Okuku *et al.* (2021a)
South Africa											
Coastal and off-shore water surface	Southwestern Cape Province from St Helena Bay to San Sebastian Bay	1977-1978	Neuston net	>0.9 mm	839 items / 9.78 g	3640 ± 14633 (0-445 860) / 42.4 ± 476.8 (0-10920)	Items km^{-2}/ g km^{-2}	By number: 36% foamed plastics, 26% user fragments, 23% pellets, 14% fibres; By mass: 40% pellets, 36% user fragments, 21% fibres, 3% foamed plastics	Industrial pellets = 99% PE and other polyolefin pellets, only two clear polystyrene pellets / User fragments = pieces of PE and other polyolefin sheets, PE bags and asymmetrical polyolefin chips / Fibres = primarily PP, only 2 pieces of nylon fishing line / Foamed plastics = 27% expanded polystyrene	Urban areas, industry, fisheries, shipping, long-distance drift	Ryan (1988)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Sea surface, does not specify how far offshore	Southern Africa in Agulhas retroflection area	Not specified	Neuston net	Not specified	2 items	50 (nr)	Items km^{-2}	Both were fragments of manufactured articles	NA	NA	Ryan (1990)
Surf zone	North side of False Bay (includes sites Strand, Macassar, Mnandi, Strandfontein, Cemetery, Muizenberg)	2013, 2014	Water transects (net)	>5 mm	439 items / 172.6 g (all 10 sites combined)	0.20 ± 0.25 (nr)	Items m^{-3}	All 10 sites combined, by number: 98% plastic; packaging (bags, wrappers, food wrappers, food bags, paper food wrappers) made up 63%	NA	Tourism, urban areas, rivers	Massot Mascaró (2015)
Surf zone	Lateral sides of False Bay (includes Simons Town, Fish Hoek, Gordons Bay, Kogel Bay)	2013, 2014	Water transects (net)	>5 mm	439 items / 172.6 g (all 10 sites combined)	0.02 ± 0.02 (nr)	Items m^{-3}	All 10 sites combined, by number: 98% plastic; packaging (bags, wrappers, food wrappers, food bags, paper food wrappers) made up 63%	NA	Tourism, urban areas, rivers	Massot Mascaró (2015)
Surf zone	Muizenberg	2013-2014	Water transects (net)	>5 mm	3606 items / 270 g	0.286 ± 0.779 (nr)	Items m^{-3}	By number: 99% plastic, of which 83% were pieces and 16% fibres; packaging (bags, wrappers, food wrappers, food papers and food bags) made up 65%	NA	NA	Massot Mascaró (2015)
Surf zone	Kenton-on-Sea	2014	Water transects (net)	0.08–5 mm	NA	461 ± 118 [SE] (254-641)	Items m^{-3}	94% blue/black fibres, 6% red fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Cannon rocks	2014	Water transects (net)	0.08–5 mm	NA	331 ± 101 [SE] (238-498)	Items m^{-3}	91% blue/black fibres, 5% red fibres, 3% fragments, 1% yellow fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Bluewater Bay	2014	Water transects (net)	0.08–5 mm	NA	565 ± 154 [SE] (376-847)	Items m^{-3}	88% blue/black fibres, 10% red fibres, 2% fragments	NA	NA	Nel & Froneman (2015)
Surf zone	PE pier	2014	Water transects (net)	0.08–5 mm	NA	472 ± 207 [SE] (249-885)	Items m^{-3}	92% blue/black fibres, 8% red fibres	NA	NA	Nel & Froneman (2015)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Surf zone	Summerstrand	2014	Water transects (net)	0.08–5 mm	NA	551 ± 80 [SE] (466-636)	Items m^{-3}	87% blue/black fibres, 11% red fibres, 7% green fibres, 1% fragments	NA	NA	Nel & Froneman (2015)
Surf zone	Jeffrey's Bay	2014	Water transects (net)	0.08–5 mm	NA	484 ± 168 [SE] (228-784)	Items m^{-3}	92% blue/black fibres, 7% red fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Aston Bay	2014	Water transects (net)	0.08–5 mm	NA	463 ± 105 [SE] (318-641)	Items m^{-3}	91% blue/black fibres, 8% red fibres	NA	NA	Nel & Froneman (2015)
Surf zone	St Francis	2014	Water transects (net)	0.08–5 mm	NA	608 ± 154 [SE] (419-879)	Items m^{-3}	93% blue/black fibres, 6% red fibres, 1% fragments	NA	NA	Nel & Froneman (2015)
Surf zone	Oyster Bay	2014	Water transects (net)	0.08–5 mm	NA	1215 ± 277 [SE] (678-1500)	Items m^{-3}	91% blue/black fibres, 8% red fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Skuitbaai	2014	Water transects (net)	0.08–5 mm	NA	927 ± 114 [SE] (742-1092)	Items m^{-3}	90% blue/black fibres, 10% red fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Nature's Valley	2014	Water transects (net)	0.08–5 mm	NA	583 ± 93 [SE] (403-700)	Items m^{-3}	93% blue/black fibres, 6% red fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Keurbooms	2014	Water transects (net)	0.08–5 mm	NA	834 ± 222 [SE] (620-1214)	Items m^{-3}	90% blue/black fibres, 8% red fibres, 1% green fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Plett main	2014	Water transects (net)	0.08–5 mm	NA	481 ± 259 [SE] (111-670)	Items m^{-3}	90% blue/black fibres, 10% red fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Robberg	2014	Water transects (net)	0.08–5 mm	NA	498 ± 92 [SE] (334-594)	Items m^{-3}	84% blue/black fibres, 16% red fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Buffels Bay	2014	Water transects (net)	0.08–5 mm	NA	532 ± 173 [SE] (254-832)	Items m^{-3}	91% blue/black fibres, 9% red fibres	NA	NA	Nel & Froneman (2015)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Surf zone	Sedgefield	2014	Water transects (net)	0.08–5 mm	NA	859 ± 241 [SE] (435-1261)	Items m^{-3}	93% blue/black fibres, 7% red fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Hartenbos	2014	Water transects (net)	0.08–5 mm	NA	429 ± 210 [SE] (217-843)	Items m^{-3}	87% blue/black fibres, 11% red fibres, 1% yellow fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Kleinbrak	2014	Water transects (net)	0.08–5 mm	NA	261 ± 110 [SE] (106-450)	Items m^{-3}	93% blue/black fibres, 5% red fibres, 1% yellow fibres, 1% green fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Diaz Strand	2014	Water transects (net)	0.08–5 mm	NA	415 ± 137 [SE] (307-594)	Items m^{-3}	87% blue/black fibres, 13% red fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Danabaai 1	2014	Water transects (net)	0.08–5 mm	NA	428 ± 30 [SE] (382-477)	Items m^{-3}	97% blue/black fibres, 2% red fibres	NA	NA	Nel & Froneman (2015)
Surf zone	Danabaai 2	2014	Water transects (net)	0.08–5 mm	NA	258 ± 53 [SE] (170-313)	Items m^{-3}	92% blue/black fibres, 8% red fibres, 1% fragments	NA	NA	Nel & Froneman (2015)
Within harbour	Durban Harbour	2019	Bulk water	>0.2 mm	1388 items	694 (50-145)	Items m^{-3}	NA	Mesoplastics: 46% PP, 38% PE, 8% PET/PS; Microplastics: 47% PE, 16% PET, 9% PS	Sewage overflow, stormwater drains, port operations, rivers	Preston-Whyte *et al.* (2021)
Surf zone	Cape Vidal	2016	Bulk water	0.063-5 mm	NA	60 ± 23 [SE] (20-100)	Items m^{-3}	56% black fibres, 28% blue fibres, 11% red fibres, 6% fragments	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Harbor	Richards Bay Harbor	2016	Bulk water	0.063-5 mm	NA	413 ± 78 [SE] (260-510)	Items m^{-3}	42% blue fibres, 27% black fibres, 26% red fibres, 6% fragments	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Surf zone	Salt Rock	2016	Bulk water	0.063-5 mm	NA	110 ± 55 [SE] (0-170)	Items m^{-3}	48% black fibres, 45% blue fibres, 6% red fibres	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Surf zone	Vetchies	2016	Bulk water	0.063-5 mm	NA	147 ± 7 [SE] (140-160)	Items m^{-3}	43% black fibres, 34% blue fibres, 11% red fibres, 11% fragments	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Harbor	Durban Harbor	2016	Bulk water	0.063-5 mm	NA	1200 ± 133 [SE] (1020-1460)	Items m^{-3}	37% blue fibres, 32% fragments, 21% black fibres, 9% red fibres	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Surf zone	Port Edward	2016	Bulk water	0.063-5 mm	NA	70 ± 36 [SE] (0-120)	Items m^{-3}	52% black fibres, 24% blue fibres, 24% red fibres	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Surf zone	Morgan's Bay	2016	Bulk water	0.063-5 mm	NA	60 ± 26 [SE] (10-100)	Items m^{-3}	44% blue fibres, 39% black fibres, 11% fragments, 6% red fibres	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Surf zone	Kenton-on-Sea	2016	Bulk water	0.063-5 mm	NA	413 ± 78 [SE] (80-170)	Items m^{-3}	59% blue fibres, 21% red fibres, 15% black fibres, 6% fragments	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Surf zone	St Francis	2016	Bulk water	0.063-5 mm	NA	180 ± 50 [SE] (80-240)	Items m^{-3}	50% blue fibres, 28% black fibres, 13% fragments, 9% red fibres	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Surf zone	Brenton-on-Sea	2016	Bulk water	0.063-5 mm	NA	73 ± 19 [SE] (50-110)	Items m^{-3}	55% blue fibres, 36% black fibres, 9% fragments	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Surf zone	Kommetjie	2016	Bulk water	0.063-5 mm	NA	20 ± 6 [SE] (10-30)	Items m^{-3}	50% blue fibres, 50% black fibres	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Harbor	Cape Town harbor	2016	Bulk water	0.063-5 mm	NA	97 ± 38 [SE] (20-140)	Items m^{-3}	52% blue fibres, 31% fragments, 17% black fibres	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Surf zone	Paternoster	2016	Bulk water	0.063-5 mm	NA	33 ± 20 [SE] (0-70)	Items m^{-3}	60% blue fibres, 40% black fibres	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Surf zone	Hondeklipbaai	2016	Bulk water	0.063-5 mm	NA	153 ± 23 [SE] (110-190)	Items m^{-3}	61% black fibres, 28% blue fibres, 11% red fibres	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Surf zone	Doringbaai	2016	Bulk water	0.063-5 mm	NA	117 ± 26 [SE] (70-160)	Items m^{-3}	37% blue fibres, 34% fragments, 14% red fibres, 14% black fibres	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Surf zone	Port Nolloth	2016	Bulk water	0.063-5 mm	NA	110 ± 12 [SE] (90-130)	Items m^{-3}	61% blue fibres, 27% black fibres, 12% red fibres	NA	Distribution mostly determined by ocean circulation	Nel *et al.* (2017)
Surface water 5km from the shore	Durban Bay	2016, 2017	Manta trawl net	>0.33 mm	NA	4.01 ± 3.28 all five sites combined [2.96 ± 2.94 in summer, 5.45 ± 3.26 in winter] (nr)	Items $100m^{-2}$	Summer: similar proportions of fragments, films and fibres (~30% each), followed by polystyrene; Winter: mostly fragments (~50%), followed by fibres (~30%), films, and polystyrene	NA	NA	Naidoo & Glassom (2019)
Surface water 5km from the shore	Isipingo	2016, 2017	Manta trawl net	>0.33 mm	NA	12.2 site-specific in winter; 4.01 ± 3.28 all five sites combined [2.96 ± 2.94 in summer, 5.45 ± 3.26 in winter] (nr)	Items $100m^{-2}$	Summer: mostly fragments (~50%), followed by lines, films, fibres, and other; Winter: mostly fragments (~55%), followed by polystyrene, films, fibres, and other	NA	NA	Naidoo & Glassom (2019)
Surface water 5km from the shore	Amanzimtoti	2016, 2017	Manta trawl net	>0.33 mm	NA	9.55 site-specific in summer; 4.01 ± 3.28 all five sites combined [2.96 ± 2.94 in summer, 5.45 ± 3.26 in winter] (nr)	Items $100m^{-2}$	Summer: mostly fragments (~75%), followed by films, pellets, polystyrene, and fibres; Winter: mostly fragments (~65%), followed by fibres, films, polystyrene, lines, and other	NA	NA	Naidoo & Glassom (2019)
Surface water 5km from the shore	iLovu	2016, 2017	Manta trawl net	>0.33 mm	NA	4.01 ± 3.28 all five sites combined [2.96 ± 2.94 in summer, 5.45 ± 3.26 in winter] (nr)	Items $100m^{-2}$	Summer: mostly fibres (~40%), films (~35%), fragments (~25%); Winter: mostly fragments (~65%), followed by fibres, films, polystyrene, and lines	NA	NA	Naidoo & Glassom (2019)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
International WIO											
Coastal waters	Off the east coast of Africa, from South Africa to Tanzania	2017	Bulk water	>0.025 mm	NA	1.2 [median] (0.3-3.0 [IQR])	Fibres L^{-1}	Fibres	51% cotton, 34% other cellulosic, 7% wool, 7% polyester, <1% silk	NA	Ryan *et al.* (2020d), Suaria *et al.* (2020b)
Off-shore water surface	Transect from Cape Town to north of the Subtropical Front	2017	Neuston net	0.2-25 mm	67	8941 / 29.8 // 128.1 / 0.4269 (nr)	Items km^{-2}/ Items L^{-1} / g km^{-2} / g L^{-1}	NA	66% PE, 30% PP, 3% PS, 1% PMMA	NA	Suaria *et al.* (2020a)
Open ocean	Indian Ocean	NA	Neuston net	>0.335 mm	NA	44 995 ± 66 033 / 1689 ± 3332 [means across 5 sites] (nr)	Items km^{-2} / g km^{-2}	NA	NA	NA	Eriksen *et al.* (2014)
Open ocean	Indian Ocean	2011	Neuston net	>0.2 mm	NA	40 846 ± 31 932 (2536-102 396) / 57.5 ± 34.8 (16.3-100.4) [values across 9 sites around southern Africa] 133 478 ± 111 425 (42 382-332 338) / 398.4 ± 462.8 (58.3-1553.1) [values across 10 sites within Indian Ocean Gyre]	Items km^{-2} / g km^{-2}	NA	NA	NA	Cózar *et al.* (2014)

Table S7. Summary of the densities, types, materials, and inferred sources of microplastics (<5 mm) in the water column of the Western Indian Ocean. NA = data not available, nr = studies that did not report a range.

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
International WIO											
Water column	Transect from Cape Town to Marion Island	2017	Bulk water from underway system (5m deep)	>0.025 mm	148	0.34 ± 0.17 (0.13-0.60)	Fibres L^{-1}	NA	NA	NA	Ryan *et al.* (2020d)

Table S8. Summary of the densities, types, materials, and inferred sources of microplastics (<5 mm) on the seafloor of the Western Indian Ocean. NA = data not available, nr = studies that did not report a range.

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
South Africa											
Bottom sediment	Durban Bay	2012	Sediment cores	0.315-1 mm	39	1.3 ± 0.79 (nr)	Items g^{-1}	72% fragments, 13% fibres, 10% films, 3% fluff, 3% bead	38% polyethylene, 26% PEP, 10% PET, 5% polyacrylates (PAK), 3% polyamide (PA), 3% polypropylene, 3% polystyrene, 3% polycaprolactanes (PCL), 10% other	Sources were not inferred, but core was collected in location that receives inflows from three rivers that receive stormwater runoff and effluent from wastewater works	Matsuguma *et al.* (2017)
Bottom sediment	Durban Harbour	2019	Sediment grabs	>0.0002 mm	NA	2400 ± 529 to 111 933 ± 29189	Items kg^{-1} dry weight sediment	NA	47% PE, 21% cellophane, 16% PP, 5% PS, 11% unknown	Sewage overflow, stormwater drains, port operations, rivers	Preston-Whyte *et al.* (2021)
International WIO											
Deepsea floor	900 m deep seamount	Not specified	Remotely Operated Vehicle fitted with corer	>0.032 mm	NA	3.5 (nr)	Fibres 50mL $sediment^{-1}$	Fibres	Polyester and synthetic	NA	Woodall *et al.* (2014)
Deepsea floor	1000 m deep seamount	Not specified	Remotely Operated Vehicle fitted with corer	>0.032 mm	NA	4 (nr)	Fibres 50mL $sediment^{-1}$	Fibres	Polyester and synthetic	NA	Woodall *et al.* (2014)
Deepsea floor	900 m deep seamount	Not specified	Remotely Operated Vehicle fitted with corer	>0.032 mm	NA	1.4 (nr)	Fibres 50mL $sediment^{-1}$	Fibres	Polyester and synthetic	NA	Woodall *et al.* (2014)

Table S9. Summary of the densities, types, materials, and inferred sources of micro- (<5 mm) and mesoplastics (5-25 mm, collected with cores, sieving, buckets or nets) in rivers and estuaries of the Western Indian Ocean. NA = data not available, nr = studies that did not report a range.

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
South Africa											
Estuarine sediment	Mdloti Estuary	Not specified	Sediment cores	0.02-5 mm	13680 microplastics (all five estuaries combined)	19.9 ± 16.2 (nr)	Items 500mL^{-1}	Mostly fibres (66%), followed by fragments, polystyrene, scrubber, pellets, films, and fishing lines	NA	Wastewater, rivers	Naidoo *et al.* (2015)
Estuarine sediment	uMgeni Estuary	Not specified	Sediment cores	0.02-5 mm	13680 microplastics (all five estuaries combined)	41.7 ± 23 (nr)	Items 500mL^{-1}	Mostly fibres (38%), followed by fragments, polystyrene, scrubber, films, pellets, fishing lines, and other	NA	Wastewater, rivers	Naidoo *et al.* (2015)
Estuarine sediment	Durban Harbour	Not specified	Sediment cores	0.02-5 mm	13680 microplastics (all five estuaries combined)	159.9 ± 271.2 (nr)	Items 500mL^{-1}	Mostly fragments (59%), followed by scrubber, fibres, films, polystyrene, pellets, and fishing lines	NA	Urban areas, industry, wastewater, rivers, discarded and weathered angling gear, ship repairs	Naidoo *et al.* (2015)
Estuarine sediment	Isipingo Estuary	Not specified	Sediment cores	0.02-5 mm	13680 microplastics (all five estuaries combined)	47.6 ± 22.8 (nr)	Items 500mL^{-1}	Mostly fibres (~45%), followed by fragments, polystyrene, films, scrubber, other, pellets, and fishing lines	NA	Wastewater, rivers	Naidoo *et al.* (2015)
Estuarine sediment	iLovu Estuary	Not specified	Sediment cores	0.02-5 mm	13680 microplastics (all five estuaries combined)	13.7 ± 5.6 (nr)	Items 500mL^{-1}	Mostly fibres (~50%), followed by fragments, scrubber, films, polystyrene, other, and fishing lines	NA	Wastewater, rivers	Naidoo *et al.* (2015)
Estuarine water surface	Mdloti Estuary	Not specified	Water transects (zooplankton net)	0.25-5 mm	13680 microplastics (all five estuaries combined)	11.0 ± 11.5 (nr)	Items 10,000mL^{-1}	Mostly fragments (~50%), followed by films, pellets, polystyrene, scrubber, and fibres	NA	Wastewater, rivers	Naidoo *et al.* (2015)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Estuarine water surface	uMgeni Estuary	Not specified	Water transects (zooplankton net)	0.25-5 mm	13680 microplastics (all five estuaries combined)	25.3 ± 6.0 (nr)	Items 10,000mL^{-1}	Mostly films (~40%), followed by polystyrene, fragments, scrubber, fishing lines, fibres, and pellets	NA	Wastewater, rivers	Naidoo *et al.* (2015)
Estuarine water surface	Durban Harbour	Not specified	Water transects (zooplankton net)	0.25-5 mm	13680 microplastics (all five estuaries combined)	70.3 ± 119.3 (nr)	Items 10,000mL^{-1}	Mostly films (~50%), followed by fragments, polystyrene, pellets, fishing lines, and scrubber	NA	Urban areas, industry, wastewater, rivers, discarded and weathered angling gear, ship repairs	Naidoo *et al.* (2015)
Estuarine water surface	Isipingo Estuary	Not specified	Water transects (zooplankton net)	0.25-5 mm	13680 microplastics (all five estuaries combined)	31.1 ± 11.1 (nr)	Items 10,000mL^{-1}	Mostly fragments (~35%), followed by films, scrubber, polystyrene, fishing lines, pellets, and fibres	NA	Wastewater, rivers	Naidoo *et al.* (2015)
Estuarine water surface	iLovu Estuary	Not specified	Water transects (zooplankton net)	0.25-5 mm	13680 microplastics (all five estuaries combined)	10.2 ± 11.3 (nr)	Items 10,000mL^{-1}	Mostly films, fragments and polystyrene, followed by scrubber	NA	Wastewater, rivers	Naidoo *et al.* (2015)
Estuarine water surface	Mhlangeni Estuary, KZN	2017	Water transects (manta trawl)	0.3-5 mm	2209 microplastics (all three estuaries and both water and beach samples combined)	4.5 ± 0.59 (nr)	Items m^{-2}	Beach and water surface combined: 60.4% fibres, 23.4% fragments, followed by films, microbeads and foam	NA	Wastewater, rivers, fisheries	Gerber (2017)
Estuarine water surface	Kongweni Estuary, KZN	2017	Water transects (manta trawl)	0.3-5 mm	2209 microplastics (all three estuaries and both water and beach samples combined)	2.34 ± 0.23 (nr)	Items m^{-2}	Beach and water surface combined: 63.7% fibres, 22.2% fragments, followed by films, microbeads, foam and twine	NA	Wastewater, rivers, fisheries	Gerber (2017)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
Estuarine water surface	Bilanhlolo Estuary, KZN	2017	Water transects (manta trawl)	0.3-5 mm	2209 microplastics (all three estuaries and both water and beach samples combined)	5.98 ± 0.46 (nr)	Items m^{-2}	Beach and water surface combined: 57.9% fibres, 23.1% fragments, followed by films, microbeads, twine and foam	NA	Wastewater, rivers, fisheries, possibly overflow from nearby landfill	Gerber (2017)
River sediment	Diep River, Western Cape	2017	Sediment cores	0.04-1 mm	NA	33 / 1.43 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Klein river, Western Cape	2017	Sediment cores	0.04-1 mm	NA	12 / 1.1 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Heuningnes river, Western Cape	2017	Sediment cores	0.04-1 mm	NA	10 / 1.04 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	De Hoop Vlei River, Western Cape	2017	Sediment cores	0.04-1 mm	NA	8 / 1.45 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Gourits River (site 1), Western Cape	2017	Sediment cores	0.04-1 mm	NA	4 / 1.33 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Gourits River (site 2), Western Cape	2017	Sediment cores	0.04-1 mm	NA	12 / 1.28 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Klein Brak river, Western Cape	2017	Sediment cores	0.04-1 mm	NA	8 / 1.28 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
River sediment	Groot Brak River, Western Cape	2017	Sediment cores	0.04-1 mm	NA	4 / 1.37 (nr)	Fibres dm^{-3} / $g\ cm^{-3}$	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Touw River, Western Cape	2017	Sediment cores	0.04-1 mm	NA	4 / 1.48 (nr)	Fibres dm^{-3} / $g\ cm^{-3}$	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Goukamma River, Western Cape	2017	Sediment cores	0.04-1 mm	NA	4 / 1.39 (nr)	Fibres dm^{-3} / $g\ cm^{-3}$	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Knysna River, Western Cape	2017	Sediment cores	0.04-1 mm	NA	4 / 1.38 (nr)	Fibres dm^{-3} / $g\ cm^{-3}$	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Keurbooms River, Western Cape	2017	Sediment cores	0.04-1 mm	NA	12 / 1.29 (nr)	Fibres dm^{-3} / $g\ cm^{-3}$	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Groot River, Western Cape	2017	Sediment cores	0.04-1 mm	NA	4 / 1.19 (nr)	Fibres dm^{-3} / $g\ cm^{-3}$	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Krom River, Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	0 / 1.47 (nr)	Fibres dm^{-3} / $g\ cm^{-3}$	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Gamtoos River, Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	8 / 1.4 (nr)	Fibres dm^{-3} / $g\ cm^{-3}$	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Swartkops River, Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	60 / 1.46 (nr)	Fibres dm^{-3} / $g\ cm^{-3}$	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
River sediment	Bushmans River, Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	48 / 1.37 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Great Fish River, Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	380 / 1.49 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Bhega River, Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	36 / 1.33 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Keiskamma River (site 1), Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	28 / 1.53 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Keiskamma River (site 2), Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	127 / 1.39 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Nahoon River, Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	92 / 1.45 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Great Kei River, Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	85 / 1.34 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Qora River (site 1), Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	95 / 1.4 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Qora River (site 2), Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	75 / 1.44 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
River sediment	Ninga River, Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	180 / 1.35 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Mbashe River, Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	52 / 1.47 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Mzimvubu River, Eastern Cape	2017	Sediment cores	0.04-1 mm	NA	65 / 1.14 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Mtamvuna River, KZN	2017	Sediment cores	0.04-1 mm	NA	567 / 1.42 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Mzimkulu, KZN	2017	Sediment cores	0.04-1 mm	NA	16 / 1.49 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Mkomaas, KZN	2017	Sediment cores	0.04-1 mm	NA	208 / 1.59 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Mgeni, KZN	2017	Sediment cores	0.04-1 mm	NA	35 / 1.42 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Mdloti, KZN	2017	Sediment cores	0.04-1 mm	NA	28 / 1.65 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River sediment	Tugela, KZN	2017	Sediment cores	0.04-1 mm	NA	68 / 1.2 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)

Habitat	Study site	Year	Sampling method	Size class	Total items or mass	Mean ± SD (range)	Unit	Types	Plastic material	Inferred source(s) of litter	Reference
River sediment	Msingazi, KZN	2017	Sediment cores	0.04-1 mm	NA	20 / 1.39 (nr)	Fibres dm^{-3} / g cm^{-3}	NA	NA	Wastewater, rivers, rural communities with no piped water who wash their clothes in rivers	De Villiers (2019)
River surface water	Orange River Mouth, Alexander Bay, Northern Cape	2018, 2020	Neuston net	>0.3 mm	1 item / 0.0049 g	0.0067 ± 0.0095/ 0.033 ± 0.047 (nr)	Items m^{-2} / mg m^{-2}	Hard plastic piece	NA	NA	Weideman *et al.* (2020c)
River surface water	Orange River Mouth, Alexander Bay, Northern Cape	2018, 2020	Bulk water	>0.025 mm	2150 items / 0.39 mg	6 ± 10.3 / 0.001 ± 0.002 (nr)	Items L^{-1} / mg L^{-1}	All microfibres	NA	NA	Weideman *et al.* (2020c)
River water surface	Swartkops River, Algoa Bay	2019	Neuston net	5-25 mm	3227 without cleaning, 2347 with cleaning	NA	Estimated number of plastics transported to the sea per day	NA	NA	NA	Moss *et al.* (2021)
River water surface	Baakens River, Algoa Bay	2019	Neuston net	5-25 mm	1606	NA	Estimated number of plastics transported to the sea per day	NA	NA	NA	Moss *et al.* (2021)
River water surface	Sundays River, Algoa Bay	2019	Neuston net	5-25 mm	709	NA	Estimated number of plastics transported to the sea per day	NA	NA	NA	Moss *et al.* (2021)

Table S10. Summary of plastic ingestion by seabirds in the Western Indian Ocean showing the targeted size of plastic, number of individuals found to ingest plastic, the mean number and mass (g), and main types of plastic ingested. NA = data not available, nr = studies that did not report a range. Values indicated with an asterisk (*) were extracted from paper using metaDigitise.

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Forage widely across south-west Indian, Atlantic and Southern Oceans							
Broad-billed prion (*Pachyptila vittata*)	1987-89	>1 mm	NA	1.73 ± 3.58 (nr)	Mean ± SD plastic items per bird	43.6% plastic pellets	Ryan (1987b, 2008)
Broad-billed prion (*Pachyptila vittata*)	1999	>1 mm	NA	2.93 ± 3.80 (nr)	Mean ± SD plastic items per bird	33.7% plastic pellets	Ryan (2008)
Broad-billed prion (*Pachyptila vittata*)	2004	>1 mm	NA	2.66 ± 5.34 (nr)	Mean ± SD plastic items per bird	15.4% plastic pellets	Ryan (2008)
Great shearwater (*Ardenna gravis*)	1983-85	>2 mm	NA	16.3 ± 19.0 (nr)	Mean ± SD plastic items per bird	64.3% plastic pellets	Ryan (1987b, 2008)
Great shearwater (*Ardenna gravis*)	2005, 2006	>2 mm	NA	11.8 ± 18.9 (nr)	Mean ± SD plastic items per bird	11.3% plastic pellets	Ryan (2008)
White-bellied storm-petrel (*Fregetta grallaria*), Black-bellied storm-petrel (*Fregetta tropica*)	1987-89	>1 mm	NA	0.63 ± 1.13 (nr)	Mean ± SD plastic items per bird	33.3% plastic pellets	Ryan (1987b, 2008)
White-bellied storm-petrel (*Fregetta grallaria*), Black-bellied storm-petrel (*Fregetta tropica*)	1999	>1 mm	NA	0.63 ± 1.37 (nr)	Mean ± SD plastic items per bird	20.9% plastic pellets	Ryan (2008)
White-bellied storm-petrel (*Fregetta grallaria*), Black-bellied storm-petrel (*Fregetta tropica*)	2004	>1 mm	NA	0.72 ± 1.87 (nr)	Mean ± SD plastic items per bird	16.2% plastic pellets	Ryan (2008)
White-chinned petrel (*Procellaria aequinoctialis*)	1983-85	>2 mm	NA	1.66 ± 3.04 (nr)	Mean ± SD plastic items per bird	38.3% plastic pellets	Ryan (1987b, 2008)
White-chinned petrel (*Procellaria aequinoctialis*)	2005, 2006	>2 mm	NA	1.39 ± 3.25 (nr)	Mean ± SD plastic items per bird	16.2% plastic pellets	Ryan (2008)
White-faced storm-petrel (*Pelagodroma marina*)	1987-89	>1 mm	NA	3.98 ± 5.45 (nr)	Mean ± SD plastic items per bird	69.6% plastic pellets	Ryan (1987b, 2008)
White-faced storm-petrel (*Pelagodroma marina*)	1999	>1 mm	NA	4.06 ± 5.93 (nr)	Mean ± SD plastic items per bird	37.5% plastic pellets	Ryan (2008)
White-faced storm-petrel (*Pelagodroma marina*)	2004	>1 mm	NA	2.52 ± 4.43 (nr)	Mean ± SD plastic items per bird	13.5% plastic pellets	Ryan (2008)
Great shearwater (*Ardenna gravis*)	1984	>2 mm	19 of 20 (95%)	0-1.441 (nr)	Range of mass (g) of plastic	NA	Ryan (1987b)

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Antarctic fulmar (*Fulmarus glacialoides*)	1979-1985	>2 mm	3 of 27 (11%)	0.1 (0-1) / 2.0 (0-55)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Antarctic petrel (*Thalassoica antarctica*)	1979-1985	>2 mm	2 of 30 (7%)	0.2 (0-3) / 1.5 (0-41)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Antarctic prion (*Pachyptila desolata*)	1979-1985	>1 mm	52 of 88 (59%)	2.7 (0-22) / 50.2 (0-615)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Arctic skua (*Stercorarius parasiticus*)	1979-1985	>2 mm	1 of 2 (50%)	1 (0-2) / 5.0 (0-10)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Atlantic petrel (*Pterodroma incerta*)	1979-1985	>2 mm	2 of 20 (10%)	0.2 (0-2) / 1.4 (0-23)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Bank cormorant (*Phalacrocorax neglectus*)	1979-1985	>5 mm	1 of 167 (1%)	<0.1 (0-1)	Number per bird	Single green fibre	Ryan (1987b)
Black-browed albatross (*Thalassarche melanophris*)	1979-1985	>5 mm	2 of 18 (11%)	0.2 (0-2) / 9.4 (0-150)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Blue petrel (*Halobaena caerulea*)	1979-1985	>1 mm	68 of 74 (92%)	9.7 (0-41) / 111.3 (0-793)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Broad-billed prion (*Pachyptila vittata*)	1979-1985	>1 mm	41 of 137 (30%)	0.8 (0-24) / 11.8 (0-505)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Common diving petrel (*Pelecanoides urinatrix*)	1979-1985	>1 mm	1 of 53 (2%)	<0.1 (0-2) / <0.1 (0-2)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Cory's shearwater (*Calonectris borealis*)	1979-1985	>2 mm	3 of 7 (43%)	1.9 (0-11) / 12.5 (0-51)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Great shearwater (*Ardenna gravis*)	1979-1985	>2 mm	45 of 50 (90%)	13.6 (0-79) / 335.2 (0-2078)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Great-winged petrel (*Pterodroma macroptera*)	1979-1985	>2 mm	1 of 13 (8%)	0.1 (0-1) / 0.8 (0-10)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Grey phalarope (*Phalaropus fulicarius*)	1979-1985	>1 mm	1 of 2 (50%)	5 (0-10) / 59 (0-108)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Grey-backed storm-petrel (*Garrodia nereis*)	1979-1985	>1 mm	4 of 12 (33%)	0.3 (0-1) / 2.6 (0-15)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Grey-headed albatross (*Thalassarche chrysostoma*)	1979-1985	>5 mm	1 of 170 (1%)	<0.1 (0-2) / 3.7 (0-1407)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Kelp gull (*Larus dominicanus*)	1979-1985	>2 mm	6 of 52 (13%)	0.1 (0-2) / 9.0 (0-230)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Kerguelen petrel (*Aphrodroma brevirostris*)	1979-1985	>2 mm	15 of 63 (24%)	0.4 (0-7) / 4.0 (0-109)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Little shearwater (*Puffinus assimilis*)	1979-1985	>1 mm	1 of 15 (7%)	0.7 (0-11) / 8.0 (0-120)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Northern giant petrel (*Macronectes halli*)	1979-1985	>2 mm	3 of 42 (7%)	0.4 (0-6) / 89.0 (0-1563)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Pintado petrel (*Daption capense*)	1979-1985	>1 mm	15 of 18 (83%)	8.6 (0-40) / 106.3 (0-391)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Rockhopper penguin (*Eudyptes chrysocome*)	1979-1985	>2 mm	2 of 177 (1%)	<0.1 (0-2) / 0.1 (0-10)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Salvin's prion (*Pachyptila salvini*)	1979-1985	>1 mm	16 of 31 (52%)	1.6 (0-10) / 50.9 (0-109)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Slender-billed prion (*Pachyptila belcheri*)	1979-1985	>1 mm	22 of 32 (69%)	2.2 (0-11) / 22.2 (0-150)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Snow petrel (*Pagodroma nivea*)	1979-1985	>1 mm	1 of 22 (5%)	<0.1 (0-3) / 0.9 (0-20)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Soft-plumaged petrel (*Pterodroma mollis*)	1979-1985	>1 mm	6 of 29 (21%)	0.3 (0-4) / 1.5 (0-50)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Sooty albatross (*Phoebetria fusca*)	1979-1985	>5 mm	1 of 73 (1%)	<0.1 (0-1) / 0.5 (0-40)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Sooty shearwater (Ardenna griseus)	1979-1985	>2 mm	32 of 63 (51%)	1.3 (0-6) / 20.0 (0-189)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Southern giant petrel (*Macronectes giganteus*)	1979-1985	>2 mm	9 of 123 (7%)	0.1 (0-3) / 28.7 (0-1481)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Brown skua (*Stercorarius antarcticus*)	1979-1985	>2 mm	113 of 494 (23%)	1.3 (0-53) / 25.6 (0-980)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Wandering albatross (*Diomedea exulans*)	1979-1985	>5 mm	7 of 156 (4%)	0.4 (0-33) / 310.9 (0-18404)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
White-bellied storm-petrel (*Fregetta grallaria*)	1979-1985	>1 mm	5 of 13 (38%)	1.2 (0-9) / 6.1 (0-42)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
White-chinned petrel (*Procellaria aequinoctialis*)	1979-1985	>2 mm	115 of 201 (57%)	1.7 (0-28) / 46.1 (0-579)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
White-faced storm-petrel (*Pelagodroma marina*)	1979-1985	>1 mm	21 of 24 (88%)	11.2 (0-40) / 38.5 (0-347)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Wilson's storm-petrel (*Oceanites oceanicus*)	1979-1985	>1 mm	3 of 4 (75%)	4 (0-7) / 4.2 (0-8)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Atlantic Yellow-nosed albatross (*Thalassarche chlororhynchos*)	1979-1985	>5 mm	2 of 87 (2%)	<0.1 (0-1) / 16.5 (0-1197)	Number / mass (g) per bird	Industrial pellets, user fragments, fibres, foamed plastics	Ryan (1987b)
Great shearwater (*Ardenna gravis*)	1981	5 mm	9 of 10 (90%)	20.6 ± 25.9 (0-78)	Mean ± SD items over all birds analysed	Polystyrene, hard plastic pieces	Furness (1983)
Sooty shearwater (*Ardenna griseus*)	1981	5 mm	0 of 13 (0%)	NA	NA	Polystyrene, hard plastic pieces	Furness (1983)
White-chinned petrel (*Procellaria aequinoctialis*)	1981	5 mm	1 of 20 (5%)	0.05 ± 0.22 (0-1)	Mean ± SD items over all birds analysed	Polystyrene, hard plastic pieces	Furness (1983)
Lesser sheathbill (*Chionis minor*)	1996/97, 1997/98	>25 mm	3	NA	Total number of individuals with debris, does not state how many were analysed	Small amounts of industrial pellets and other plastic pieces	Nel & Nel (1999)
Southern giant petrel (*Macronectes giganteus*)	1996/97, 1997/98	>25 mm	2	NA	Total number of individuals with debris, does not state how many were analysed	1 had small amounts of industrial pellets and other plastic pieces, 1 with >100 cm^3 of debris from toothfish fishery	Nel & Nel (1999)
Wandering albatross (*Diomedea exulans*)	1996/97, 1997/98	>25 mm	3	NA	Total number of individuals with debris, does not state how many were analysed	All had >100 cm^3 of debris from toothfish fishery	Nel & Nel (1999)
White-chinned petrel (*Procellaria aequinoctialis*)	1996/97, 1997/98	>25 mm	2	NA	Total number of individuals with debris, does not state how many were analysed	1 had small amounts of industrial pellets and other plastic pieces, 1 with >100 cm^3 of debris from toothfish fishery	Nel & Nel (1999)
Blue petrel (*Halobaena caerulea*)	1984, 1985	>5 mm	14 of 15 pre-breeding (93%), 11 of 15 post-moult (73%)	0-0.211 pre-breeding, 0-0.235 post-moult	Range of mass (g) of plastic	NA	Ryan (1987c)
Atlantic yellow-nosed albatross (*Thalassarche chlororhynchos*)	2005-2015	>0.5 mm	0 of 18 (0%)	NA	NA	NA	Ryan *et al.* (2016b)

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Black-browed albatross (*Thalassarche melanophris*)	2005-2015	>0.5 mm	0 of 157 (0%)	NA	NA	NA	Ryan *et al.* (2016b)
Indian yellow-nosed albatross (*Thalassarche carteri*)	2005-2015	>0.5 mm	0 of 77 (0%)	NA	NA	NA	Ryan *et al.* (2016b)
Royal albatross (*Diomedea epomophora/sanfordi*)	2005-2015	>0.5 mm	0 of 6 (0%)	NA	NA	NA	Ryan *et al.* (2016b)
Shy albatross (*Thalassarche cauta*)	2005-2015	>0.5 mm	16 of 601 (3%)	NA	NA	Mostly hake hooks/snoods, only 3 shy albatross had ingested plastic - 2 x single fragments, 1 x ball of synthetic fibres	Ryan *et al.* (2016b)
Tristan albatross (*Diomedea dabbenena*)	2005-2015	>0.5 mm	0 of 5 (0%)	NA	NA	NA	Ryan *et al.* (2016b)
Wandering albatross (*Diomedea exulans*)	2005-2015	>0.5 mm	0 of 4778 (0%)	NA	NA	NA	Ryan *et al.* (2016b)
Comoros (including Mayotte)							
Grey plover (*Pluvialis squatarola*)	NA	<0.25 mm, 0.25-0.5 mm, 0.5-1 mm, >1 mm	1 of 1 (100%)	36.7 (nr)	Number per bird	Mostly fibres (app 70%), followed by foam, then fragments	Chebani (2020)
La Réunion and Juan de Nova islands							
Barau's petrel (*Pterodroma baraui*)	2002-2016	>5 mm	39 of 62 (63%)	6.1 ± 1.3 (nr)	Mean ± SE items per bird with debris	Hard fragments, films	Cartraud *et al.* (2019)
Brown noddy (*Anous stolidus*)	2002-2016	>5 mm	3 of 9 (33%)	1.0 ± 0.02 * (nr)	Mean ± SE items per bird with debris	100% fibres	Cartraud *et al.* (2019)
Cape gannet (*Morus capensis*)	2002-2016	>5 mm	1 of 2 (50%)	NA	NA	100% fibres	Cartraud *et al.* (2019)
Lesser noddy (*Anous tenuirostris*)	2002-2016	>5 mm	9 of 21 (43%)	1.5 ± 0.3 * (nr)	Mean ± SE items per bird with debris	Fibres, fragments	Cartraud *et al.* (2019)
Mascarene petrel (*Pseudobulweria aterrima*)	2002-2016	>5 mm	1 of 1 (100%)	NA	NA	Not specified	Cartraud *et al.* (2019)
Sooty tern (*Ornithoprion fuscatus*)	2002-2016	>5 mm	4 of 27 (15%)	1.0 ± 0.04 * (nr)	Mean ± SE items per bird with debris	100% fibres	Cartraud *et al.* (2019)
Tropical shearwater (*Puffinus bailloni*)	2002-2016	>5 mm	44 of 56 (79%)	3.8 ± 0.6 (nr)	Mean ± SE items per bird with debris	Fibres, fragments, films	Cartraud *et al.* (2019)
Wedge-tailed shearwater (*Ardenna pacifica*)	2002-2016	>5 mm	3 of 9 (33%)	1.7 ± 0.3 * (nr)	Mean ± SE items per bird with debris	Fibres, fragments, films	Cartraud *et al.* (2019)
White-tailed tropicbird (*Phaethon lepturus*)	2002-2016	>5 mm	10 of 35 (29%)	2.0 ± 0.4 * (nr)	Mean ± SE items per bird with debris	Fibres, fragments, films	Cartraud *et al.* (2019)

Table S11. Summary of plastic ingestion by invertebrates and zooplankton in the Western Indian Ocean showing the targeted size of plastic, number of individuals found to ingest plastic, the mean number and mass (g), and main types of plastic ingested. NA = data not available, nr = studies that did not report a range.

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Comoros (including Mayotte)							
Sea cucumber (*Stichopus chloronotus*)	NA	<0.25 mm, 0.25-0.5 mm, 0.5-1 mm, >1 mm	2 of 2 (100%)	40.3 (nr)	Number per individual	Mostly fibres (app 65%), followed by fragments, foam and microbeads	Chebani (2020)
Oyster (*Lopha* sp.)	NA	<0.25 mm, 0.25-0.5 mm, 0.5-1 mm, >1 mm	3 of 3 (100%)	132.1 (nr)	Number per individual	Mostly fibres (app 63%), followed by foam, fragments and films	Chebani (2020)
Kenya							
Amphipoda	2017	<5 mm	NA	0.22 (nr)	Total number ingested microplastics per individual	97% filaments, 3% fragments across all four groups	Kosore *et al*. (2018)
Chaetognatha	2017	<5 mm	NA	0.46 (nr)	Total number ingested microplastics per individual	97% filaments, 3% fragments across all four groups	Kosore *et al*. (2018)
Copepoda	2017	<5 mm	NA	0.33 (nr)	Total number ingested microplastics per individual	97% filaments, 3% fragments across all four groups	Kosore *et al*. (2018)
Fish larvae	2017	<5 mm	NA	0.16 (nr)	Total number ingested microplastics per individual	97% filaments, 3% fragments across all four groups	Kosore *et al*. (2018)
Oyster (*Saccostrea cuccullata*)	2018	<5 mm	70 of 70 (100%)	3.36 ± 0.53 (2.94-5.75)	Mean ± SE microplastics per gram wet tissue	Mostly fibres	Awuor *et al*. (2020), Awuor (2020)
Brachyuran crab (*Tubuca dussumieri*)	2018	<5 mm	136 of 136 (100%)	0.70 (0.13-1.24)	Mean microplastics per gram wet tissue	Mostly fibres	Awuor *et al*. (2020), Awuor (2020)
Brachyuran crab (*Cranuca inversa*)	2018	<5 mm	18 of 18 (100%)	0.43 (0.33-0.52)	Mean microplastics per gram wet tissue	Mostly fibres	Awuor *et al*. (2020), Awuor (2020)
Brachyuran crab (*Gelasimus vocans*)	2018	<5 mm	52 of 52 (100%)	0.79 (0.79)	Mean microplastics per gram wet tissue	Mostly fibres	Awuor *et al*. (2020), Awuor (2020)
Jellyfish (*Crambionella spp.*)	2018	<5 mm	9 of 9 (100%)	0.03 ± 0.01 (0.03-0.05)	Mean ± SE microplastics per gram wet tissue	Mostly fibres	Awuor (2020)

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
South Africa							
Brown mussel (*Perna perna*)	2017	<5 mm	85 of 85 (100%)	2.22 ± 0.79 (0-78)	Mean ± SD items per gram w/w	61.8% microfibres	Gerber (2017)
Ribbed mussel (*Aulacomya ater*)	2018	20 µm-5 mm	164 of 168 (98%, includes all species analysed)	2.8 / 2.9 (nr)	Number particles per gram / number particles per individual	67% fibres for all species combined	Sparks (2020)
Black mussel (*Choromytilus meridionalis*)	2018	20 µm-5 mm	164 of 168 (98%, includes all species analysed)	1.8 / 5.6 (nr)	Number particles per gram / number particles per individual	67% fibres for all species combined	Sparks (2020)
Mediterranean mussel (*Mytilus galloprovincialis*)	2018	20 µm-5 mm	164 of 168 (98%, includes all species analysed)	2.8 / 3.4 (nr)	Number particles per gram / number particles per individual	67% fibres for all species combined	Sparks (2020)
Sandy sea anemone (*Bunodactis reynaudi*)	2015-2019	>25 mm	NA	9.4 ± 14.9 (nr)	Mean ± SD ingested items per month	Mostly flexible plastics	Weideman *et al*. (2020a)
Tanzania							
Cockle (*Anadara antiquata*)	2018	11 µm-5 mm	76 of 160 (48%)	0.86 ± 1.24 (0-5)	Mean ± SD particles per individual	75% fibres, 25% fragments	Mayoma *et al*. (2020)
Deep-sea sites, south-west Indian Ocean off coast of Madagascar							
Arthropoda - Hermit crab	2011	<5 mm	1 of 1 (100%)	NA	NA	All fibres: 2 acrylic, 1 synthetic (nylon or polyethylene), 3 natural, 1 polyester, 1 polypropylene	Taylor *et al*. (2016)
Cnidaria - Seapen (octocoral)	2011	<5 mm	1 of 1 (100%)	NA	NA	All fibres: 1 viscose, 2 natural, 1 polyester	Taylor *et al*. (2016)
Cnidaria - Zoanthid	2011	<5 mm	1 of 1 (100%)	NA	NA	All fibres: 1 modified acrylic, 1 polyester	Taylor *et al*. (2016)
Octocoral (Anthomastus)	2011	<5 mm	0 of 1 (0%)	NA	NA	NA	Taylor *et al*. (2016)

Table S12. Summary of plastic ingestion by bony and cartilaginous fish in the Western Indian Ocean showing the targeted size of plastic, number of individuals found to ingest plastic, the mean number and mass (g), and main types of plastic ingested. NA = data not available, nr = studies that did not report a range.

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Comoros (including Mayotte)							
Brown-marbled grouper (*Epinephelus fuscoguttatus*)	NA	<0.25 mm, 0.25-0.5 mm, 0.5-1 mm, >1 mm	1 of 1 (100%)	324 (nr)	Number per individual	Mostly fibres (app 95%), followed by fragments	Chebani (2020)
South Africa							
European anchovy (*Engraulis encrasicolus*)	2019	>2.7 µm	102 of 178 (57%)	1.13 (0-7)	Mean ± SD items per individual	82% microfibres, 18% fragments	Bakir *et al.* (2020)
South African sardine (*Sardinops sagax*)	2019	>2.7 µm	163 of 227 (72%)	1.58 (0-9)	Mean ± SD items per individual	76% microfibres, 24% fragments	Bakir *et al.* (2020)
West Coast round herring (*Etrumeus whiteheadi*)	2019	>2.7 µm	136 of 188 (72%)	1.38 (0-7)	Mean ± SD items per individual	81% microfibres, 19% fragments	Bakir *et al.* (2020)
Southern mullet (*Chelon richardsonii*)	2018, 2019	>0.5 mm	60 of 150 (40%) with microfibres, 8 of 150 (5%) with fragments	1.6 / 0.06 (nr)	Number of fibres per fish / number of fragments per fish (over all individuals sampled)	96% microfibres, 4% fragments	McGregor & Strydom (2020)
Estuarine mullet (*Mugil cephalus*)	2014	>0.2 mm	51 of 70 (73%)	3.8 ± 4.7 (0-23)	Mean ± SD particles per fish (over all fish)	51.2% fibres, 34.6% fragments, 7.3% polystyrene, 5.0% films, 1.5% monofilament line, 0.4% twine	Naidoo *et al.* (2016)
Pursemouth (*Gerres filamentosus*)	NA	>20 µm	9 of 9 (100%)	8 ± 4.7 (nr)	Mean ± SE particles per fish (over all fish)	94% microfibres	Naidoo *et al.* (2017)
Razorbelly (*Hilsa kelee*)	NA	>20 µm	9 of 9 (100%)	9 ± 3.5 (nr)	Mean ± SE particles per fish (over all fish)	94% microfibres	Naidoo *et al.* (2017)
Silver sillago (*Sillago sihama*)	NA	>20 µm	9 of 9 (100%)	6 ± 5.2 (nr)	Mean ± SE particles per fish (over all fish)	98% microfibres	Naidoo *et al.* (2017)

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Glassfish (*Ambassis dussumieri*)	2019	>10 µm	20 of 29 (69%)	0.93 ± 0.75 (nr)	Mean ± SD particles per fish (over all fish)	68% fibres, 21% fragments (across all species); plastic polymers mostly rayon 70%, polyester 10%, nylon 5%, PVC 3%	Naidoo *et al*. (2020a)
Juvenile mullet (*Mugil spp.*)	2019	>10 µm	16 of 29 (55%)	1.00 ± 1.46 (nr)	Mean ± SD particles per fish (over all fish)	68% fibres, 21% fragments (across all species); plastic polymers mostly rayon 70%, polyester 10%, nylon 5%, PVC 3%	Naidoo *et al*. (2020a)
Thornfish (*Terapon jarbua*)	2019	>10 µm	14 of 29 (48%)	0.66 ± 0.81 (nr)	Mean ± SD particles per fish (over all fish)	68% fibres, 21% fragments (across all species); plastic polymers mostly rayon 70%, polyester 10%, nylon 5%, PVC 3%	Naidoo *et al*. (2020a)
Tilapia (*Oreochromis mossambicus*)	2019	>10 µm	11 of 29 (38%)	0.41 ± 0.57 (nr)	Mean ± SD particles per fish (over all fish)	68% fibres, 21% fragments (across all species); plastic polymers mostly rayon 70%, polyester 10%, nylon 5%, PVC 3%	Naidoo *et al*. (2020a)
European anchovy (*Engraulis encrasicolus*)	2015-2016	<5 mm	20 of 25 (80%)	2.32 (nr)	Mean number of microplastics per fish (over all fish)	>99% microfibres, <1% fragments	Ross (2017)
Hector's lanternfish (*Lampanyctodes hectoris*)	2015-2016	<5 mm	16 of 25 (64%)	2.4 (nr)	Mean number of microplastics per fish (over all fish)	>99% microfibres, <1% fragments	Ross (2017)
Lightfish (*Maurolicus walvisensis*)	2015-2016	<5 mm	16 of 25 (64%)	2.92 (nr)	Mean number of microplastics per fish (over all fish)	>99% microfibres, <1% fragments	Ross (2017)
Red-eye round herring (*Etrumeus whiteheadi*)	2015-2016	<5 mm	11 of 25 (44%)	0.8 (nr)	Mean number of microplastics per fish (over all fish)	>99% microfibres, <1% fragments	Ross (2017)
South African sardine (*Sardinops sagax*)	2015-2016	<5 mm	19 of 25 (76%)	2.8 (nr)	Mean number of microplastics per fish (over all fish)	>99% microfibres, <1% fragments	Ross (2017)

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Cape gurnard (*Chelidonichthys capensis*)	2019	>20 µm	91 of 105 (87%, includes all species)	3.4 ± 0.4 / 0.25 ± 0.04 (nr)	Number particles per fish gut / number particles per gram fish gut	95% fibres, 5% fragments (across all species)	Sparks & Immelman (2020)
Cape horse mackerel (*Trachurus capensis*)	2019	>20 µm	91 of 105 (87%, includes all species)	3.9 ± 1.0 / 0.21 ± 0.06 (nr)	Number particles per fish gut / number particles per gram fish gut	95% fibres, 5% fragments (across all species)	Sparks & Immelman (2020)
Carpenter seabream (*Argyrozona argyrozona*)	2019	>20 µm	91 of 105 (87%, includes all species)	2.8 ± 0.7 / 0.03 ± 0.01 (nr)	Number particles per fish gut / number particles per gram fish gut	95% fibres, 5% fragments (across all species)	Sparks & Immelman (2020)
Chub mackerel (*Scomber japonicus*)	2019	>20 µm	91 of 105 (87%, includes all species)	4.6 ± 0.8 / 0.28 ± 0.05 (nr)	Number particles per fish gut / number particles per gram fish gut	95% fibres, 5% fragments (across all species)	Sparks & Immelman (2020)
Deep-water Cape hake (*Merluccius paradoxus*)	2019	>20 µm	91 of 105 (87%, includes all species)	3.8 ± 0.7 / 0.15 ± 0.04 (nr)	Number particles per fish gut / number particles per gram fish gut	95% fibres, 5% fragments (across all species)	Sparks & Immelman (2020)
Round herring (*Etrumeus whiteheadi*)	2019	>20 µm	91 of 105 (87%, includes all species)	3.3 ± 0.5 / 0.05 ± 0.01 (nr)	Number particles per fish gut / number particles per gram fish gut	95% fibres, 5% fragments (across all species)	Sparks & Immelman (2020)
Shallow-water Cape hake (*Merluccius capensis*)	2019	>20 µm	91 of 105 (87%, includes all species)	4.2 ± 0.6 / 0.25 ± 0.03 (nr)	Number particles per fish gut / number particles per gram fish gut	95% fibres, 5% fragments (across all species)	Sparks & Immelman (2020)

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Blacktip shark (*Carcharhinus limbatus*)	1978-2000	>25 mm	4 of 1785 (0.2%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)
Bull shark (*Carcharhinus leucas*)	1978-2000	>25 mm	4 of 661 (0.6%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)
Copper shark (*Carcharhinus brachyurus*)	1978-2000	>25 mm	1 of 1404 (0.1%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)
Dusky shark (*Carcharhinus obscurus*)	1978-2000	>25 mm	4 of 2741 (0.2%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)
Great hammerhead shark (*Sphyrna mokarran*)	1978-2000	>25 mm	0 of 177 (0%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)
Great white shark (*Carcharodon carcharias*)	1978-2000	>25 mm	2 of 524 (0.4%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)
Java shark (*Carcharhinus amboinensis*)	1978-2000	>25 mm	0 of 222 (0%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)
Sandbar shark (*Carcharhinus plumbeus*)	1978-2000	>25 mm	0 of 379 (0%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Scalloped hammerhead shark (*Sphyrna lewini*)	1978-2000	>25 mm	2 of 1916 (0.1%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/ container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)
Shortfin mako shark (*Isurus oxyrinchus*)	1978-2000	>25 mm	2 of 231 (1%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/ container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)
Smooth hammerhead shark (*Sphyrna zygaena*)	1978-2000	>25 mm	2 of 1154 (0.2%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/ container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)
Spinner shark (*Carcharhinus brevipinna*)	1978-2000	>25 mm	0 of 1699 (0%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/ container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)
Spotted ragged-tooth shark (*Carcharias taurus*)	1978-2000	>25 mm	1 of 2268 (0.04%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/ container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)
Tiger shark (*Galeocerdo cuvier*)	1978-2000	>25 mm	38 of 505 (7.52%)	NA	NA	Across all species analysed: 48% plastic bag, 17.8% plastic sheet, 11% bottle/ container, 5.5% rope, 4.1% sack, 2.7% ring/loop, 2.7% other, 8.2% unidentified	Cliff *et al.* (2002)

Table S13. Summary of plastic ingestion by sea turtles in the Western Indian Ocean showing the targeted size of plastic, number of individuals found to ingest plastic, the mean number and mass (g), and main types of plastic ingested. NA = data not available, nr = studies that did not report a range.

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Oceanic waters around La Réunion and Madagascar							
Loggerhead turtle (*Caretta caretta*)	2007-2013	>0.5 cm	38 of 74 (51%)	41.09 ± 7.22 (1-149) / 16.4 ± 2.85 (max 75.05g)	Mean number ± SE / mass (g) ± SE per turtle with debris	All plastics contributed 96.2% (1265 pieces); 84.3% hard plastics, 9.1% soft plastic, 2.8% plastic caps, 2.2% fishing items, 1.6% miscellaneous items	Hoarau *et al*. (2014)
Loggerhead turtle (*Caretta caretta*)	2007-2018	Not specified	NA	52.35 ± 57.6 (1-207) / 19.08 ± 18.7 (0.18-85.07)	Mean number ± SD / mass (g) ± SD per turtle with debris	NA	Barret *et al*. (2018)
Green turtle (*Chelonia mydas*)	2007-2018	Not specified	NA	18.6 ± 32.5 (1-95) / 1.9 ± 2.7 (0.1-7.4)	Mean number ± SD / mass (g) ± SD per turtle with debris	NA	Barret *et al*. (2018)
Hawksbill turtle (*Eretmochelys imbricata*)	2007-2018	Not specified	NA	11.6 ± 5.7 (6-20) / 1.4 ± 1.4 (0.1-3.8)	Mean number ± SD / mass (g) ± SD per turtle with debris	NA	Barret *et al*. (2018)
Olive Ridley turtle (*Lepidochelys olivacea*)	2007-2018	Not specified	NA	5.5 ± 3.1 (3-10) / 0.7 ± 0.7 (0.13-1.6)	Mean number ± SD / mass (g) ± SD per turtle with debris	NA	Barret *et al*. (2018)
La Réunion							
Green turtle (*Chelonia mydas*)	2005-2010	Not specified	4 of 12 (33%)	NA	NA	Mostly plastic fragments	Claro & Hubert (2011)
Loggerhead turtle (*Caretta caretta*)	2005-2010	Not specified	12 of 28 (43%)	NA	NA	Mostly plastic fragments	Claro & Hubert (2011)
Olive Ridley turtle (*Lepidochelys olivacea*)	2005-2010	Not specified	1 of 8 (12%)	NA	NA	Mostly plastic fragments	Claro & Hubert (2011)
Hawksbill turtle (*Eretmochelys imbricata*)	2005-2010	Not specified	0 of 5 (0%)	NA	NA	Mostly plastic fragments	Claro & Hubert (2011)
Comoros (including Mayotte)							
Hawksbill turtle (*Eretmochelys imbricata*)	2004-2010	Not specified	2 of 8 (25%)	NA	NA	1 piece of net, 1 plastic fragment	Claro & Hubert (2011)
Hawksbill turtle (*Eretmochelys imbricata*)	NA	<0.25 mm, 0.25-0.5 m, 0.5-1 mm, >1 mm	2 of 2 (100%)	16.5 (nr)	Number per individual	Mostly fibres (app 70%), followed by fragments and films	Chebani (2020)
Hawksbill turtle (*Eretmochelys imbricata*)	NA	Macrolitter, but size not specified	0 of 2 (0%)	NA	NA	NA	Chebani (2020)

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Green turtle (*Chelonia mydas*)	NA	Macrolitter, but size not specified	2 of 2 (100%)	NA	NA	Fishing nets and pieces of plastic bags	Chebani (2020)
South Africa							
Loggerhead turtle (*Caretta caretta*)	NA	>1 mm	4 of 37 (11%)	NA	NA	Spherical 1 mm plastic beads, pieces of fine plastic sheet about 30x20 mm	Hughes (1973)
Loggerhead turtle (*Caretta caretta*)	NA	>1 mm	4 of 26 (15%)	NA	NA	Plastic strip, plastic bags, piece of glass	Hughes (1973)
Loggerhead turtle (*Caretta caretta*)	2015	>300 µm	24 of 40 (60%)	16.1 ± 17.2 (1-61) / 0.1205 ± 0.1428 (0.002-0.493)	Mean number ± SD / mass (g) ± SD per turtle (of 16 turtles for which plastic was kept)	99% by number and 99.3% by mass was plastic; of the plastics, 76% hard fragments, 11% flexible packaging, 8% fibres, 3% industrial pellets	Ryan *et al.* (2016a)

Table S14. Summary of plastic ingestion by marine mammals in the Western Indian Ocean showing the targeted size of plastic, number of individuals found to ingest plastic, the mean number and mass (g), and main types of plastic ingested. NA = data not available, nr = studies that did not report a range.

Species	Year	Size	# individuals with interaction (%)	Mean items per individual (range)	Reporting unit	Types	Reference
Comoros (including Mayotte)							
Spinner dolphin (*Stenella longirostris*)	NA	<0.25 mm, 0.25-0.5 mm, 0.5-1 mm, >1 mm	1 of 1 (100%)	26.5 (nr)	Number per individual	Mostly fibres (app 93%), followed by films	Chebani (2020)
Spinner dolphin (*Stenella longirostris*)	NA	Macrolitter, but size not specified	0 of 1 (0%)	NA	NA	NA	Chebani (2020)
Melon headed whale (*Peponocephala electra*)	NA	<0.25 mm, 0.25-0.5 mm, 0.5-1 mm, >1 mm	1 of 1 (100%)	61.5 (nr)	Number per individual	Mostly fibres (app 90%), followed by fragments, films and foam	Chebani (2020)
Melon headed whale (*Peponocephala electra*)	NA	Macrolitter, but size not specified	0 of 1 (0%)	NA	NA	NA	Chebani (2020)
South Africa							
Fur seals (Sub-Antarctic fur seal *Arctocephalus tropicalis*, Antarctic fur seal *Arctocephalus gazella*)	1989-2014	>0.5 mm	0 of 8066 (0%)	NA	NA	NA	Ryan *et al.* (2016b)

Table S15. Summary of plastic entanglement by marine organisms in the Western Indian Ocean showing the number of individuals found entangled in marine debris, the frequency of occurrence (FOC) and main types of marine debris found entangling organisms. NA = data not available.

Taxon	Species	Study site	Year	# individuals with interaction	FOC (%)	Reporting unit	Types	Reference
Seychelles								
Corals	Species not specified	Outer islands	2011-2015	NA	Found in 37% of Fish Aggregating Devices washed up	NA	Fish Aggregating Devices (FADs)	Balderson & Martin (2015)
Turtles	Hawksbill turtle (*Eretmochelys imbricata*)	Outer islands	2011-2015	3	NA	NA	Fish Aggregating Devices (FADs)	Balderson & Martin (2015)
Turtles	Olive Ridley turtle (*Lepidochelys olivacea*)	Outer islands	2011-2015	1	NA	NA	Fish Aggregating Devices (FADs)	Balderson & Martin (2015)
South Africa								
Invertebrates	Encrusting, branching, massive and plate stony corals; soft corals; tunicates; sponges	Sodwana Bay	1994, 1995	Damage seen in 5 of 6 types of invertebrates (encrusting, branching, plate stony corals; soft corals; tunicates)	83% of studied invertebrate types	NA	Fishing line	Schleyer & Tomalin (2000)
Invertebrates	Sea fan (*Lophogorgia flamea*)	False Bay	1991	3	NA	Total number of pieces of fishing line seen with the central core or skeleton of the sea fan entangled	Fishing line	Rundgren (1992)
Mammals	Cape fur seal (*Arctocephalus pusillus*)	Kleinsee	1977-79	1977: 8 of 14000 1978: 2 of 14045 1979: 6 of 15000	1977: 0.06% 1978: 0.01% 1979: 0.04%	% of harvested individuals entangled	1977: not officially recorded, but inspector said half of the items were plastic strap; 1978: 3 nets, 3 ropes, 2 unidentified; 1979: 1 string, 1 monofilament line, 6 nets, 5 ropes, 1 plastic strap	Shaughnessy (1980)
Mammals	Cape fur seal (*Arctocephalus pusillus*)	Geyser Rock	1978	0 of 256	0%	% of harvested individuals entangled	NA	Shaughnessy (1980)
Mammals	Cape fur seal (*Arctocephalus pusillus*)	Seal Island, False Bay	1977-79	1978: 4 of 1843 1979: 9 of 2656	1978: 0.22% 1979: 0.34%	% of harvested individuals entangled	NA	Shaughnessy (1980)

Taxon	Species	Study site	Year	# individuals with interaction	FOC (%)	Reporting unit	Types	Reference
Mammals	Fur seals (Sub-Antarctic fur seal *Arctocephalus tropicalis*, Antarctic fur seal *Arctocephalus gazella*)	Marion Island	1991-2001	89 sub-Antarctic, 14 Antarctic	0.15% for period prior to mid-April 1996, 0.24% for three years subsequent; 0.014% entanglement for December 1994	Total number of individuals seen entangled	Mostly PP packaging straps, trawl netting, rope, string; pieces of elastic, cloth, plastic bags and hooks/fishing line found in small quantities	Hofmeyr *et al*. (2002)
Mammals	Southern elephant seal (*Mirounga leonina*)	Marion Island	1991-2001	5	NA	Total number of individuals seen entangled	Mostly PP packaging straps, trawl netting, rope, string; pieces of elastic, cloth, plastic bags and hooks/fishing line found in small quantities	Hofmeyr *et al*. (2002)
Mammals	Fur seals (Sub-Antarctic fur seal *Arctocephalus tropicalis*, Antarctic fur seal *Arctocephalus gazella*)	Marion Island	1991-1996	28 sub-Antarctic fur seals, 10 Antarctic fur seals	0.15%	Entanglement rate for seals older than 1 year	Types of neck collar (n=38): 39% PP packaging straps, 21% fishing net, 24% synthetic rope/string, 11% unknown, 3% elastic strap, 3% cloth strip	Hofmeyr & Bester (2002)
Mammals	Southern elephant seal (*Mirounga leonina*)	Marion Island	1991-1996	1	NA	NA	NA	Hofmeyr & Bester (2002)
Sharks	Blacktip shark (*Carcharhinus limbatus*)	KwaZulu-Natal	1978-2000	9 of 2527	0.36%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Bull shark (*Carcharhinus leucas*)	KwaZulu-Natal	1978-2000	2 of 1107	0.18%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Copper shark (*Carcharhinus brachyurus*)	KwaZulu-Natal	1978-2000	4 of 2588	0.16%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Dusky shark (*Carcharhinus obscurus*)	KwaZulu-Natal	1978-2000	27 of 5736	0.47%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Great hammerhead shark (*Sphyrna mokarran*)	KwaZulu-Natal	1978-2000	0 of 257	0%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Great white shark (*Carcharodon carcharias*)	KwaZulu-Natal	1978-2000	5 of 850	0.59%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Java shark (*Carcharhinus amboinensis*)	KwaZulu-Natal	1978-2000	0 (does not specify total number caught)	0%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Sandbar shark (*Carcharhinus plumbeus*)	KwaZulu-Natal	1978-2000	2 of 524	0.38%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Scalloped hammerhead shark (*Sphyrna lewini*)	KwaZulu-Natal	1978-2000	0 of 3521	0%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Shortfin mako shark (*Isurus oxyrinchus*)	KwaZulu-Natal	1978-2000	0 of 310	0%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Smooth hammerhead shark (*Sphyrna zygaena*)	KwaZulu-Natal	1978-2000	0 of 1691	0%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Spinner shark (*Carcharhinus brevipinna*)	KwaZulu-Natal	1978-2000	2 of 3092	0.06%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Spotted ragged-tooth shark (*Carcharias taurus*)	KwaZulu-Natal	1978-2000	0 of 4778	0%	NA	PP strapping bands	Cliff *et al*. (2002)
Sharks	Tiger shark (*Galeocerdo cuvier*)	KwaZulu-Natal	1978-2000	2 of 1078	0.19%	NA	PP strapping bands	Cliff *et al*. (2002)

* Woodall *et al*. (2014, 2015) noted fibres entangled around octocorals, sponges, fish and crustacea at deep-sea sites on the east coast of Madagascar but did not quantify.

Table S16. Summary of records of epibionts growing on marine debris in the Western Indian Ocean, showing the study site, number of individuals recorded interacting with debris and the frequency of occurrence (FOC). NA = data not available.

Species	Study site	Year	# individuals with interaction	FOC (%)	Reporting unit	Reference
Kenya						
Bryozoans, Spirorbis worms, goose barnacles and some benthic biota	9 beaches (Mombasa, Bamburi, Diani, Watamu, Coco, Uvombo, Ngomeni, Mareneni)	2019	NA	Epibionts found on 4% urban bottles, 29% resort bottles, 16% remote bottles	% bottles with epibionts	Ryan (2020a)
Madagascar						
Cheilostome bryozoans, bivalves, lepadomorph and balanomorph barnacles, polychaete annelid worms (Spirorbidae), hydroids, corals and sponges	Nosy Ve	1996-2002	NA	34% of litter colonised	NA	Barnes (2004)
Mauritius						
NA	Rodrigues Island	1996-2002	NA	0% of litter colonised	NA	Barnes (2004)
Mozambique						
Cheilostome bryozoans, bivalves, lepadomorph and balanomorph barnacles, polychaete annelid worms (Spirorbidae), hydroids, corals and sponges	Quirimba Island	1996-2002	NA	48% of litter colonised	NA	Barnes (2004)
Cheilostome bryozoans, bivalves, lepadomorph and balanomorph barnacles, polychaete annelid worms (Spirorbidae), hydroids, corals and sponges	Inhaca Island	1996-2002	NA	30% of litter colonised	NA	Barnes (2004)
South Africa						
Pink encrusting coralline algae *Lithothamnion*	False Bay	1991	28	NA	Total number plastic pieces with epibionts	Rundgren (1992)
Balanus sp.	False Bay	1991	23	NA	Total number plastic pieces with epibionts	Rundgren (1992)
Mussel *Choromytilus meridionalis*	False Bay	1991	19	NA	Total number plastic pieces with epibionts	Rundgren (1992)
Anemone *Bunodosoma capensis*	False Bay	1991	1	NA	Total number plastic pieces with epibionts	Rundgren (1992)
Barnacles, polychaete worms, brachiopods, bryozoans, hydroids, tunicates, ascidians, macroalgae, amphipods, brittle stars, molluscs	Southern continental shelf	2019	NA	Epibionts found on 77% of items	% litter items with epibionts	Ryan *et al*. (2020c)

Species	Study site	Year	# individuals with interaction	FOC (%)	Reporting unit	Reference
Bryozoans, crustaceans	Table Bay (Milnerton and Koeberg beaches)	1994	NA	<1% of litter colonised	NA	Swanepoel (1995)
Goose barnacles (*Dosima fascicularis, Lepas anserifera, L. pectinata, L. testudinata, L. anatifera* and *L. australis*)	South-west coast (16 sites)	2009	NA	NA	NA	Whitehead *et al.* (2011)
Goose barnacles (*Dosima fascicularis, Lepas anserifera, L. pectinata, L. testudinata, L. anatifera* and *L. australis*)	South coast (3 sites)	2009	NA	NA	NA	Whitehead *et al.* (2011)
Goose barnacles (*Dosima fascicularis, Lepas anserifera, L. pectinata, L. testudinata, L. anatifera* and *L. australis*)	East coast (3 sites)	2009	NA	NA	NA	Whitehead *et al.* (2011)
Mussels, algae, balanoid barnacles, bryozoans, sea anemones, sea cucumbers, starfish, Spirorbis worms, other polychaete worms, limpets, chitons	Muizenberg beach, False Bay	2015-2019	Not quantified, just anecdotal notes	NA	NA	Weideman *et al.* (2020b)
Algae, bryozoan, Lepas barnacles, other barnacles, polychaete worms and mussels	Milnerton, Muizenberg	2014	NA	4% of litter had algae, 1% had mussels, 95% with nothing	NA	Fazey & Ryan (2016)
Algae, bryozoan, Lepas barnacles, other barnacles, polychaete worms and mussels	16 Mile beach West Coast National Park, Dia Plaat Walker Bay	2014	NA	43% of litter had algae, 3% bryozoans, 1% Lepas barnacles, 2% other barnacles, 1% polychaete worms, 1% mussels, 49% nothing	NA	Fazey & Ryan (2016)
Algae, bryozoan, Lepas barnacles, other barnacles, polychaete worms and mussels	Rocher Pan Nature Reserve, De Mond Nature Reserve	2014	NA	19% of litter had algae, 8% bryozoans, 3% Lepas barnacles, 2% other barnacles, 1% polychaete worms, 6% mussels, 60% nothing	NA	Fazey & Ryan (2016)
Bryozoans, gooseneck barnacles, balanoid barnacles, spirorbid worms, hyrdozoans, algae, and benthic organisms (mainly coralline algae and polychaete tubes)	32 sites along South African coast	2019-2020	NA	Epibionts found on 6.4% of bottles, being more frequent on foreign (9.2%) than local bottles (2.8%), and also on bottles collected along the southeast coast (9.2%) than the west coast (3.4%)	% bottles with epibionts	Ryan *et al.* (2021)
Tanzania						
Cheilostome bryozoans, bivalves, lepadomorph and balanomorph barnacles, polychaete annelid worms (Spirorbidae), hydroids, corals and sponges	Pemba Island	1996-2002	NA	12% of litter colonised	NA	Barnes (2004)

* Rundgren (1992) noted 43 sea urchins (*Parechinus angulosus*) using pieces of plastic as sunshades in False Bay.

* Weideman *et al.* (2020b) also noted sea urchins (*Parechinus angulosus*) occasionally using plastic debris as sunshades, as well as sandy anemones (Bunodactis reynaudi) and cask sea cucumbers (*Pentacta doliolum*) with plastic fragments adhered to their sides.

* Woodall *et al.* (2015) saw corals and hydroids encrusting marine debris at deep-sea sites on the east coast of Madagascar. They also saw fish, crinoids, anemones, sea urchins and brittle stars using marine debris as habitats.

Table S17. Summary of records of marine debris found at seabird nests in the West Indian Ocean, showing the study site, number of nests with debris, the mean number and mass (g) of debris items per nest, and the types and colours of debris. NA = data not available, nr = studies that did not report a range.

Species	Study site	Year	# nests with debris (%)	Mean items per nest (range)	Reporting unit	Type	Colour	Reference
Forage widely across south-west Indian, Atlantic and Southern Oceans								
Grey-headed albatross (*Thalassarche chrysostoma*)	Marion Island	1996/97, 1997/98	NA	72 (nr)	Total number of items associated with nests	23.6% fishery, 76.4% non-fishery	NA	Nel & Nel (1999)
Southern giant petrel (*Macronectes giganteus*)	Marion Island	1996/97, 1997/98	NA	69 (nr)	Total number of items associated with nests	31.9% fishery, 68.1% non-fishery	NA	Nel & Nel (1999)
Brown skua (*Stercorarius antarcticus*)	Marion Island	1996/97, 1997/98	NA	7 (nr)	Total number of items associated with nests	28.5% fishery, 71.4% non-fishery	NA	Nel & Nel (1999)
Wandering albatross (*Diomedea exulans*)	Marion Island	1996/97, 1997/98	NA	102 (nr)	Total number of items associated with nests	78.4% fishery, 21.6% non-fishery	NA	Nel & Nel (1999)
White-chinned petrel (*Procellaria aequinoctialis*)	Marion Island	1996/97, 1997/98	NA	4 (nr)	Total number of items associated with nests	50% fishery, 50% non-fishery	NA	Nel & Nel (1999)
Macaroni penguin (*Eudyptes chrysolophus*)	Marion Island	1996/97, 1997/98	NA	1 (nr)	Total number of items associated with nests	100% fishery	NA	Nel & Nel (1999)
Northern giant petrel (*Macronectes halli*)	Marion Island	1996/97, 1997/98	NA	7 (nr)	Total number of items associated with nests	14.3% fishery, 85.7% non-fishery	NA	Nel & Nel (1999)
Salvin's prion (*Pachyptila salvini*)	Marion Island	1996/97, 1997/98	NA	1 (nr)	Total number of items associated with nests	100% non-fishery	NA	Nel & Nel (1999)
Lesser sheathbill (*Chionis minor*)	Marion Island	1996/97, 1997/98	NA	1 (nr)	Total number of items associated with nests	100% non-fishery	NA	Nel & Nel (1999)
Wandering albatross (*Diomedea exulans*)	Marion Island	1997-2018	NA	NA	NA	51% fishery-related, 39% rigid plastic, 3% food packaging, 2% other flexible plastics, 1% PE bag, 3% miscellaneous	NA	Perold *et al.* (2020)
Giant petrels (Northern: *Macronectes halli*, Southern: *Macronectes giganteus*)	Marion Island	1997-2018	NA	NA	NA	58% rigid plastics, 28% fishery-related, 4% PE bags, 3% food packaging, 3% other flexible plastics, 4% miscellaneous	NA	Perold *et al.* (2020)

Species	Study site	Year	# nests with debris (%)	Mean items per nest (range)	Reporting unit	Type	Colour	Reference
Grey-headed albatross (*Thalassarche chrysostoma*)	Marion Island	1997-2018	NA	NA	NA	86% rigid plastics, 8% fishery-related, 4% other flexible plastics, <1% PE bags, <1% food packaging, 1% miscellaneous	NA	Perold *et al.* (2020)
South Africa								
Hartlaub's gull (*Chroicocephalus hartlaubii*)	Kleinriviersvlei, Hermanus	2020	4 of 50 (8%)	NA	NA	100% PP ropes	1 blue, 3 black	Ryan (2020c)
Hartlaub's gull (*Chroicocephalus hartlaubii*)	Meeuw Island	1996	2 of 265 (0.8%)	NA	NA	1 soft plastic, 1 fishing gear	NA	Tavares *et al.* (2020)
African penguin (*Spheniscus demersus*)	St Croix Island	1994	3 of 100 (3%)	NA	NA	2 with fishing gear, 1 unidentified	NA	Tavares *et al.* (2020)
Great white pelican (*Pelecanus onocrotalus*)	Dassen Island	1992	5 of 78 (6%)	NA	NA	2 soft plastic, 1 hard plastic, 1 fishing gear, 1 unidentified	NA	Tavares *et al.* (2020)
White-breasted cormorant (*Phalacrocorax lucidus*)	Meeuw Island	1995	31 of 121 (26%)	NA	NA	19 soft plastic, 1 hard plastic, 10 fishing gear, 1 unidentified	NA	Tavares *et al.* (2020)
Kelp gull (*Larus dominicanus*)	Strandfontein (open nests)	2013	49 of 60 (82%)	3.4 ± 3.4 (0-19) / 0.8 ± 1.0 (0-5.3)	Mean number ± SD / mass (g) ± SD per nest	Mostly plastic packaging	NA	Witteveen *et al.* (2017)
Kelp gull (*Larus dominicanus*)	Strandfontein (vegetated nests)	2013	25 of 62 (40%)	1.7 ± 3.2 (0-15) / 0.5 ± 0.8 (0-3)	Mean number ± SD / mass (g) ± SD per nest	Mostly plastic packaging	NA	Witteveen *et al.* (2017)
Kelp gull (*Larus dominicanus*)	De Mond (open beach)	2013	29 of 37 (78%)	3.1 ± 2.5 (0-10) / 1.5 ± 1.5 (0-6.6)	Mean number ± SD / mass (g) ± SD per nest	Mostly rope/strapping	NA	Witteveen *et al.* (2017)
Kelp gull (*Larus dominicanus*)	De Mond (open estuary)	2013	16 of 30 (53%)	0.9 ± 1.0 (0-3) / 1.3 ± 3.1 (0-15.8)	Mean number ± SD / mass (g) ± SD per nest	Mostly rope/strapping	NA	Witteveen *et al.* (2017)
Kelp gull (*Larus dominicanus*)	Robberg (open nests)	2013	1 of 6 (17%)	0.3 ± 0.8 (0-2) / 0.3 ± 0.6 (0-1.5)	Mean number ± SD / mass (g) ± SD per nest	Mostly plastic packaging	NA	Witteveen *et al.* (2017)
Kelp gull (*Larus dominicanus*)	Robberg (vegetated nests)	2013	11 of 34 (32%)	0.8 ± 1.5 (0-6) / 0.6 ± 1.1 (0-5)	Mean number ± SD / mass (g) ± SD per nest	Mostly plastic packaging	NA	Witteveen *et al.* (2017)
Kelp gull (*Larus dominicanus*)	Keurbooms (open nests)	2013	6 of 53 (11%)	0.3 ± 0.8 (0-3) / 0.3 ± 1.1 (0-5.8)	Mean number ± SD / mass (g) ± SD per nest	Mostly plastic packaging	NA	Witteveen *et al.* (2017)
Kelp gull (*Larus dominicanus*)	Keurbooms (vegetated nests)	2013	70 of 158 (44%)	1.8 ± 3.6 (0-26) / 0.7 ± 1.2 (0-8)	Mean number ± SD / mass (g) ± SD per nest	Mostly plastic packaging	NA	Witteveen *et al.* (2017)

* Nel & Froneman (2018) analysed the incorporation of microplastics in the tube structures of the reef-building polychaete *Gunnarea gaimardi*, at 9 sites in Western and Eastern Cape in 2016 and 2017. They quantified an overall mean density of 0.275 ± 0.215 (range 0.056-1.113) microplastic particles per gram dry weight.