A PLASTIC-FREE OCEAN

CHALLENGES TO REDUCE MARINE PLASTIC POLLUTION IN BRAZIL

OCEANA Proteger os oceanos e alimentar o mundo

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Photograph: Oceana/Enrique Talledo

PRESENTATION

Since plastics were invented more than 100 years ago, they have been present in virtually every aspect of daily life – from water bottles to construction materials and medical equipment. News and studies on plastic pollution in the oceans began to emerge back in the 1970s, but it was not until 2010 that accumulated evidence reached alarming levels, not only for the scientific community but also for society.

While there is plenty of global information on the topic, this report is the first effort to consolidate an overview on marine plastic pollution in Brazil based on publicly available data that cover the whole country.

The first section characterizes plastic as a material, providing data on global production and apparent national consumption while the second section focuses on single-use plastics. The third section investigates plastic waste, providing data on its collection, recycling and final treatment, the legal and regulatory framework that governs solid waste management in Brazil, and environmental agents' roles and interests in single-use plastics.

Once plastic becomes waste, the fourth section presents the pathways and vectors involved in its journey to the sea, and Brazil's contribution to marine plastic pollution. It also provides new information about the impacts of plastics ingestion on Brazil's marine fauna and what is known so far about the risks of exposure to microplastics for human health.

Given this scenario, the last section examines opportunities and concrete solutions for single-use plastic pollution, including international legislation cases focused on reducing single-use plastics as well as technological and innovative solutions to reduce, reuse and return packaging. Finally, Oceana makes three recommendations for Brazil's contribution to reducing the global problem of plastic pollution.

With this document, we hope to contribute to the debate on single-use plastics in Brazil based on the country's scenario and to the search for concrete measures that make our oceans clean and abundant again.

Ademilson Zamboni

Vice President of Oceana in Brazil

EXECUTIVE SUMMARY

When plastic entered the market in the 1950s, it was celebrated for making life more convenient and efficient. Today, we drink our coffee in plastic cups with plastic lids, and we use plastic straws. We carry our groceries – many of which are packaged in plastic – in plastic shopping bags. Our personal care products and cleaning supplies are packaged in plastic designed to be discarded after a single use.

In Brazil, we produce almost 3 million tonnes of single-use plastics – products and packages that are not conceived, designed or placed on the market to make multiple trips or rotations during their life cycles. Of the total volume of single-use plastic produced, 87% are packaging, which represent the largest share of the single-use plastics market. And 13% are disposable products such as plates, cups, cutlery, plastic bags and straws. In other words, Brazil produces 500 billion single-use plastic items every year.

The same properties that made plastics so useful also turn waste into an environmental threat. Their durability means that they persist in the environment for many years, and their low density means that they are easily dispersed by water and wind. As a result, plastic waste is now a ubiquitous pollutant that can be found even in the world's most remote areas. Plastic debris has been found floating on the sea surface, melting on Arctic ice and accumulating at the deepest parts of the ocean.

On average, Brazil contributes 325,000 tonnes of plastic that end up in the ocean per year – from land-based sources such as open dumpsites. Disposable plastic products and packaging are at the heart of the debate about ocean plastic pollution, given the evidence that they make up most of marine litter. Beach cleanups around the world have consistently demonstrated that disposable plastics and packaging are the big problem. In Brazil, the scenario is no different: 70 percent of the waste collected in beach cleanups on the Brazilian coast are plastic, especially packaging. And once it gets to the sea, plastic does not degrade. Instead, it breaks into smaller and smaller pieces and becomes microplastics that work as magnets for harmful chemical pollutants.

As plastic continues to flood our oceans, the list of marine species affected by that debris only gets longer. Tens of thousands of marine organisms are ingesting plastic – from zooplankton and fish to turtles, mammals and seabirds, many of which are already threatened. One out of ten animals that ingest plastic will die. In Brazil, more than 3,700 animals that had ingested waste have been necropsied, and 50 percent had plastic in them. The figure is underestimated because beach monitoring projects are limited to Brazil's Southeast and South regions, but it warns of a bigger, worldwide problem. Animals are not only having contact with waste from human production; they are also dying from it

6,67
million tonnes
is the national plastic production

2.95
million tonnes
is Brazil's production of single-use plastics

87%
Packaging
13%
Disposable products

500
billion single-use
plastic items are consumed by Brazil every year

10.1
million tonnes
of plastic waste were collected in 2018

325,000
tonnes
is Brazil's contribution to plastic marine pollution

70%
of the waste found in beach cleanups in Brazil are plastic

1 out of 10
animals that ingested plastic died

Flawed waste management systems have been blamed for the problem of plastic pollution. This view has transferred responsibility – and blame – to consumers (who fail to segregate their waste) and cities (which fail to provide recyclable garbage collection services, invest in recycling infrastructure and regularize their dump sites). Thus, policy solutions have focused on improving recyclability and recycling rates of plastic products and packaging and, in some cases, promoting energy recovery from that waste.

However, a realistic assessment of the potential impact of recycling shows that it is not enough to prevent ocean plastic pollution. Even according to the most optimistic estimates about increased rates, recycling will not keep pace with the growth trend in total disposable plastic production and therefore will not prevent the flow of plastic into the oceans.

In Brazil, the National Solid Waste Policy (PNRS) requieres the implementation of a Sectorial Agreement for Reverse Logistics of Packaging, where plastic packaging is included. Phase I of the Agreement has been challenged in its effectiveness by the Public Ministry in several states and Phase II, scheduled to start in 2018, has not yet been implemented. As for the waste of disposable plastic products, such as cutlery, bags, plates and cups, there are no specific provisions by the PNRS. Worthless for the recycling market, disposable products become waste and represent a cost to the waste management system. To prevent plastic from entering our oceans, we need to reduce the amount of unnecessary and problematic plastic that is produced at the source. This approach is in line with the principles of Circular Economy and opens space for the development of innovative businesses, new technologies and markets that favor the reuse of packaging, a crucial part of the solution for plastic pollution. **Oceana recommends that (1) Brazil approves a national law regulating the use of single-use plastics; (2) that companies reduce the amount of plastic they are placing in the supply chain and offer consumers plastic-free options for their products; (3) that commercial establishments become Plastic-Free Zones. Without immediate and concrete changes, the amount of plastic waste that enters the marine environment will triple in the next 20 years.**

Photograph: Instituto Mar Urbano / Ricardo Gomes

INTRODUCTION

Light, versatile, cheap and polluting. Plastic is now a ubiquitous material found in almost every sector of the economy and in all spheres of modern life. In 50 years, global consumption of fossil polymers has increased more than 20 times,[1] and the material has become a symbol of consumer society and disposable products. More than half of all plastic consumed in the world was produced after 2005 and it is mainly used for packaging and single-use products.[2]

According to a European Union directive regulating the issue, single-use plastic is defined as **a product that is made wholly or partly from plastic and that is not conceived, designed or placed on the market to accomplish, within its life span, multiple trips or rotations by being returned to a producer for refill or re-used for the same purpose for which it was conceived.**[3] The category includes disposable items such as cups, plates, straws, cutlery and some packaging. This work adopts the European Union's definition of single-use plastics.

While much of the plastic is used once and discarded, the material takes hundreds of years to decompose since most of it is not biodegradable. It undergoes a process called photodegradation, in which the action of light slowly breaks it into small fragments called microplastics.[4]

Each year, at least 8 million tonnes of plastic end up in the oceans[5] – a truckload of garbage per minute. At this rate, the amount of plastic accumulated in the oceans will be four times higher by 2040.[6] This pollution causes several problems for hundreds of marine species, including ingestion, suffocation, entanglement and death, and it poses risks to the health of human beings who ingest those microplastics.[7] Furthermore, it has adverse impacts on fishing and tourism, and on landscape quality, in addition to its high removal and disposal costs. Its burning – whether voluntary or not – pollutes the atmosphere with highly toxic substances and exposes communities to severe health impacts.

Single-use plastics are among the most common types of waste found off the coast of several countries in the world. In the European Union, 80-85 percent of marine waste – counted during beach cleanups – is plastic, and single-use items account for 50 percent of it.[8]

A Brazilian study published in 2020 conducted a large-scale assessment of litter off the country's coast and found that most of it is plastic, confirming the global trend. Along with cigarette butts, food packaging was the most common item found on Brazilian beaches.[9] According to the study's lead author Ryan

Andrade, the most frequent types of waste are food packaging or items associated with food such as candy wrappers, ice cream and cookie containers, soft drink straws and caps, and shopping bags.

Governments around the world have recognized the gravity of this pollution and passed laws and measures to reduce the supply of single-use plastics. Consequently – but not at the same pace of the problems caused by excess and misuse of fossil polymers – a search is underway for more environment-friendly materials as well as changes in consumption patterns and product design.

In replacing plastic to produce disposable packaging and utensils, well-known raw materials gain ground, such as paper, aluminum and even wood from managed plantations. Unusual and innovative materials also stand out, such as cups from cassava pulp, seaweed-based packaging and sugarcane bagasse plates. Plastics from renewable biodegradable sources and initiatives to change consumption patterns also enter the picture, combining old practices and innovation. This is the case with stores specializing in selling products by weight or measure, brands that offer reusable ecological utensils and smart reuse systems. But so far nothing has been able to cope with the industry's eagerness to flood the world with what has no other purpose but remaining a few hours in our hands until – for lack of other uses – it becomes garbage.

Therefore, plastic pollution in the oceans or elsewhere is a problem without borders, which starts on land and in decisions made by actors at all levels – from governments, legislators and large companies to consumers.

Photograph: Instituto Mar Urbano / Ricardo Gomes


Photograph: Needpix

1. THE AGE OF PLASTIC

The word 'plastic' comes from the Greek verb *plassein*, which means 'to mold or model.' Plastic can be molded due to its structure made of long and flexible chains of molecules linked in a repetitive pattern, known as polymers.[10]

Polymers are abundant in nature and play vital roles for living beings: the cellulose in cell walls is a polymer, as are the proteins present in muscles, skin and the complex molecules that support our DNA. Other well-known organic polymers are lignin, silk and natural rubber.[11]

Polymers may also be synthetic or natural. Latex and cellulose were the first raw materials used to manufacture plastic, but today most plastics are made by refining oil and natural gas. Whether a polymer is natural or synthetic, at the core of its chemical composition is a carbon atom and other elements like oxygen, nitrogen and hydrogen – which often join with carbon to produce specific varieties of polymers.[12]

Distinct molecular arrangements can give rise to an almost infinite variety of polymers with numerous properties. As a result, for better or for worse, the discovery of plastic revolutionized our way of consuming by introducing a variety of light, resistant, flexible materials suitable for multiple uses, but which will not degrade.[13]

A BRIEF HISTORY OF PLASTICS

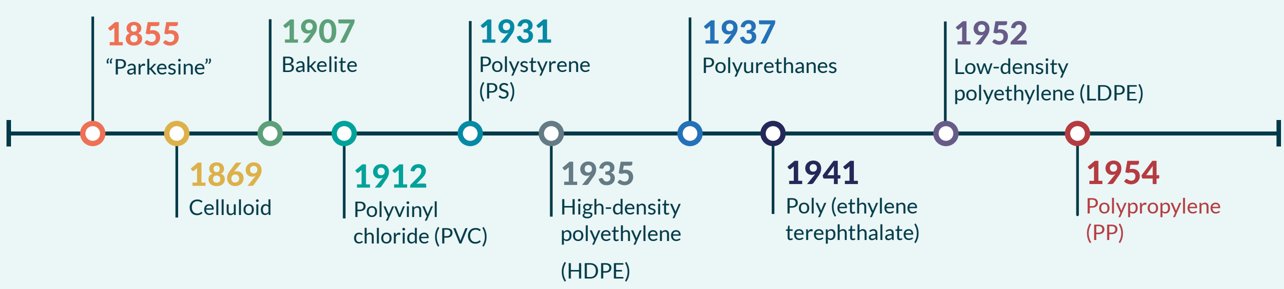
The history of plastic production begins in 1855, when British inventor Alexander Parkes created and patented 'Parkesine,' the first man-made plastic ever produced, which was made from cellulose. Parkes presented the world with a material that could be modeled when heated and maintained its shape when cooled. A few years later, he founded the Parkesine Company in London, laying the foundations for the plastics industry.[14] Another revolutionary discovery was made in 1869 by John Wesley Hyatt, who conceived celluloid by treating the cellulose from cotton fibers with camphor. As a result of its wide supply and the low cost of its raw material, celluloid replaced ivory, whose demand was associated with the growing popularity of billiards at the time.[15]

Until then, plastics used to be produced from natural raw materials. It was in 1907 that the first completely synthetic plastic was developed by Leo Hendrik Baekeland, who is considered the father of the plastic industry. Baekeland was looking for a material to replace shellac, a natural electrical insulator, and supply the US electrical industry. His research resulted in the invention of the first durable plastic –

bakelite – whose characteristics such as thermal insulation and malleability earned it the title of 'the material of a thousand uses.'[16]

Other types of plastics have been developed since the creation of Baekeland, (FIGURE 1), but they occupied only a small market niche until the mid-20th century. World War II triggered the rapid expansion of the oil and gas industry and its secondary products, causing significant increase in demand for materials and equipment. New petrochemical plants were built in the United States to process oil into plastic, resulting in a 300-percent increase in production.[17]

FIGURE 1.
Timeline of the invention of key plastic resins

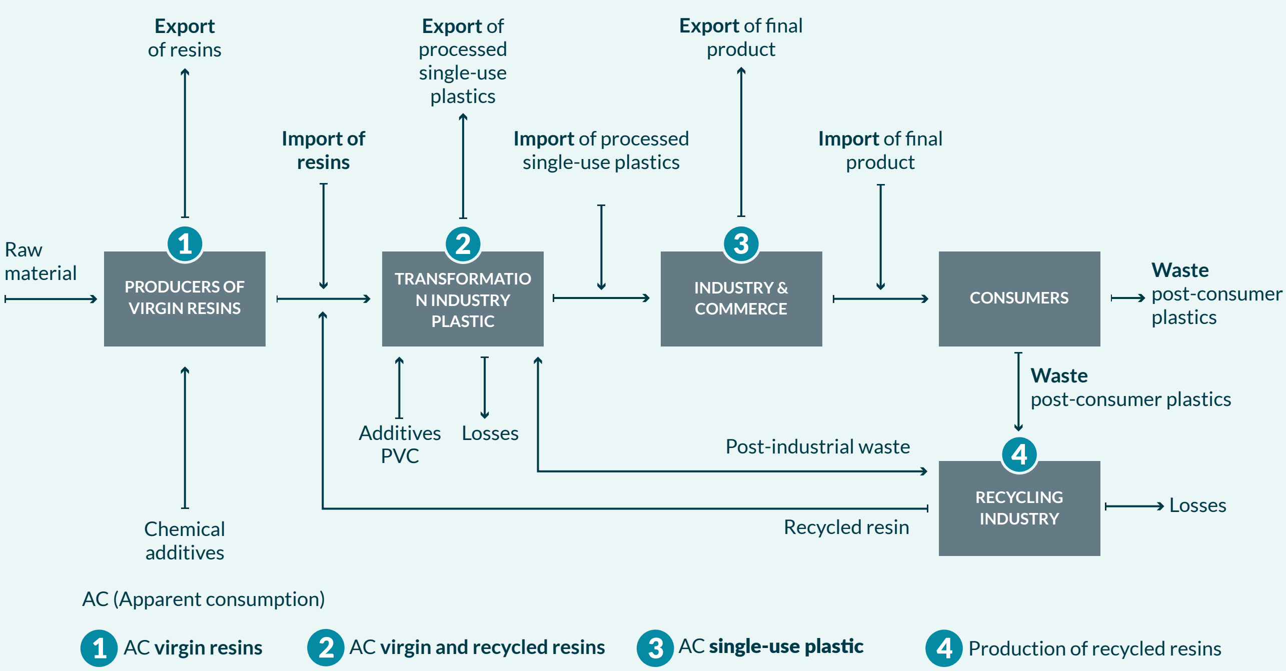


From the late 1950s on, the postwar economy was driven by the need to consume ever-increasing amounts of goods. According to journalist Susan Freinkel, "in product after product, market after market, plastics challenged traditional materials and won, taking the place of steel in cars, paper and glass in packaging, and wood in furniture."[18] With cheap raw materials, manufacturers simplified their supply chains and started to produce plastics on a large scale. In the early 1960s, billions of plastic items were already filling dumpsites, landfills and incinerators all over the world. The shift toward disposable packaging in the 1970s marked the emergence of the culture of wasting and a lifestyle that generates alarming amounts of plastic waste.

SUPPLY CHAIN

The plastic supply chain begins with oil extraction and refining to make products such as gasoline, diesel oil and naphtha. From naphtha or natural gas, the petrochemical industry produces basic raw materials, especially ethylene (or ethene) and propylene (or propene), which are processed into virgin petrochemical resins such as polyethylenes (PEs) and polypropylenes (PPs). From virgin resins or recycled resins, the manufacturing industry will produce plastic items for numerous applications, including single-use plastics. Finally, the recycling industry will manufacture recycled resins from recyclable materials that are sorted, cleaned and processed (FIGURE 2).[19]

FIGURE 2.
Plastic supply chain flow chart



Prepared by: Giral Viveiro de Projetos

The main thermoplastic resins used in manufacturing processes are low- or high-density polyethylene (LDPE/HDPE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS) and polyethylene terephthalate (PET).

Using these thermoplastic resins as inputs, the manufacturing industry is able to make a wide variety of products for several markets, using distinct production processes:[20]

- **injection** (plastic utensils in general, such as basins, lids, boxes, bumpers and hubcaps)
- **extrusion** (mainly LDPE films for shopping bags or PVC pipes)
- **blowing molding** (hollow items such as bags, jars or bottles)
- **rotational molding** (water tanks and other types of tanks)
- **thermoforming** (rigid packaging)
- **vacuum forming** (crankcase protectors} and bumpers)

CLASSIFICATION AND USES

Plastics have become ubiquitous. From plastic bags to disposable syringes, from PVC pipes to electronic parts, plastics are part of every aspect of daily life. Their wide range of applications are a result of numerous characteristics and consumption demands **(TABLE 1).** Their properties give rise to two distinct groups: thermosets and thermoplastics.[21]

Thermosets: Polymers that harden irreversibly, that is, they do not return to their original shapes after being heated or cured. Thermosets are valued for their durability and resistance, and are widely used in cars and construction, in applications such as adhesives, paints and coatings. Some examples of thermosets and their applications in products are:

- Polyurethanes (PUR) (mattresses, pillows, insulation);
- Unsaturated polyesters (bathtubs and showers, furniture, boat hulls);
- Epoxies (glues and adhesives, coating for electrical parts);
- Bakelite (home appliances, electrical circuit boards and switches).

Thermoplastics: Thermoplastic polymers melt when heated and solidify when cooled, in a reversible process, and they can also be dissolved in solvents. Thermoplastics are usually employed in general packaging, such as food and beverage containers, as they can be molded quickly and economically.

TABLE 1.
Types, properties and uses of thermoplastic polymers.

SYMBOL	TYPE OF POLYMER	PROPERTIES	EXAMPLES OF APPLICATIONS
1 PET	Poly (ethylene terephthalate)	Physical and chemical resistance, transparency, lightness	Bottles for non-alcoholic beverages; packaging for food and cosmetics
2 HDPE	High-density polyethylene	Hardness, rigidity, chemical resistance	Rigid bottles for household cleaning and personal hygiene products; containers
3 PVC	Polyvinyl chloride	Hardness, flexibility, high chemical resistance	Tubes and pipes for water and sewage; hoses; hospital supplies
4 LDPE	Low-density polyethylene	Chemical resistance, flexibility; it forms films	Food packaging; bags and sacks; containers, films
5 PP	Polypropylene	Thermal, chemical and wear resistance; hardness and flexibility	Sacks, food packaging, straws, pharmaceutical containers
6 PS	Polystyrene	Low density and moisture absorption; lightness	Styrofoam – food delivery packaging; foam trays; packaging for fragile items; disposable cups
7 OTHERS	Others	Combinations of other resins	CDs, electronics, snacks packaging etc.

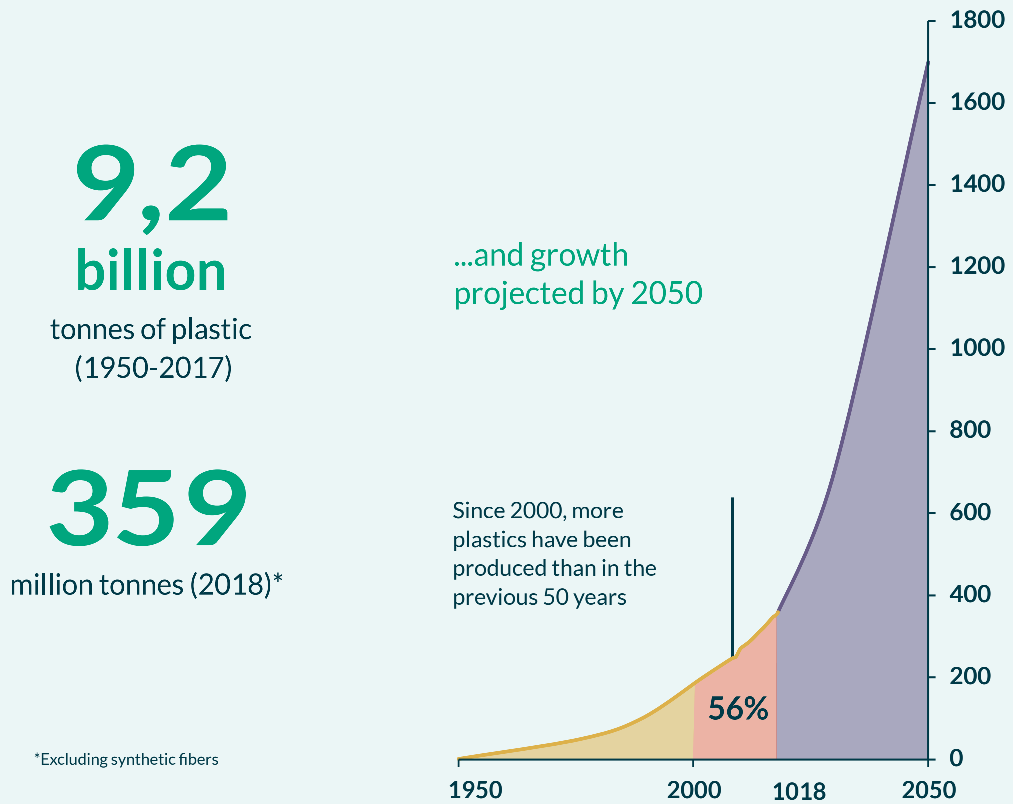
Source: ABNT NBR 13230 Standard – Recyclable plastic packaging – Identification and symbology; Plastic Industry Society[22]

GLOBAL PRODUCTION

Since the early times of industrial polymer production in 1950 until 2017, it is estimated that about 9.2 billion tonnes of plastic were made from virgin resins, and more than half of that was produced in the last 20 years.[23]

In 2018, 359 million tonnes of plastic were produced globally – a 3.2-percent increase over the previous year (Figure 3). China alone accounted for 30 percent of that volume while Latin America contributed 4 percent.[24]

FIGURE 3.
Global plastics production from 1950 to 2018 and growth projected by 2050



Sources: Ryan, P. G. (2015);[25] Plastics Europe (2018);[26] UNEP, GRID-Arendal (2016);[27] Plastic Atlas (2019)[28]

Plastics production is projected to increase fourfold by 2050. If the current trend of increasing global production by approximately 5 percent per year is maintained, 33 billion tons of plastic will have accumulated worldwide by 050.[29]

Photograph: Depositphotos

2. SINGLE-USE PLASTICS

Brazilian law does not define single-use plastics, but according to Article 3 of the European Plastics Directive (2019/904),[30] in its Definitions:

> **Single-use plastic product** is a product manufactured wholly or partially from plastic and which is not conceived, designed or placed on the market to make multiple trips or rotations in its life cycle by returning it to a producer for refilling or reusing it for the same purpose for which it was designed.

In other words, these materials are designed to be used only once during their lifetime and then discarded. They are highly varied in the resins used for their manufacture, their shapes, and applications. Two categories of products fit this definition: **disposable products and plastic packaging** in general. The terms 'single-use plastic' and 'disposable plastic' are therefore synonymous.

DISPOSABLE PRODUCTS

Disposable products are demanded for several applications that include shopping bags, cups, plates, cutlery and straws. Resins used for these applications include PP, PS, HDPE, LDPE, LLDPE and EPS (Table 2).

TABLE 2.
Classification of disposable products according to the industries that demand them, example of applications, and resins used in manufacturing.

TYPES	DEMANDING INDUSTRY	EXAMPLES OF APPLICATIONS	RESINS
Disposable products	Retail	Shopping Bags	HDPE, LDPE, LLDPE
	Disposables	Water and coffee cups	PP, PS, EPS
	Disposables	Disposable Plates, Cutlery	PS
	Disposables	Straws	PP, PS

Source: Giral Viveiro de Projetos.

PACKAGING

Packaging is used in many sectors of the economy, especially the food, beverage, personal hygiene, household cleaning, pet food and pharmaceutical industries. It includes several products such as plastic containers, lids, bottles, flexible packages and labels. The manufacturing industry uses several types of resins to produce these packages, including Polypropylene (PP), Polystyrene (PS), High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), Linear Low-Density Polyethylene (LLDPE), Polyethylene terephthalate (PET) and expanded polystyrene (EPS) **(TABLE 3)**.

TABLE 3.
Classification of packaging by demanding industry, examples of applications, and resins used in manufacturing.

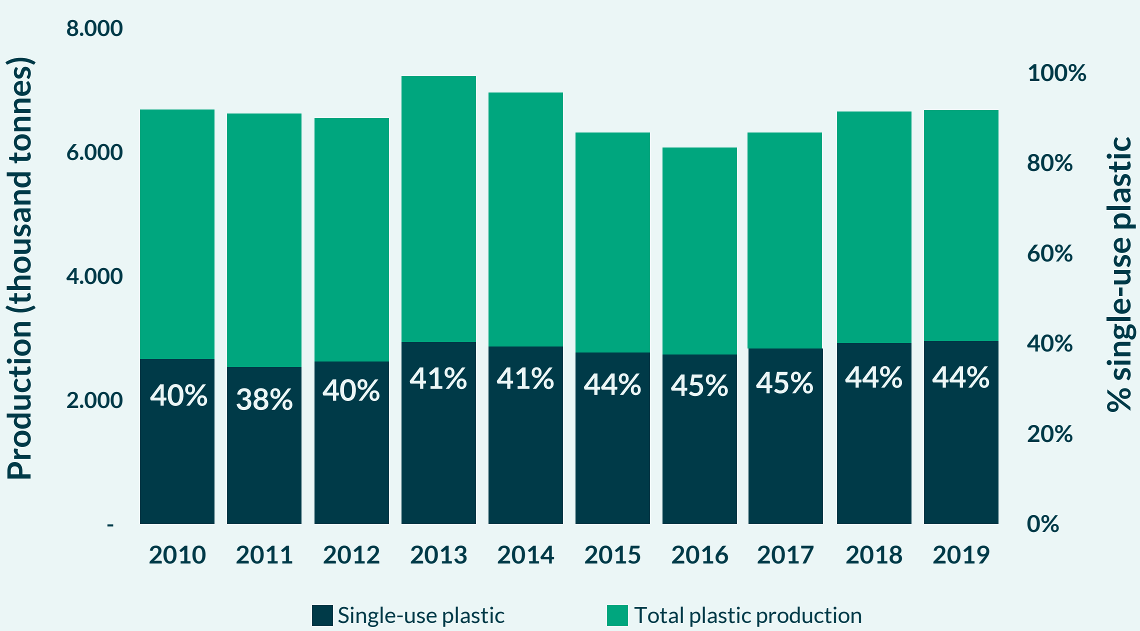
TYPES	DEMANDING INDUSTRY	EXAMPLES OF APPLICATIONS	RESINS
PACKAGING	**Food**	Plastic containers (yogurt, ice cream, chocolate powder), flexible packaging (pasta, biscuit, cereal, rice, beans, soup, meat and cold cuts, coffee), hard packaging (ketchup, mayonnaise, oil and vinegar bottles, margarine), coffee sachets and capsules, Styrofoam trays, labels and caps	LDPE, LDPE, HDPE, PP, PS, PVC, PET, EPS
	Beverages	Bottles for water, soft drinks and juices; carboys, labels and caps	LDPE, LDPE, HDPE, PP, EPS, PET
	Personal hygiene	Bottles for shampoo, conditioner, deodorant, liquid soap; flexible cosmetic packaging; toothpaste tubes, labels and caps	LDPE, LLDPE, HDPE, PP, PS, PET
	Household cleaning	Bottles for disinfectants, detergents, fabric softener and cleaning products in general	LDPE, LDPE, HDPE, PP, PS, PET
	Pharmaceuticals	Serum vials, jars and bottles for medicine; caps and labels	HDPE, LDPE, PVC, PET
	Animal feed	Flexible packaging for animal feed	LDPE, LDPE, PET

Source: MaxiQuim database (2020) commissioned by consulting firm Giral Viveiro de Projetos.

PRODUCTION OF SINGLE-USE PLASTICS

According to a MaxiQuim study commissioned by the consultancy Giral Viveiro de Projetos,, Brazil manufactured 6.67 million tonnes of plastic items from virgin resins in 2019. Of that, 44 percent (or 2.95 million tonnes) correspond to **items manufactured for single-use applications such as general packaging and disposable products**. Between 2010 and 2019, the amount of plastic produced did not change much, with single-use plastics accounting for almost half of products manufactured in the last decade **(FIGURE 4)**.

FIGURE 4.
Production of single-use plastic from virgin resins and its relationship
to the total production of manufactured plastic products in Brazil, from 2010-2019.



Source: MaxiQuim database (2020) commissioned by Giral Viveiro de Projetos.

Regarding applications, 87 percent (or 2.56 million tonnes) of the total of single-use plastics processed in 2019 went to packaging production, while 13 percent (or 396,000 tonnes) were used to make disposable products **(FIGURE 5)**. In terms of volume, the packaging segment exceeds the disposables segment by more than six times.

FIGURE 5.
Production of single-use plastics in Brazil in 2019

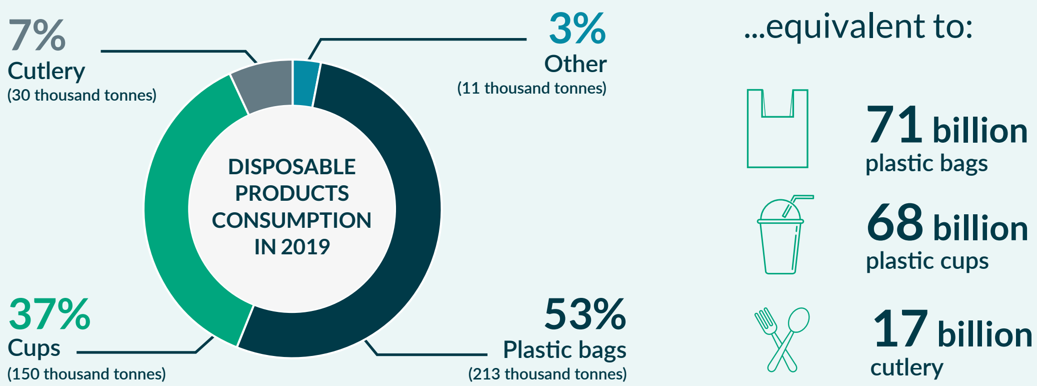
Source: MaxiQuim database (2020) commissioned by Giral Viveiro de Projetos.

Packaging accounts for 40 percent of the total plastics produced from virgin resins, which makes the segment one of the largest markets for Brazil's manufacturing industry.

The most common resin used in single-use plastic items is Polyethylene (PE), including its families of HDPE (high-density polyethylene), LDPE (low-density polyethylene) and LLDPE (linear low-density polyethylene). In 2019, this family of resins accounted for 52.3 percent of single-use plastic products. Polypropylene (PP), PET, Polystyrene (PS) and PVC accounted for 22.3 percent, 18.2 percent, 6.1 percent and 1 percent, respectively.

More than 90 percent of single-use plastics consumed in Brazil are made in the country. Imports are only 4.1 percent, with 3.8 percent for packaging and 0.3 percent for disposable products. Shopping bags accounted for the largest share of disposable products consumed in 2019, with 53 percent, followed by cups (37 percent), utensils such as plates and cutlery (7 percent), and other items such as straws and beverage stirrers, with 3 percent **(FIGURE 6)**.

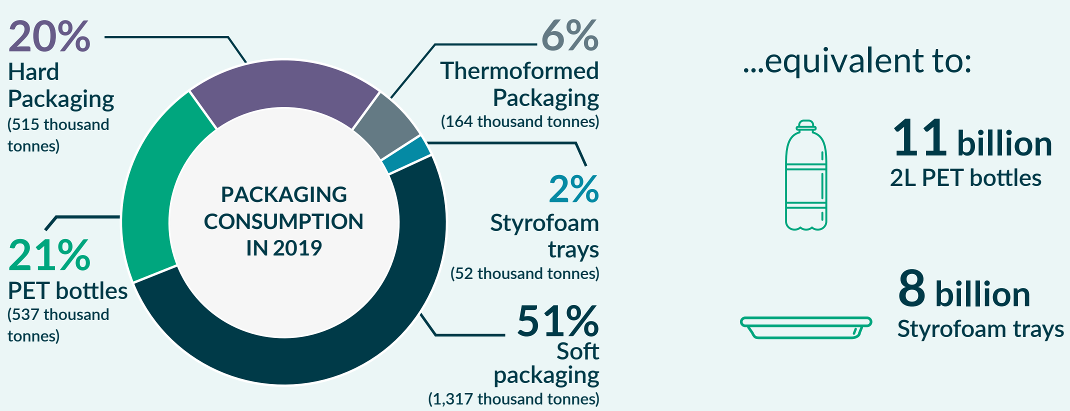
FIGURE 6.
Consumption of disposables in 2019, according to application, and equivalent quantity in units.[1]



Source: MaxiQuim database (2020) commissioned by Giral Viveiro de Projetos.

In the packaging category, with the largest share of the single-use plastics market, flexible packaging accounted for 51 percent of total consumption, followed by PET bottles (21 percent), other rigid packaging (20 percent), thermoformed packaging (7 percent) and foam trays (2 percent).

FIGURE 7.
Consumption of packaging in 2019, by application, and equivalent amount in units



Source: MaxiQuim database (2020) commissioned by Giral Viveiro de Projetos.

When analyzing the equivalent quantity in units (see Annex 1), we obtain a probable value of around 500 billion single-use plastic items consumed per year, which are present in the most diverse applications in our daily lives. Most of these items will remain

accumulated in landfills, dumps and the environment, as it will be presented in the next chapters.

1 More detail on the calculation methodology can be found on Appendix 1.

Photograph: Pixabay

3. PLASTIC WASTE MANAGEMENT

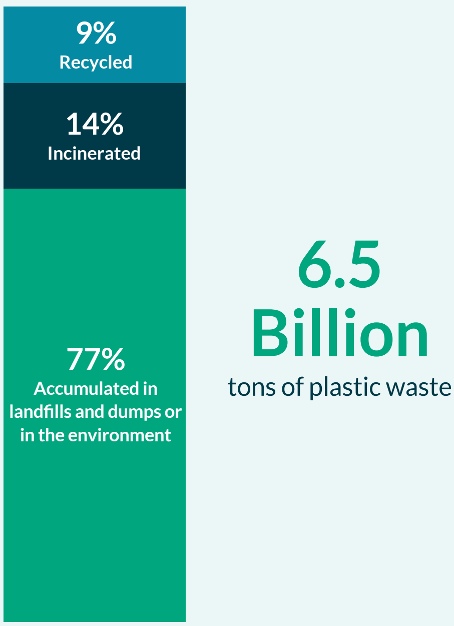
The increasing concentration of plastics discarded and not recovered by production processes is not a new problem. It has been worsening as plastics are produced and consumed, and the real impact of their permanence on soils and oceans is unknown.

After World War II, changes in consumption patterns created a 'disposable' lifestyle, intensified by population growth and urbanization processes. Goods once made to be durable and reusable started to be produced with shorter life cycles to boost consumption and therefore the economy. Food used to be sold in bulk (by weight or measure) or packaged in paper; bottles were reused or returned; people would take their groceries home in their own bags or in brown bags. Today, a variety of these items are produced or packaged in plastics meant to be discarded to make modern life easier.

In the 21st century, the fast pace of modern life required easy ways for consumers, who started demanding frozen and pre-prepared foods, ordering delivery on cell phone applications or consuming food in increasingly smaller and lighter packages. This lifestyle based on convenience and fast consumption is supported by products made of plastic intended for a single use.

The growing demand and the output of single-use items often exceed our capacity for managing plastic waste after use – both locally, nationally, and internationally. While about 29 percent (or 2.7 billion tonnes) of all plastic produced globally between 1950 and 2017 remain in use as durable goods and items such as appliances or construction materials, 71 percent (6.5 billion tonnes) became waste, of which only 9 percent were recycled, 14 percent were incinerated while the remaining 77 percent are in landfills, dumpsites or have been thrown in the environment[31] **(FIGURE 8)**. In other words, 5 billion tonnes of plastic waste are accumulated.

FIGURE 8.
Destination of plastic waste generated between 1950 and 2017



Adapted from: *Single-use plastics – a roadmap for sustainability, UN Environment*, 2018.
source: Geyer, Jambeck, and Law (2017); Jambeck et al. 2015; The Plastic Atlas, 2019

HOW DOES SOLID WASTE MANAGEMENT WORK IN BRAZIL?

In Brazil, solid waste management is governed by Law 12305 of 2010, which sets the National Solid Waste Policy (*Política Nacional dos Resíduos Sólidos*, PNRS)[32] and by Law 11445 of 2007,[33] which establishes the National Guidelines for Basic Sanitation, which was updated by Law 14026 of July 15, 2010.[34] In addition to these, numerous rules apply to solid waste management in Brazil. Federal, state and municipal rules set general guidelines while technical standards and regulations govern specialized work in these processes.

The National Guidelines for Basic Sanitation Act (*Lei de Diretrizes Nacionais para o Saneamento Básico*, LDNSB), regulated by Executive Order 7217/2010, considers public services for urban cleaning and solid waste management as part of basic sanitation, which includes waste collection and transshipment, transportation, sorting for reuse or recycling, treatment and final disposal. These services are provided by cities while the Federal Government transfers funds to be used in the sector.

The LDNSB was updated by the New Regulatory Framework for Basic Sanitation (*Novo Marco Regulatório do Saneamento Básico*, NMRSB), which changed sanitation services management by adopting processes to establish the imperative of capital. The New Framework brought to light the economic feasibility of disposing of non-recyclable waste in landfills, opening up other economically viable options for final disposal in order to avoid damages or risks to public health and safety, and to minimize environmental impacts.

Brazil's National Solid Waste Policy (PNRS) – Law 12305/2010 – sets the principles, goals, tools, guidelines, targets and actions for integrated management and leaves the operationalization of solid waste management to the National Guidelines for Basic Sanitation Act. The PNRS sets priorities for solid waste management: a) non-generation; b) reduction; c) reuse; d) recycling; e) treatment; f) environmentally adequate final disposal of non-recyclable waste, applicable to individuals and companies, whether public or private, that directly or indirectly generate solid waste, and those that engage in actions related to integrated management of solid waste.

The principles of the Law include shared responsibility for products' life cycles, in which the private sector (manufacturers, importers, distributors and traders), the public sector (urban cleaning and solid waste management services) and consumers are responsible for reducing the volume of – recyclable or non-recyclable – solid waste as well as its impacts on the environment and human health.

Two instruments are essential to implement shared responsibility: recyclable garbage collection services, which must be implemented by cities with the participation of waste pickers and recycling cooperatives; and reverse logistics, regulated by Executive Order 7404/2010, in which manufacturers, importers, distributors and traders

"must set and implement reverse logistics systems where consumers return products after use, regardless of urban cleaning and solid waste management services" (Art. 33).

In practice, reverse logistics is intended to reinclude useless products or post-consumption packaging into the production cycle through systems that promote collection, reuse, recycling, treatment and/or final disposal of the waste. These systems must be implemented under sectoral agreements and terms of commitment signed by governments and companies.

Therefore, the National Solid Waste Policy established mandatory implementation of Reverse Logistics Systems (RLS) for pesticides, their waste and their packaging; batteries; tires; lubricating oils, their waste and packaging; fluorescent, sodium/mercury vapor and mixed light lamps; electrical and electronic products and their parts. For products sold in plastic, metal or glass packaging and for other products and packaging, Executive Order 7404/2010 requires technical and economic feasibility studies (TEFS) conducted before the systems are implemented.

When implementing and operationalizing reverse logistics, procedures may be established to purchase used products or packaging as well as collection points for reusable and recyclable waste, with priority to cooperatives or other organizations of recyclable or reusable material pickers.

The responsibility of manufacturers, importers, distributors and commercial establishments for carrying out reverse logistics is proportional to the products they place on the domestic market, according to gradual, intermediate and final targets set in the instrument that mandates the implementation of reverse logistics.

Finally, the National Solid Waste Policy bans the disposal of untreated solid waste – whether it is recyclable or not – on beaches, the sea or any water bodies, disposal of untreated waste in the open (except for mining waste) and their burning in the open or in containers, facilities and equipment not licensed for this purpose, in addition to other destinations and final disposal banned by the State.

PLASTIC WASTE UNDER THE NATIONAL GUIDELINES FOR BASIC SANITATION ACT AND THE NATIONAL SOLID WASTE POLICY

In Brazil, solid waste management is not carried out or planned according to chains of materials (glass, plastics, metals, papers, etc.) as it is the case in European countries. Rather, management is based on their origin, that is, by types of household waste (dry and wet/organic), which in turn is conditioned to management systems adopted by each city. Sectoral Agreements and Terms of Commitment guide households as to the destination to be given to distinct types of materials. While the General Packaging Sectoral Agreement builds capacity and trains cooperatives to receive and process plastic waste, when there are recyclable garbage collection services available, they are public services. Thus, plastic waste is portrayed in public policies as a portion of urban solid waste, with specificities set by Sectoral Agreements.

Both the New Regulatory Framework for Basic Sanitation and the National Solid Waste Policy advocate local or regional planning for household waste, including plastics, and cities are in charge of organizing their sorting, collection and destination. The National Guidelines for Basic Sanitation Act regulates a range of activities, infrastructures and operational facilities for collection, transportation, transshipment, treatment and final destination of household waste – as well as that originating from sweeping and cleaning of public areas and streets (solid waste management). The National Solid Waste Policy, in turn, sets guidelines for integrated management of that waste, waste generators' and public authorities' responsibilities, and the economic instruments applicable. Under both, waste is classified according to its origin.

Thus, plastic waste is considered as municipal solid waste (MSW) when it comes from households (in domestic activities of urban residences), as well as when it is a result of sweeping and cleaning of public places and streets, and other urban cleaning services. Some cities equate waste generated by commercial and service activities to household waste (volume or composition). In these cases, it is collected with – and considered similar to – other types of MSW, sorted for reuse or recycling/composting purposes, and then disposed of by cities through public urban cleaning and solid waste management services.

An important instrument for the management of plastic packaging waste – the largest share of single-use plastics – is the General Packaging Sectoral Agreement. It was signed in 2015 between Brazil's Ministry of the Environment (MMA) and packaging producers and traders, organized as a group of 3,768 companies organized in 22 associations represented by the Packaging Coalition.

The Agreement sets targets and instruments for collection and recycling of packaging in general, aimed at reducing landfill disposal of paper and cardboard, plastic, aluminum, steel and glass – or combinations of these materials – by at least 22 percent by 2018. According to the Agreement, the system should be implemented in two phases. Phase I focuses on collection in the 12 state capitals that hosted the 2014 FIFA World Cup and their metropolitan areas, by strengthening/structuring cooperatives of recyclable and reusable material pickers and by increasing the number of voluntary collection points (VCPs).

Based on the results of Phase I, companies would examine the main obstacles faced and outline strategies for Phase II, which consists of expanding Phase I measures to cities and towns whose number and locations are to be based on criteria presented by companies themselves.

The Coalition pledged to present the implementation plan for Phase II to the Ministry of the Environment within 90 days after the end of Phase I, when targets should be renegotiated. However, as of the date of publication of this report, Phase II had not officially started.

The performance report on Phase I of the reverse logistics system for general packaging[35] (2017) points out that, as a result of the application of R$ 2.8 billion, the material recovery rate was increased by 2.4 percent – from 29.5 percent in 2015 (when the Agreement was signed) to 31.9 percent in 2017. That means a 1-percent increase in the material recovery rate for each R$ 1.2 billion invested. Furthermore, in the same period (2015-2017), a 3-percent reduction (18.3-21.3 percent) was observed in the amount of packaging sent to landfills (the terms of the final environmentally adequate disposal in 'landfills' are not mentioned).

The results show extremely high amounts of money invested for a very low material recovery rate – 0.5 percent per year. This percentage is not even in line with the results presented by the cities in the National Sanitation Information System – Solid Waste component (*Sistema Nacional de Informações sobre Saneamento – Resíduos Sólidos*; SNIS-RS, 2018) – which indicated a 0.1-percent increase in recovery of dry recyclables between 2016 and 2018, with a 1.6-percent reduction in the mass received at solid waste processing units.

Unlike the other Sectoral Agreements signed and implemented, the General Packaging Sectoral Agreement had its effectiveness challenged by the Public Prosecution Service in several states. In the state of Acre, prosecutors sustained that the Agreement was not sufficient and filed public civil lawsuits in the state's 22 cities against the signatory associations, based on non-compliance with the National Solid Waste Policy, since they had not met their legal duties to implement reverse logistics systems. Prosecutors asked for a court injunction ordering the defendants to start immediate collection of all steel, aluminum, paper, cardboard, plastic and glass packaging in each of the municipalities of Acre and providing for their adequate final destination (Public Civil Lawsuit No. 9999999-99.2019.8.01.9999).

The Public Prosecution Service of the State of Paraná (MPPR), through its Support

Photograph: Instituto Mar Urbano / Ricardo Gomes

Center for the Environment Protection Office and the Housing and Urban Planning Office – CAOPMAHU, started an Administrative Procedure (MPPR 0046.19.004508-1) to determine if the legal duty to implement reverse logistics systems was complied with. According to the MPPR, no action, measure or procedure related to reverse logistics for general packaging was found in the State of Paraná – or, if it exists, it is not sufficient.

Furthermore, Civil Investigation 06.2016.00000122-8 of the 26th Office of the Prosecution Service in the State of Mato Grosso do Sul addresses the packaging industry's failure to fulfil its duty to implement reverse logistics, arguing that the situation has caused damage to the environment, the public treasury and recyclable waste pickers. The report says that, by not complying with the law, companies profit from the work of pickers, who have not been paid for sorting the materials – work that companies themselves should do or pay pickers to do.

As can be seen, the General Packaging Sectoral Agreement, as conceived and signed, was not successful in its implementation, and that will have to be taken into account to prevent it from compromising Phase II.

THE PLASTIC RECYCLING CHAIN

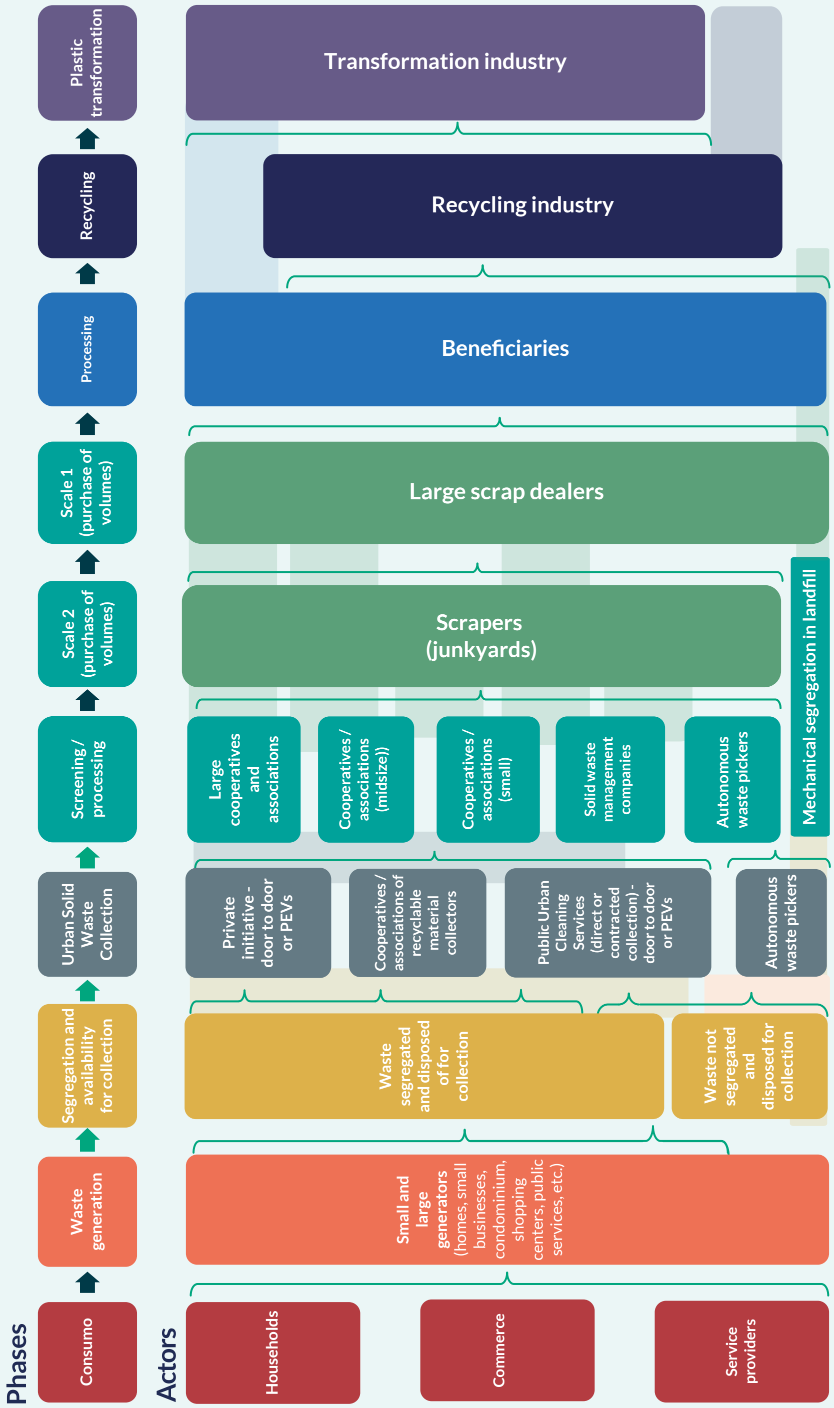
The recycling chain of plastic resulting from municipal solid waste is established as a hierarchy with several stages and multiple actors such as generators and municipal governments providing public urban cleaning and solid waste management services, either directly or under contract; waste pickers' organizations; recyclers; scrap dealers; landfill operators; solid waste management companies – besides, of course, the recycling and processing industry **(FIGURE 9)**.

Raw materials feeding the chain consist mainly of packaging made from different resins, which are usually highly contaminated by organic matter – labels, seals, printing inks, etc. Waste from industrial chips and product processing (post-industrial or pre-consumer plastics) is recycled within the manufacturing industry itself or sold to recyclers.

In the first stage of the recycling chain, MSW plastics are sorted at sources (households, commercial establishments in general and service providers) and then are ready for collection.

An important distinction has to be made between sources in terms of volumes (minor or major generators). These limits are usually defined by cities' laws or established by their Municipal Plans for Integrated Solid Waste Management. This framing will define the responsibilities for managing solid waste. As a rule, it is up to major generators to ensure waste segregation and proper disposal. Examples of large solid waste generators include shopping malls, restaurants, commercial spaces for services provision, condominiums, among others.

FIGURE 9. General scheme of stages in the Plastics Recovery Industry.



PEV Voluntary delivery points

Prepared by: Giral Giral Viveiro de Projetos / Revised by: SMA Ambiental

Major generators may hire services offered by cities, which may be door-to-door collection or Voluntary Collection Points (VCPs), or those provided by private companies. Collection may take place under door-to-door systems or through VCPs, as long as private companies offer these services.

Minor generators are responsible for making segregated waste available for collection services provided by cities through public urban cleaning and solid waste management services. Examples of minor generators are households, small businesses, individual service providers, among others.

If that waste is disposed of together with other MSW, it will end up in landfills or dumps (depending on the option adopted by each city), where it will remain for centuries, with impacts that persist even after these facilities are shut down. However, abandoned waste is one of the biggest concerns. For several reasons, both major and minor generators may abandon their waste on vacant lots, public road intersections, ditches resulting from erosion, abandoned sites, river banks and water courses, etc., and that waste will cause environmental impacts and promote pollution that needs to be tackled.

However, if recyclable waste is segregated and made available for collection, part of it may become recycled resin.

Sorted waste may be collected in several ways:

- By cities, either as direct services provided by their own employees or contracted out. It is carried out by equipment (trucks) that collects segregated recyclable waste from door to door or in public VCPs that are established and operational;
- At VCPs associated with reverse logistics for general packaging whose collection is managed by private companies, as established in the Sectoral Agreement;
- By waste pickers' cooperatives/associations (working on their own or contracted by cities) at specific points or also under the door-to-door system, using different equipment depending on their sizes;
- By informal pickers who collect dry waste – whether it has been sorted or not – and transport it in more precarious equipment (trolleys, carts, bicycles, etc.). They select light materials with higher market value – such as PET, aluminum cans and cleaning product bottles – and single-use plastic waste (disposables, bags and flexible packaging) that are not collected and go to their final destination with other MSW.

Sorting also takes place at landfills, in addition to informal pickers who collect waste at dumpsites.

After collection, the material is received at sorting centers operated by waste pickers' cooperatives or associations, with or without support from cities. The waste collected is sorted and processed manually or mechanically, decontaminated (caps, seals and labels are removed), and then separated by types of resin, colors or manufacturing processes, on tables or conveyor belts. At this stage, a large part of the plastic waste collected ends up being discarded and sent for final disposal – because it is contaminated with food scraps, chemicals and other materials or because their recycling is not possible or economically viable.

During processing, after the materials have been sorted, they are pressed as bales,

weighed and sold directly to the recycling industry or to small intermediaries such as small scrap dealers (junkyards) or large scrap dealers (major facilities). They receive the waste from VCPs and cooperatives/associations and sell it at higher prices to the recycling industry, precisely because of their scale (volumes sold). In the scrap market, both the quality and the volumes of the waste processed and traded are crucial for good business (high added value).

In the recycling industry, in turn, the waste traded goes through a new **processing** stage, which includes grinding, washing to remove dirt and contaminants, drying, and separation of rigid and flexible plastics. In the recycling industry, the plastics already separated will undergo an extrusion process to form granulated products or recycled pellets. Some waste pickers' cooperatives carry out this processing by extruding or granulating the plastics they collect.

As with virgin plastic resins, **the market for recycled resins includes companies that process plastic products**. In most cases, recycled resins are purchased by companies that manufacture plastic products, which, in turn, supply companies in distinct market segments. There are cases where recycled resins are purchased directly by brand owners that pass the raw material on to contracted recyclers.

ENVIRONMENTAL AGENTS: RECYCLABLE WASTE PICKERS

The Waste Pickers Movement (Movimento dos Catadores de Materiais Recicláveis, MNCR) estimates that they are between 800,000 and one million in Brazil – whether their work is formalized or not[1]. They collect 90 percent of everything that is recycled in the country today. Informal waste pickers are an important but often unrecognized part of the waste management system.

Their work contributes to reduce final disposal of reusable waste and consumption of virgin raw material. Nevertheless, they are not paid for the environmental services they provide, and their income depends exclusively on selling the material collected. Since recyclable materials' availability is not always constant or predictable, waste pickers depend on its movements and fluctuations.

In 2018, organizations supported by the National Association of Waste Pickers and Recyclers (Associação Nacional dos Catadores e Catadoras de Materiais Recicláveis, ANCAT) collected an estimated 26,000 tons of plastics – 17 percent of the total revenues generated from waste.[2] Paper/cardboard have the highest collected volume as a result of demand for their recycling.

Waste of lower commercial value does not pay enough for the hours that workers dedicate to collection and sorting. Thus, in practice, cooperatives seek to work with a waste mix consisting primarily of those of higher value.

1 Movimento Nacional dos Catadores de Materiais Recicláveis disponível em http://www.mncr.org.br/sobre-o-mncr/duvidas-frequentes.

2 Anuário da Reciclagem 2017-2018. Disponível em: https://ancat.org.br/wp-content/uploads/2019/09/Anua%CC%81rio-da-Reciclagem.pdf

PLASTIC WASTE GENERATION AND COLLECTION IN BRAZIL

Data on generation, collection, recycling and disposal of plastic waste are highly complex, mainly because of the distinct calculation methodologies and data sources used in Brazil. The sources differ in whether they use primary or secondary data in their respective databanks, in their sample sizes or the different methodological rules they adopt for computing data. The National Sanitation Information System, in its Solid Waste component, is Brazil's only official public database and, therefore, was the main source of information used in this document to describe solid waste management.

In Brazil, the term 'generation' is supported by Law 12305/2010 – the National Solid Waste Policy (Article 3, Paragraph 9), which defines waste generators as individuals and state-owned or private companies whose activities generate solid waste – including consumption. The National Sanitation Information System does not calculate the solid waste generation indicator because it assumes that the mass actually generated should not be much larger than what is collected (urban population), since collection services cover nearly the entire population (98.8 percent).

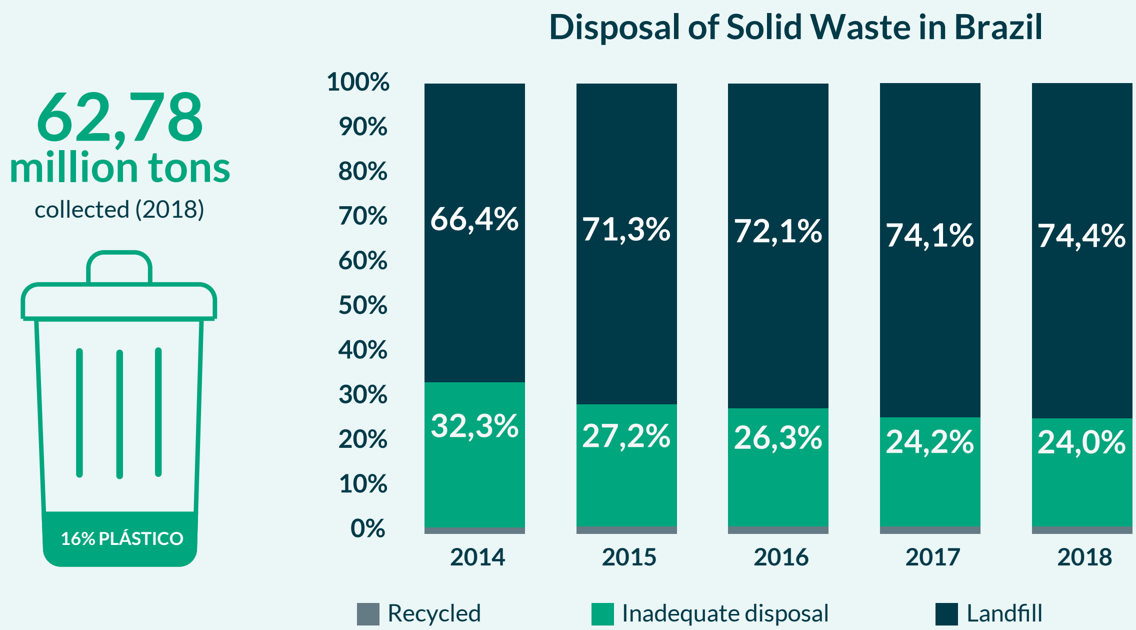
According to the Solid Waste Management Assessment, 62.78 million tonnes of municipal solid waste (MSW) were **collected** in 2018, of which 1.67 million were collected through recyclable waste collection services. As for the total population served by regular or conventional collection services, the collected mass of MSW was 0.96 kg/person/day.[36]

According to the United Nations Environment Program, waste generation in the countries of Latin America and the Caribbean in 2018 was approximately 1.0 kg/person/day.[37] Considering the mass that is collected in Brazil, estimated at 0.96 kg/person/day, and the deficits in collection coverage, it is possible to say that 4 percent of the waste generated is still dispersed, without receiving adequate final destination.

The amount of plastic waste collected can be inferred from the gravimetric characterization of solid waste collected in Brazil. Using the simple average of the gravimetric composition of 93 Brazilian cities surveyed between 1995 and 2008, IPEA estimated that plastics made up 13.5 percent of the solid waste collected in the country.[38] More updated data were not found, but based on the simple average of the gravimetric composition available in eight State Solid Waste Plans – Alagoas (2015),[39] Maranhão (2012),[40] Pernambuco (2010),[41] Piauí (2011),[42] Rio de Janeiro (2013),[43] Rio Grande do Norte (2012)[44] and Santa Catarina (2014),[45] it is estimated that, on average, 16 percent of the mass of household waste are plastics, which matches the data collected by the UN for the countries of Latin America and the Caribbean. **This means that in 2018, around 10.1 million tonnes of plastic waste were collected in Brazil** (FIGURE 10).

FIGURE 10.

Amount of municipal solid waste (MSW) collected in Brazil in 2018 and its final disposal in 2014-2018.



Source: SNIS-RS (2014-2018)

The National Solid Waste Policy (Art. 3) considers reuse, recycling, composting, energy recovery and utilization, and final disposal in landfills as the environmentally adequate final destination. While public services determine the ways for collecting solid waste, it is the market that determines its effective recovery and boosts intermediary activities, especially those carried out by waste pickers and recycling cooperatives.

Most of the waste collected is finally disposed of in landfills (74.4 percent in 2018), or dumpsites (24 percent). According to the National Sanitation Information System – Solid Waste component, final disposal in landfills is still common in most Brazilian cities and towns. Of the 3,468 cities that participated in the Solid Waste Management Assessment, only 607 (17.5 percent) said they dispose of their waste in landfills. The same applies to countries of Latin America and the Caribbean, where 26 percent of the waste generated is still sent to landfills – 12 percent of which is plastic waste.

Recyclable waste collection and recycling have very small shares in the general destination of MSW, and little has improved in recent years, indicating that recyclable waste collection alone could not meet the National Solid Waste Policy's recycling targets. One factor that contributes to such low rates is that 62 percent of Brazilian cities and towns do not have collection systems for recyclable waste.

Formal participation of waste pickers in collection, in partnership with governments, accounted for 30.7 percent of everything collected in 2018. According to the survey, 1,232 waste picker organizations – associations or cooperatives – were identified in the country, distributed throughout 827 cities, including more than 27,000 individuals linked to those organizations.

PLASTIC WASTE RECYCLING

The data available on recycling rates are divergent, mainly due to the different databases and methodologies used in their calculations. According to the SNIS-RS (2018), only 4% of the waste is collected selectively (for every 10 kg made available, only 411 grams are recyclable waste collected).

It indicates that the share of potentially recyclable materials present in the MSW may be 30% and that the recovered mass of dry recyclables in relation to the total mass of dry recyclables present in the MSW is 7.3%. It shows that the recovery rate of recyclable materials (except organic matter) in relation to the total amount of MSW collected is 2.2% and that 22.6% of this portion is attributed to plastics.

Considering the presented indices and the collected mass registered for the year 2018 (62.78 million tons), it is possible to estimate that 1.26 million tons (2.2%) were recovered by selective collection programs, of which 280 thousand tons are waste plastics (22.6%). However, as plastic waste is portrayed in public policies as a portion or fraction of solid urban waste, the SNIS-RS does not include data or information on the effective recycling of these materials - data obtained from the recycling industry - and the data on recoverable mass is approximately 30% of Brazilian municipalities, so it is not representatitve.

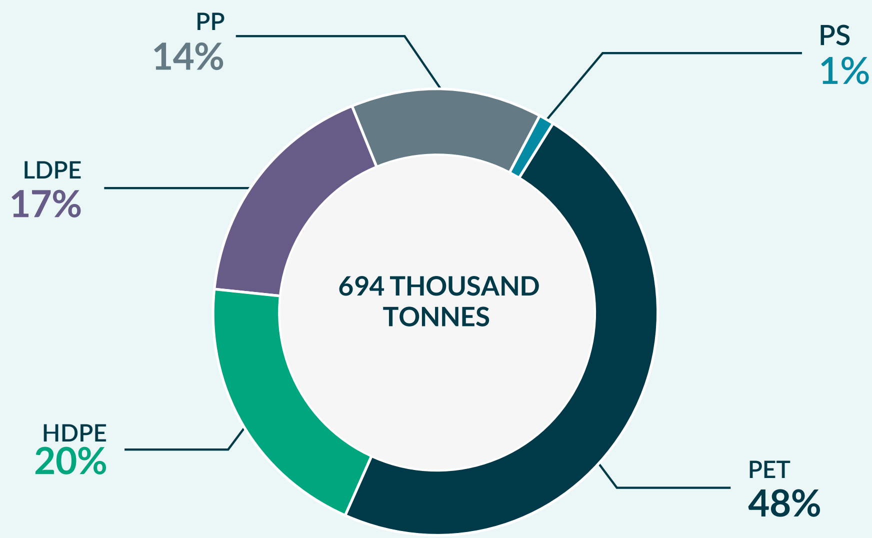
The data from the PICPlast study 46 showed that the country generated a total of 3.4 million tons of plastic waste and that 757 thousand tons of plastic waste were effectively recycled, with a recycling rate of 22.1%. The study does not present the methodology and origin of the waste generation data obtained [46].

In view of the different percentages found in the various available databases, and the differences between the indicators portrayed, it becomes necessary to consolidate a single database that really reflects the conditions for the recovery of plastics in the country, with transparency. Thus, it will be possible to assess the real capacity of industries in the recovery of plastic waste placed on the consumer market, assuming their responsibilities.

Single-use plastic waste, especially packaging, makes up most of the plastic effectively recycled – 694,000 tonnes, or 91.6 percent.

Of the total single-use plastic waste recycled in 2018 (694,000 tonnes), 48 percent were processed into PET, 20 percent into HDPE, 17 percent into LDPE/LLDPE and 14 percent into PP **(FIGURE 11)**.

FIGURE 11.
Shares of single-use materials in the recycling industry in 2018



Source: MaxiQuim database commissioned by the consultancy Giral Viveiro de Projetos and primary research with statistical analysis.

PET and PE resins (HDPE and LLDPE) are highly relevant in secondary material markets. They account for 48 percent and 37 percent of the market, respectively. PET reaches the highest average prices and is the most attractive material for recycling because large amounts of it are available, providing more predictable sales prices to waste pickers. Prices paid for the other resins are highly variable, and revenues from their sales are highly unpredictable. These price variations often follow the variable quality of recyclable waste (color and composition, for example), their purity and the buyer market's interest in them.

In most cases, recycled resin is purchased by companies that process plastic products, which, in turn, supply companies in several market segments. According to the PICPlast study prepared by Maxiquim, when it comes to and not just its single-use plastics sector, distribution is as follows: 18 percent of recycled plastic is used in the Personal Hygiene and Home Cleaning industry; 13 percent in Construction; 10 percent in the Beverages segment; 9 percent in clothing and textiles; and 9 percent in housewares[46].

Historically, the plastic processing industry uses recycled resins by purchasing cheaper raw material to manufacture products that do not require high performance. In other words, for products with lower added value and no advanced technical requirements, the use of recycled resins is more profitable and is therefore chosen over virgin resins made from petrochemicals. As a result, some classic applications for recycled resins with low added value were developed and are now well established. They include garbage bags, broom bristles, household cleaning product containers (bleach), tarpaulin, etc. (TABLE 4).

TABLE 4.
Main markets for products from the single-use plastic recycling industry

RECYCLED RESIN	DEMANDING SECTOR/MARKET	MAIN APPLICATIONS
PET (Poly ethylene terephthalate)	Personal Hygiene and Household Cleaning Products	Product bottles and broom bristles
	Beverages	Bottles
	Clothing/Textiles	Polyester thread, fibers and ropes
	Food	Laminated packaging, jars and bottles
	Automotive	Fibers for seat belts and car mats
	Transport/Industrial	Bending Tape
LLDPE (Linear low-density polyethylene)	Disposable	Garbage bags and bags, bubble wrap
	Agroindustry	Tarpaulins, irrigation hoses
	Personal Hygiene and Household Cleaning	Product lids, flexible secondary packaging
	Construction	Pipes, electrical or other types of conduits, boarding, buckets, sandbags
	Furniture	Stools, tables, chairs, planters, bubble wrap and packaging films
	Industrial	Flexible films for palletizing and unitizing
HDPE (High-density polyethylene)	Construction	Corrugated hoses, pipes, connections.
	Agroindustry	Tarpaulins, pesticide packaging and irrigation hoses
	Personal Hygiene and Household Cleaning	Bottles and secondary packaging
	Manufacturing industry	Drums, boxes, pallets, films
	Housewares	Buckets, basins, shovels, clothespins, hangers, holders
	Disposables	Garbage bags and shopping bags
	Infrastructure	Plastic wood for decks and pergolas, park benches, gardens and leisure areas

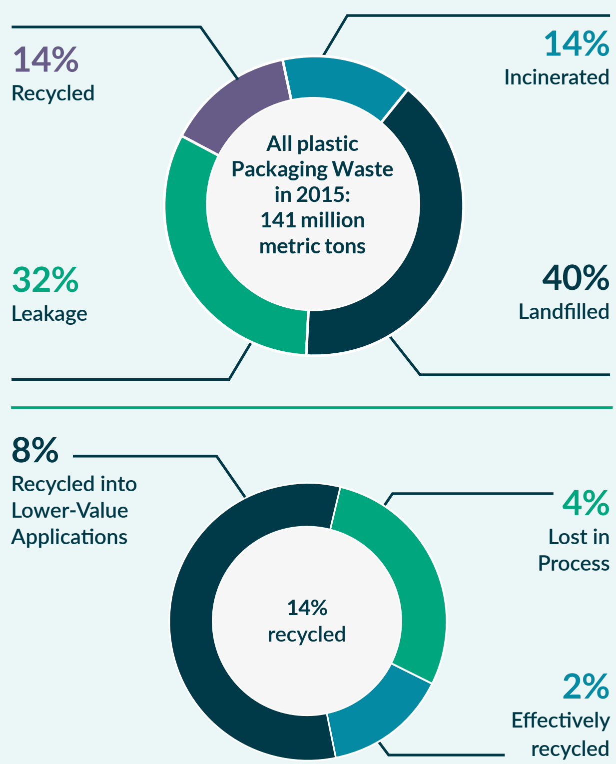
RECYCLED RESIN	DEMANDING SECTOR/MARKET	MAIN APPLICATIONS
	Housewares	Buckets, basins, bins, clothespins
	Toys	Toy cars, dolls, sand buckets and shovels, and secondary packaging
	Automotive	Car parts demanding lower-quality plastics, such as bumpers
PP (polypropylene)	Manufacturing industry	Boxes, pallets, films
	Home appliances & electrical and electronic products	Electronic components demanding lower quality plastics, frames
	Furniture	Tables, chairs, handles
	Construction	Sockets, switches, electricity boxes

Source: MaxiQuim database commissioned by consultancy firm Giral Viveiro de Projetos.

Therefore, most of the plastic that goes to recycling will result in products of lower quality and low added value than the original items. It is the case of several packages, which are usually difficult to recycle due to their materials (multilayer, low-recyclability polymers) or the lack of markets.

On a global scale and using data from 2015, it is estimated that only 14 percent of plastic packaging were sent for recycling[47] **(FIGURE 12)**. The largest share – 72 percent – is not 'recovered' and data confirms that its recycling rates are below expectations. Of the 14 percent of all plastic packaging collected for recycling in 2015, only 2 percent were effectively recycled into products of equal or higher value (upcycled); 4 percent were considered process losses, and 8 percent were processed into lower-value items (downcycled). **Therefore, only 2 percent of the total plastic packaging waste were actually recycled.48**

FIGURE 12.
Destination of plastic packaging waste on a global scale based on plastic packaging waste generated in 2015



Source: World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company, The New Plastics Economy — Rethinking the future of plastics, (2016,http://www.ellenmacarthurfoundation.org/publications)

WHY DO WE RECYCLE SO LITTLE?

In 2018, at least 77,9% of the plastic waste generated in Brazil were not accessed or used by the recycling industry. Countless factors account for the inefficiency of plastic recycling in the country.

The wide range of products and packaging placed on the market, made of several polymers and with distinct recyclability rates turns the management of these materials into a quite complex operation. For example, the variety in properties and compositions of PE and PP waste – including many flexible plastics – makes collection, segregation and recycling difficult. Quality variation in the recycled resins hampers the emergence of markets and restricts their application in new items. These characteristics restrict the demand for waste, making its commercialization difficult or impracticable.

Most single-use plastics will not be recycled simply because they have not been designed to be recycled or require specific handling not planned for in their management. This is the case with disposable products such as cups, plates or cutlery, which were not included in reverse logistics systems and are not segregated at sorting centers because neither waste pickers nor the market is interested in recycling them. For these products, as well as for many other types of packaging, recycling is not a viable option and, as a result, that waste ends up disposed of and polluting.

Measures adopted and practiced for managing solid waste in Brazil have not increased recycling rates or reduced the environmental impacts caused by inadequate disposal.

However, this is not an exclusive problem of waste management; it is also a result of these materials' production and consumption rates, which have not been followed by investments in innovative technologies – from product design and development to consumption, and then to recovery or recycling. **This failure allows large amounts of plastics to be produced and consumed at very low prices, not least because production does not internalize pollution costs and its effects on the environment and human health.**

The industry that makes and uses plastics in its products avoids the responsibility of reducing or redirecting its production and supply. Therefore, all adverse externalities caused by consumption are transferred to society, which is held responsible for the final destination of recyclable waste and has poor alternatives – from household separation and disposal to collection.

THE RECYCLING SECTOR'S INTEREST IN SINGLE-USE PLASTIC MATERIALS

The universe of single-use plastic items is quite diverse, and waste pickers' cooperatives and associations' interest vary according to the distinct types of materials available **(TABLE 5)**. It has to be considered that the market for these materials will always be conditioned to the existence of buyers who operate within a feasible delivery radius (the costs of transporting recyclable materials are quite significant in a large country whose transport networks are restricted to roads).

The informal recycling sector is very good at identifying waste with potential market value. Profit margins are the main criterion for selecting materials, although it also depends on accessibility, convenience and ease of transportation and handling.[49] Therefore, PET is important for recycling in Brazil, especially for its higher market value when compared to other types of waste, but also because of its abundance in municipal solid waste and its easy identification among other MSW components.

TABLE 5.
Waste pickers, their cooperatives and associations' main criteria when searching for recyclable plastic waste.

TERRITORIAL PROXIMITY TO RECYCLABLE WASTE BUYERS	Materials should have a viable destination chain. There must be buyers within an economically viable radius to transport/deliver these materials.
PURITY AND RECYCLABILITY	Contamination is not a problem as long as it does not lower the product's final quality or prevent its handling. If packaging including several types of plastics (multi-material packaging), aluminum seals, paper labels, etc. is placed on the market, its parts must be segregable. Product composition (additives and colors) may affect recyclability.
EASE OF DENSIFICATION/ COMPACTING	It should be as compact/compactable as possible to enable higher productivity when waste pickers transport it (distances covered).
EASY IDENTIFICATION OF THE MATERIAL DURING SORTING	It should be easy to distinguish from other similar materials during processing.
AMOUNT AVAILABLE AND EASE TO FORM LOADS	The time required for material scalability should be as short as possible to require less working capital. Long times require storage areas and more pest control.
PRICE OF RECYCLABLE MATERIAL (POTENTIAL PROFIT MARGIN)	The higher the price of materials, the greater the interest of pickers. Best value obtained by distance covered.

Prepared by: Giral Viveiro de Projetos, based on interviews with recycling cooperatives in South Brazil.

Lightness is intrinsic to all types of plastics, which hampers their sorting and processing by waste pickers' cooperatives and associations when compared to other recyclable materials. Plastic is a preferred choice in several applications, including single-use items, for being a light and resistant material. However, the same characteristics – lightness and resistance – pose challenges to waste pickers in terms of the scale or accumulation of plastic material (mass) and its densification/compacting.

In general, waste pickers' interest in single-use plastic waste depends only on the existence of markets and can be classified into three categories: no interest, low interest and high interest. Some disposable items usually arouse low or no interest from waste pickers because even though potential exist, there are major difficulties to build marketable volumes **(TABLE 6)**.

The exceptions are disposable items made of polypropylene (PP), which can be packed/bundled together with other PP items, and some types of plastic bags – those that do not contain oxo-degradable additives.

TABLE 6.

Classification of waste pickers' interest in disposable products.

DISPOSABLE PRODUCTS		
NO INTEREST	**LOW INTEREST**	**HIGH INTEREST**
Cutlery Straws Beverage stirrers	Bags (with oxo-degradable additives) PS and EPS cups PS plates	Bags (without oxo-degradable additives) PP cups and plates

PS = Polystyrene; EPS = Expanded polystyrene; PP = Polypropylene. Prepared by: Giral Viveiro de Projetos, based on interviews with recycling cooperatives in South Brazil.

In the specific case of plastic bags, adverse effects of oxo-degradable additives on the recycling chain have been observed since the collection stage. Even in small amounts, these additives impact the quality of recycled resins, affecting recyclable material buyers' interest in these bags and reflecting on prices paid to cooperatives.

Furthermore, an extremely relevant point regarding disposables is that **buyers and consequently waste pickers are not interested in smaller and lighter plastic items – such as cutlery, beverage stirrers and straws. These materials are discarded when they arrive at sorting units**. Therefore, they have no value in the recycling chain, do not generate income for waste pickers and overload the sorting work. That reduces productivity when separation is conducted on tables and belts, even burdening waste pickers, who must bear the costs of giving these materials a final destination.

Still with regard to plastic packaging **(TABLE 7)**, clear (colorless) and green PET bottles stand out in waste pickers' interest, together with rigid and flexible mono-material packaging (made with single materials) – both HDPE and PP.

TABLE 7.

Classification of waste pickers' cooperatives' interest in single-use plastic packaging

SINGLE-USE PLASTIC PACKAGING		
NO INTEREST	**LOW INTEREST**	**HIGH INTEREST**
Thermoformed PVC packaging Multilayer PET bottles Multi-material flexible packaging	Foam trays (EPS) PET thermoformed packaging Colored PET bottles (amber, red, blue)	Clear and green PET bottles HDPE flexible packaging HDPE and PP rigid packaging

PVC = polyvinyl chloride; PET = polyethylene terephthalate; EPS = expanded polystyrene; HDPE = high-density polyethylene; PP = polypropylene.
Prepared by: Giral Viveiro de Projetos, based on interviews with recycling cooperatives in Southeast Brazil.

Materials of lower interest include EPS (Styrofoam) foam trays, which are increasingly used in food delivery packaging. In addition to being difficult to aggregate as a result of its lightness, they are usually discarded together with many organic contaminants (food scraps), thus hampering their handling and requiring pest control. A feature of EPS causes waste pickers to lose interest: it demands very specific technology to be recycled. In Brazil, that technology is not widely available and cannot be found in all regions of the country, and therefore a large part of the material discarded is not recycled.

Thermoformed PET packaging raises little interest for being confused with PVC. Telling PET from PVC at sorting belts is not easy. Colored PET bottles – with the exception of green and transparent bottles – also raise little interest among waste pickers due to the small volumes found, which makes their marketing difficult and reduces their value.

Materials that do not raise any interest from waste pickers and their cooperatives include thermoformed PVC packaging, multilayer PET bottles (milk) and flexible multi-material packaging, since the market for their recycling is small. Therefore, the waste's environmentally adequate final destination is determined by the demand for each material (market), which in turn depends on its potential use by the industry.

The same properties that made plastics so useful also turn waste into a management issue and an environmental threat to the health of humans as well as and that of cities and countries. Their durability means that they persist in the environment for centuries, and their low density means that they are easily dispersed by water and wind, until they reach the sea.

Photograph: Instituto Mar Urbano / Ricardo Gomes

Photograph: shutterstock

4. MARINE PLASTIC POLLUTION IN BRASIL

Marine plastic pollution is not a recent problem. The scientific community started documenting its presence in and impacts on the ocean as early as the 1970s,[50] after plastics were found in sea turtles'[51] and birds' digestive tracts in New Zealand and[52] Canada,[53] and in puffins in the North Atlantic.[54] It is also a known fact that, back in the 1970s, fossil fuel industries and plastic manufacturers were aware of the issue and already attended conferences to discuss this problem in the oceans.[55]

Since the 2000s, accumulated evidence has reached alarming levels not only in the scientific community but also in society. News and reports warned of large plastic islands floating in the middle of the ocean.[56] In 2015, a study conducted by a team of scientists led by University of Georgia Professor Jenna Jambeck measured the volume of plastic entering the ocean based on the volume of mismanaged waste, including that disposed of directly in the environment or in uncontrolled landfills and dumps. Between 4.8 and 12.7 million tonnes of plastic reach the marine environment every year – the most adopted figure is 8 million tonnes.[57]

Most of these pollutants dumped into the ocean come from land sources **(FIGURE 13)**[58] and may be transported in several ways:

- **i.** Plastic garbage disposed of directly on streets, beaches and roads will be taken away by water and sewage drainage systems and may be thrown into the sea by outfalls or the sewage network.
- **ii.** Disposal of plastic waste directly into streams and rivers – which will take it to the sea through its watersheds – or into coastal areas such as mangroves, where it may be taken by tides.
- **iii.** Winds and storms may carry the plastic disposed of in dumpsites and controlled landfills to streams or rivers that flow into the ocean.
- **iv.** Manufactured plastic products that may be lost in the process and in transportation.

FIGURE 13.
Main sources and means for plastic waste to get to the sea

HOW DOES PLASTIC REACH THE SEA?

Plastic trash on the streets washes into storm drains that empty the ocean

Wind and rain can transport plastic waste form landfills to streams and rivers

Industrial products can be improperly disposed of or lost during transport

According to data from the latest census conducted by the Brazilian Institute of Geography and Statistics (IBGE), in 2010, about 26.5 percent of the country's population lived on the coast – around 50 million people at the time.[59] The country is crossed by countless rivers forming twelve watersheds that contribute to take plastic waste to the Atlantic Ocean – including the Amazon River Basin, the world's largest watershed.[60] While the country does not have a significant number of landfills close to the sea, as is the case in Southeast Asia, mangroves and streams are taken over by irregular occupation and litter, and countless towns and villages located near water bodies end up receiving large amounts of waste.

Essentially, when plastic reaches the ocean it either floats on the surface or sinks. As it wears out as a result of sunlight or salt water, it breaks down into smaller pieces and is ingested by marine life.[61] It is estimated that at least 5 trillion pieces of plastic are in the ocean[62] **(FIGURE 14)**, of which about 94 percent are below the surface.[63] Most of the plastic that is dispersed consists of pieces too small to be collected in beach cleanups or in high seas. And that figure is only expected to increase as production continues.

FIGURE 14.

Estimated amounts of plastic in the main marine areas, in billions of items. Adapted from Plastic Atlas (2019).

Source: Lebreton et al. (2014)[64]

A study published in *Science – Plastic waste inputs from land into the ocean* (Jambeck et al, 2015) – used 2010 data based on waste generated by coastal populations across the world to estimate the total amount of plastic entering the ocean. Brazil came in 16th place among the 20 countries with the highest volumes of mismanaged plastic waste.[65] **Using the same methodology and based on 2018 data, Brazil was found to contribute 325,000 tonnes of plastic waste to marine pollution by plastics every year (FIGURE 15).**[2]

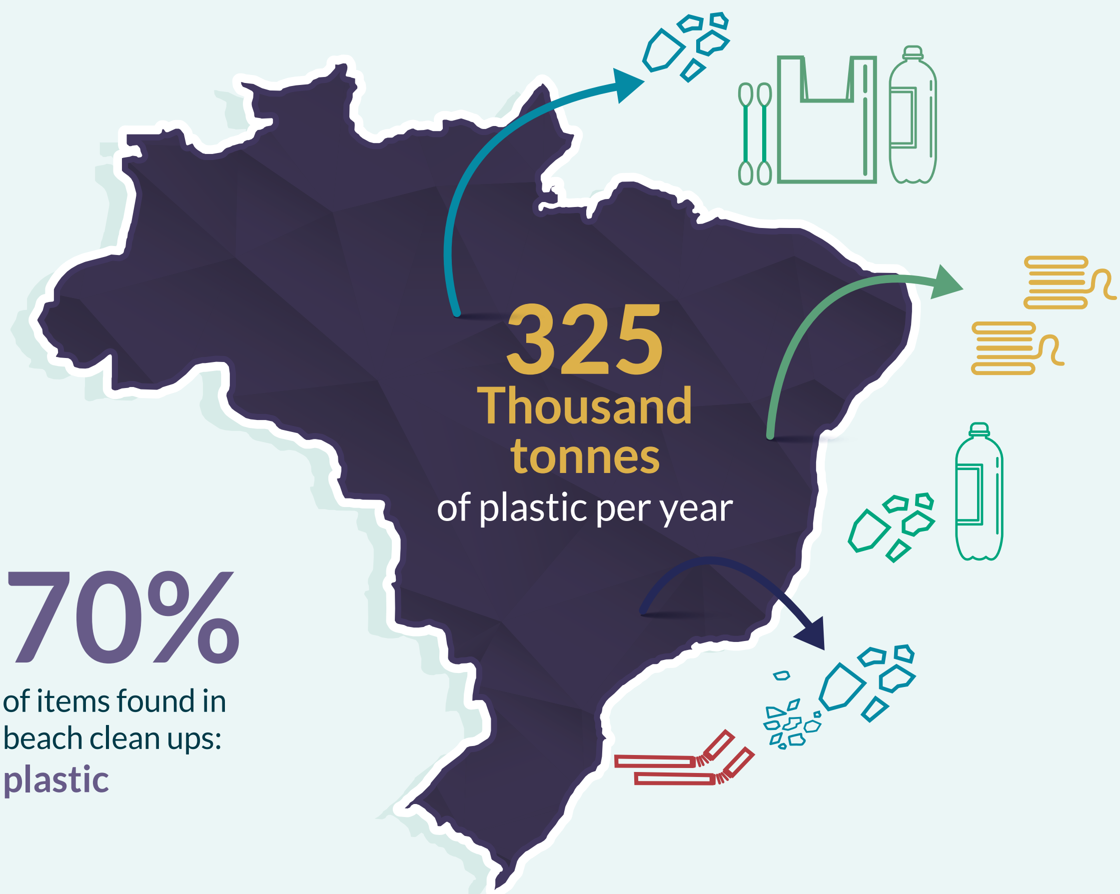
This methodology considers only the part of the population that lives near the coast. However, scientific literature already points out watersheds' role in taking waste to the sea.[66] Thus, inland cities distant more than 50 km from the coast with inadequate waste manage-

2 More information on the calculation methodology can be found in Appendix 1.

ment may also contribute to marine plastic pollution through watersheds draining them. Therefore, the volume of plastic reaching the sea may be even larger.

Disposable plastic products and packaging are at the heart of the debate on ocean pollution because of indisputable evidence that they make up the bulk of marine litter. Beach cleanups around the world have consistently shown that disposable plastics and packaging are the big problem.

FIGURE 15.
Brazil's annual contribution to marine pollution by plastics and the amount of plastic items found in beach cleanups.



Source: Andrades et al (2020) and Jambeck et al (2015)[67]

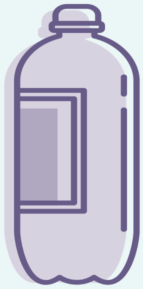
A Brazilian study by Andrades et al. (2020) conducted the first systematic survey of anthropogenic litter on 44 Brazilian beaches distributed throughout the country. Plastic was the most abundant type, followed by cigarette butts and paper.[68] According to the authors, rivers and estuary run-offs were the main drivers of waste accumulation on beaches, confirming the role played by watersheds in taking waste from the country's inland areas to the ocean.

The results of that study indicate that 70 percent of all items found in beach cleanups are plastic, with food packaging as the most common. Data compiled[69] by the Ministry of the Environment confirm that plastic was also the most common type of litter in beach cleanups (46 percent),[3] followed by cigarette butts (36 percent). The remaining 18 percent were glass, wood, paper, rubber and other materials.

In addition to packaging, beverage bottles are also common. Oceana analyzed 2018 data from *Global Data* on soft drink sales to 76 different coastal countries to determine PET bottles pollution by country. Our analysis found that, in 2018, 21-34 billion one-liter PET bottles produced globally by the soft drink industry reached the ocean – or 706,000-1.1 million metric tonnes of plastic bottle waste.[70]

21 to 34 billion
of PET bottles
in the ocean

706 thousand to 1.1 million
metric tons



IMPACTS ON BRAZIL'S MARINE FAUNA

As plastic continues to flood our oceans, the list of marine species affected by debris gets longer. More than 800 species of mammals, seabirds, fish and turtles suffer from the impacts of entanglement in fishing nets or plastic ingestion. Plastic is a pollutant that affects the entire food chain – from zooplankton to marine mammals and birds[71] – and about 90 percent of sea bird and turtle species have already consumed it.[72] Seventeen percent of species affected by such waste were listed as threatened or near-threatened by the International Union for Conservation of Nature.[73]

Other organisms such as corals seem more attracted to microplastics than to their natural nutrition sources.[74] And studies have shown that when corals come into direct contact with plastic fragments **(FIGURE 16)**, their likelihood of getting ill increases from 4 percent to an impressive 89 percent.[75]

3 Considering all plastic items, diapers and menstrual pads, syringes and fishing nets.

FIGURE 16.
A plastic bag tangled in a gorgonian. Rio de Janeiro, 2020.

In Brazil, the Beach Monitoring Projects for the Santos (PMP-BS) and Campos (PMP-BC) Basins – both linked to environmental licensing for Petrobras oil and gas exploitation activities –monitor stranded marine animals in Brazil's South and Southeast regions.[76] They aim is to assess oil production and transportation activities' impact on marine tetrapods in the Pre-Salt layer.

These programs collect a range of information about stranded species of marine birds, turtles and mammals – from their health status to interaction with and ingestion of marine litter. They monitor beaches on a daily basis and provide medical-veterinary care for animals rescued alive and weak, as well as necropsies. All data on strandings are entered and updated daily on an open online platform, which is now considered Brazil's largest source of information about these animals' interaction with plastic waste.

Between 2015 and 2019, 29,010 necropsies were conducted on marine tetrapods (birds, reptiles and marine mammals) found along the beaches of South and Southeast Brazil. Of those, 3,725 individuals, including dolphins, whales, pinnipeds, birds and reptiles, presented some type of *unnatural* debris in their digestive tracts. **About 13 percent had their deaths directly associated with consumption of anthropogenic materials. In other words, one in ten animals that ingested some type of solid waste died as a result of that ingestion. In addition, 85 percent of those that ingested solid waste, including plastic, are threatened species (FIGURE 17).**

FIGURE 17.
Number of individuals and species of mammals, birds and sea turtles that ingested plastic waste in the Southeast and South regions of Brazil in 2015-2019, including threatened species.

MARINE SPECIES THAT HAVE INGESTED LITTER

50% of animals ingested plastic

Source: Aquatic Biota Monitoring Information System/Petrobrás.

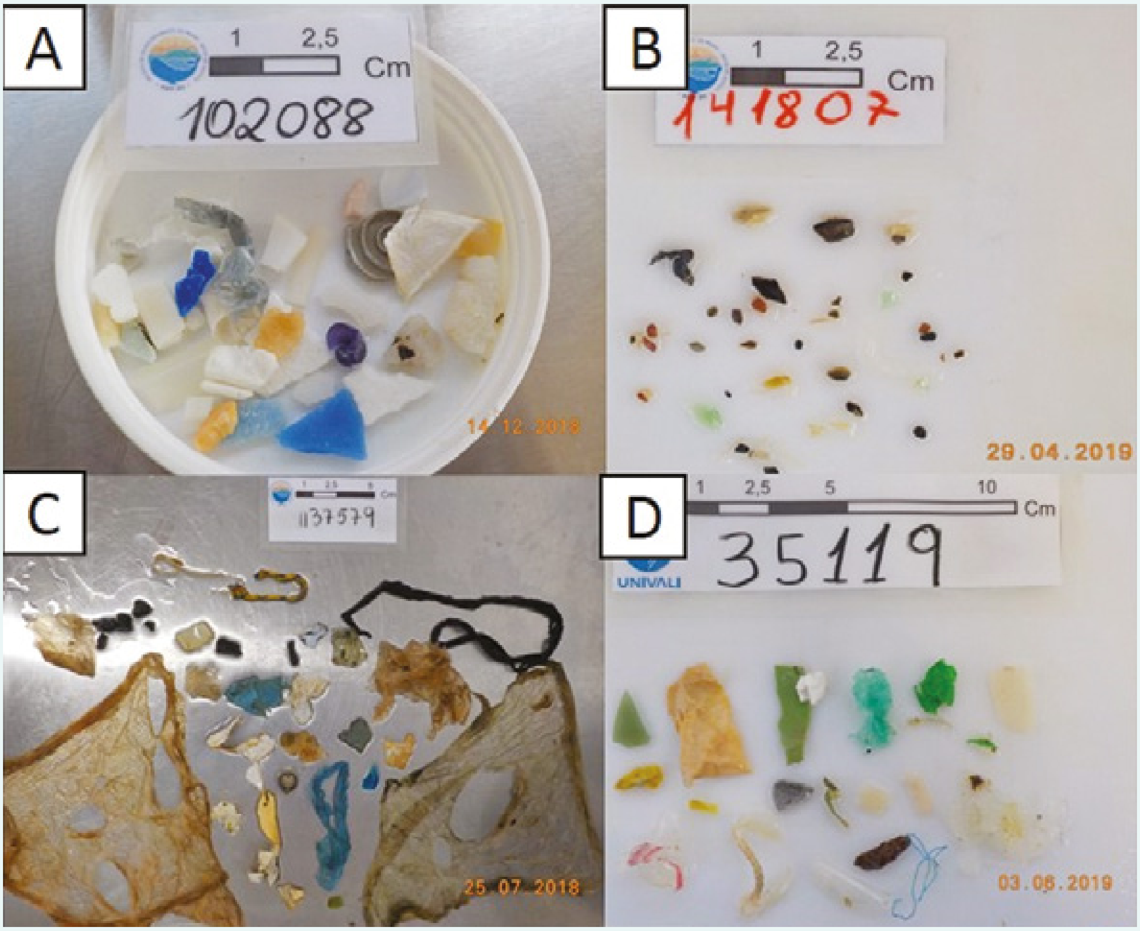
These figures refer only to those animals that were necropsied and found in Southeast and South Brazil. Therefore, the number of species and individuals being impacted by plastic waste ingestion is highly underestimated. The impact of their interaction with litter can be seen in the number of species affected – many of which are threatened, such as Porpoises, whose small population has coastal habits and live close to polluted water sources. Young females are also affected, such as turtles, which have not yet started oviposition, negatively impacting future generations.

The same monitoring procedures pointed out plastic as the anthropogenic material most often found in animals' digestive tracts, described in the screening records of 1,837 specimens including 1,496 reptiles, 295 birds and 46 mammals. Items found included shopping bags, packaging, pen and PET bottle caps, buttons, screw plugs, bracelets, straws, sausage seals, toothpicks, disposable cups and other materials described only as 'plastics or microplastics.' This category also includes all synthetic polymers that originally derived from plastic such as nylon threads, yarns and fishing lines, fishing nets, cleaning sponges, styrofoam, adhesive tapes, electrical tape, synthetic fibers and multifilament cords, etc.

An increasing number of studies point at litter, especially plastic, as the cause of death for marine animals.[77] Analysis of data from the Beach Monitoring Project confirmed this trend. **About half (49.3 percent) of the solid waste found during screening of digestive systems was derived from plastic (FIGURE 18).**

FIGURE 18.

Solid waste found during screening of digestive tracts of necropsied animals. A: Colored rigid plastic and Styrofoam. B: Microplastic and glass fragment. C: Fragments of bags, cap. D: Colored malleable plastic.



Marine species are not only having more contact with human-produced waste but also dying from it. Second only to physical trauma, obstruction of the digestive tract is the first direct effect of its ingestion. When animals' tracts are full, whether of food or other substances such as marine debris, neuroendocrine pathways are activated that give them a sense of satiety. Thus, when their stomachs are filled with plastic waste, they feel full and stop looking for food, resulting in starvation and death.[78] Sublethal effects may also result from bioaccumulation of organic pollutants and toxins, causing genetic changes and impacting future generations, and compromising species' reproduction, growth and longevity rates.[79]

Most of those items float on the surface or remain in the water column. This may help understand why more than 83 percent of animals whose deaths were associated with ingestion of marine litter were turtles. Turtles ingest waste because they mistake it for natural foods such as jellyfish, fish and algae – although animals may eat waste when they are hungry since their food selectivity is low.[80]

Waste has been found in digestive tracts of all species of turtles living in the Brazilian coast **(FIGURE 19).** They include: *Caretta caretta* (loggerhead), *Eretmochelys imbricata* (hawksbill), *Dermochelys coriacea* (leatherback) and *Lepidochelys olivacea* (olive) – all classified as threatened ('Vulnerable,' 'Endangered' or 'Critically Endangered') on the International Union for Conservation of Nature's Red List.[81]

FIGURE 19.
Magellanic penguin (*Spheniscus magellanicus*) and green turtle (*Chelonia mydas*) – both found with plastic bags among their stomach content.

Source: Aquatic Biota Monitoring Information System/Petrobrás

As for birds, of the 32 species found with anthropogenic materials during autopsy, three are threatened. They are: Hooded Pardela (*Pterodroma incerta*), Yellow-Nosed Albatross (*Thalassarche chlororhynchos*) and Southern Royal Albatross (*Diomedea epomophora*). The species with the highest incidence of solid waste were Magellanic penguins (*Spheniscus magellanicus*) and Manx Shearwater (*Puffinus puffinus*), followed by Seagulls (*Larus dominicanus*) and the White-Chinned Petrel (*Procellaria aequinoctialis*). Waste-related death rates of Brown Boobies (*Sula leucogaster*) and Kelp Gulls (*Larus dominicanus*) were high, possibly because they are often on beaches and use the strip of sand as a forage source, so their stranding figures are higher because their carcasses are easily found.

Porpoises (*Pontoporia blainvillei*) and Gray Dolphins (*Sotalia guianensis*) had highest rates of solid waste ingestion. Both are threatened species with coastal habitats where interactions with anthropogenic materials are more common **(FIGURE 20)**.

FIGURE 20.
Two Porpoises (Pontoporia blainvillei), a critically threatened dolphin species with a record of plastic ingestion. The individual in the upper photo was found in Bombinhas on November 11, 2016; the individual in the lower photo was found in in Laguna.

Source: Aquatic Biota Monitoring Information System/Petrobrás

Animals that ingested marine litter and were the focuses of these analyzes were distributed throughout the strip of sand monitored on the southeastern and southern coasts of Brazil (FIGURE 21). While these strandings are numerous and significant in terms of species and details, they represent only a fraction of those taking place all over Brazil's territory. The distribution of occurrences of marine animals ingesting solid waste throughout the monitored strip of sand indicates that the waste is spread over Brazilian waters and that it may be causing more deaths from North to South.

FIGURE 21.
Distribution of marine animals that ingested solid waste, including plastic, on the Southeast and South coasts of Brazil, from 2015 to 2019.

Source: Aquatic Biota Monitoring Information System/Petrobrás.
The interactive map can be accessed at: https://www.google.com/maps/d/embed?mid=1OJ-yZ10po2JM4lIDAIHsb_UDfEAD6j5b

Furthermore, international scientific literature has shown ingestion of plastic fragments by countless species of fish[82] such as Norwegian cod[83] and tuna[84] as well as sharks.[85] Recent studies have also found plastic ingestion in eight commercial species of fish in Southeast and South[86] Brazil and in mussels.[87]

MICROPLASTICS

There is no international standard definition for micro and nanoplastics. **Microplastics** include a wide range of materials made of distinct substances, with varied densities, chemical compositions, shapes and sizes. While there is no scientifically agreed definition, these materials are generally described as plastic particles **less than 5 mm long**. [88] So-called primary microplastics are manufactured to have this size while secondary microplastics are the result of fragmentation of larger pieces.

Nanoplastics, in turn, are even smaller microplastics, less than one micrometer long – the equivalent of a **thousandth of a centimeter (0.0001 centimeter)**. Some have been designed by materials engineering to have this size while others may have originated from excessive fragmentation.[89]

The three main polymers that form microplastics are polyethylene (PE), polypropylene (PP) and polystyrene (PS). About 4 percent of these small plastic fragments' weight are comprised of additives,[90] which can be organic or non-organic substances. Half of them are plasticizers, such as phthalates, but alkylphenols and bisphenol-A (BPA) are also present. Titanium dioxide nanoparticles, as well as barium, sulfur and zinc, are inorganic additives that have also been found.[91]

Since 2010, when research on microplastics in marine fauna started to be conducted, many robust studies have found microplastics in marine animals consumed by humans. So far, research has shown trophic transfer of microplastics between species. In other words, predators (larger fish) that feed on prey containing those particles will also take them in their digestive systems.[92]

Fish and other seafood, such as bivalves, are the most often studied, and Blue Mussels (*Mytilus edulis*) have the largest number of scientific articles dedicated to them. This higher representativeness of marine species in research can be explained by the attention that science has given to pollution of the seas. Fish are also used for chicken and swine feed, but no evidence of microplastics' migration to poultry, beef or pork has been found so far.[93]

RISKS FOR HUMAN HEALTH: WHAT DO WE KNOW?

Our air, food and drinking water is contaminated with microplastics. They have been found in household dust, sea salt, seafood such as fish, oysters and shellfish, honey, beer and even in human feces. But no consensus has been reached on how these microplastics affect our health. What is known for certain is that our exposure to microplastics and their potential risks should increase with the projected growth in plastic production.[94]

We are exposed to microplastics through ingestion, inhalation and possibly by touching and handling plastic materials all day. The main potential routes for contamination include sources from industry (plastics manufacturing) as well as urban (tires) and domestic (cleaning chemical products) life, which transport microplastics to populations through water (rain, rivers, seas, sewage) and air (wind, inhalation).[95]

There are still no conclusive studies or data on human absorption of microplastics, since, according to the World Health Organization, **particles above 150 micrometers are easily excreted by the human organism and therefore would not pose major risks to health**.[96] Particular attention should be paid to particles smaller than that – including nanoplastics – because they can be absorbed by the body. **They are most likely to penetrate deeply into organs and tissues** as happens with other organisms – from fish to mammals.[97]

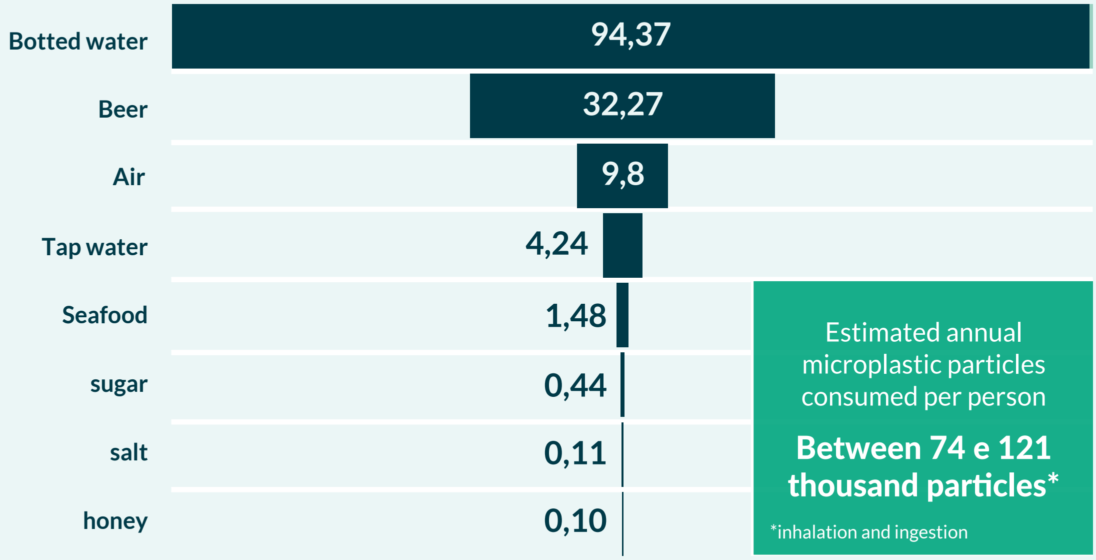
In August 2019, the World Health Organization released the report *Microplastics in drinking-water*,[98] which found and analyzed more than 50 studies about the presence of particles and plastic fibers in natural, drinking and sewage waters in order to assess risks to human health. As microplastics are ubiquitous in the environment, they have also been detected in a wide range of distinct concentrations in sea, residual, fresh and potable water from both bottles and taps **(TABLE 8)**, in addition to several studies that show their presence in the air.[99]

TABLE 8.
Examples of scientific studies on microplastics found in water.

SOURCE	PARTICLE SIZE	CONCENTRATION	MAIN STUDIES
Bottle water	1-100 micrometers	10.4-6,292 particles per liter	Oßmann et al. 2018[100] Schymanski et al., 2018[101] Mason, Welch and Neratko, 2018[102]
Tap water (varied sources)	60-100 micrometers	5.45 particles per liter	Kosuth, Mason and Wattenberg (2018)[103]
Underground sources	10-100 micrometers	0.0007-0.312 particle per liter	Strand et al. 2018[104]

Another study carried out by a group of scientists from the Department of Biology at the University of Victoria, Canada, looked into the amounts of these particles in distinct types of seafood, sugar, salt, alcohol, tap and bottled water and in the air itself. Then it assessed how much of these foods is usually eaten by men, women and children, and found that a person may be eating 74,000-121,000 plastic particles on average each year[105] **(FIGURE 22)**.

FIGURE 22.
Amount of microplastics found in items consumed by humans and estimated annual consumption per person



Source: Kieran Cox (2019).

A study conducted by the Division of Gastroenterology and Hepatology at the Medical University of Vienna, Austria, was widely publicized and commented on in the global press. It found microplastic particles in human stool of individuals from eight different countries: Finland, Italy, Japan, the Netherlands, Poland, Russia, the United Kingdom and Austria. All of them had contact with food packaged in plastic and six ate fish and seafood during the experiment's observation period. About 95 percent of the stool contained 20 microplastic particles per 10 grams. The most common substances were polypropylene (PP), Polyethylene terephthalate (PET), Polystyrene (PS) and Polyethylene (PE). The study did not assess amounts or possible concentrations or contamination by components and additives.[106]

Scientists are also concerned about the chemical risks of microparticles being ingested or inhaled by humans and animals. Microplastics are capable of accumulating highly toxic substances such as persistent organic pollutants (POP), including polychlorinated biphenyls, known as PCBs, polycyclic aromatic hydrocarbons (PAH) and pesticides. That is why they are used as markers in environmental monitoring.[107]

The toxicity of microplastics and associated chemical components depends on a wide range of properties and conditions that include concentration and chemical composition. The toxic damage caused by inhaled particles is better understood than that of ingested particles. The destination and transportation of these fibers after ingestion have not been sufficiently studied by science. To date, most toxicological tests on microplastics have focused on water organisms, and no epidemiological studies on microplastics ingested by humans were found.

What we know so far is that we are ingesting and inhaling microplastics by different means, including food, water or air. The scientific community has not yet established the concentration required in the human digestive system to affect our health. Toxicological studies that explore the dose-effect relationship – whether that effect is chronic or acute – take time to be performed. While there is not enough data to draw more concrete conclusions about nanoparticles' toxicity, no reliable information suggests that this concern should be ruled ot.

Photograph: Depositphotos

5. SOLUTIONS FOR A PLASTIC-FREE OCEAN

AN EXERCISE IN FUTILITY: FALSE SOLUTIONS FOR THE PLASTIC CRISIS

Single-use plastic is a growing threat to our oceans. Despite abundant evidence and scientific studies on the irreversible damage that plastic may cause to the environment and people, this crisis is far from over. In fact, plastic production is projected to significantly increase and flood markets – and oceans – in the coming years.

Collecting recyclable materials or sending them for recycling is not enough to stop this flow of pollution. The amount of plastics has to be reduced at the sources. Companies need to step up and take on their role in this vital cycle, to reduce the amount of disposable plastics by offering plastic-free options to their customers.

Instead, governments and companies are promoting false solutions that do not effectively interrupt the pollution flow and do not reduce the amount of single-use plastics consumed. They include recycling, energy recovery from waste and replacement of conventional plastic with biodegradable or oxo-biodegradable types, leaving consumers or users with the exclusive responsibility for any efforts to contain pollution – which is not enough.

THE MYTH OF RECYCLING AS A SOLUTION

While recycling is an important step in managing solid waste that has already been produced, it is not economically viable or technologically feasible for many plastic items. Only 9 percent of all plastic waste ever produced in the world has been recycled. In Brazil, recycling rates are divergent, but point out that at least 77.9% of the plastic waste is accumulated in landfills, dumps or dispersed in the environment.

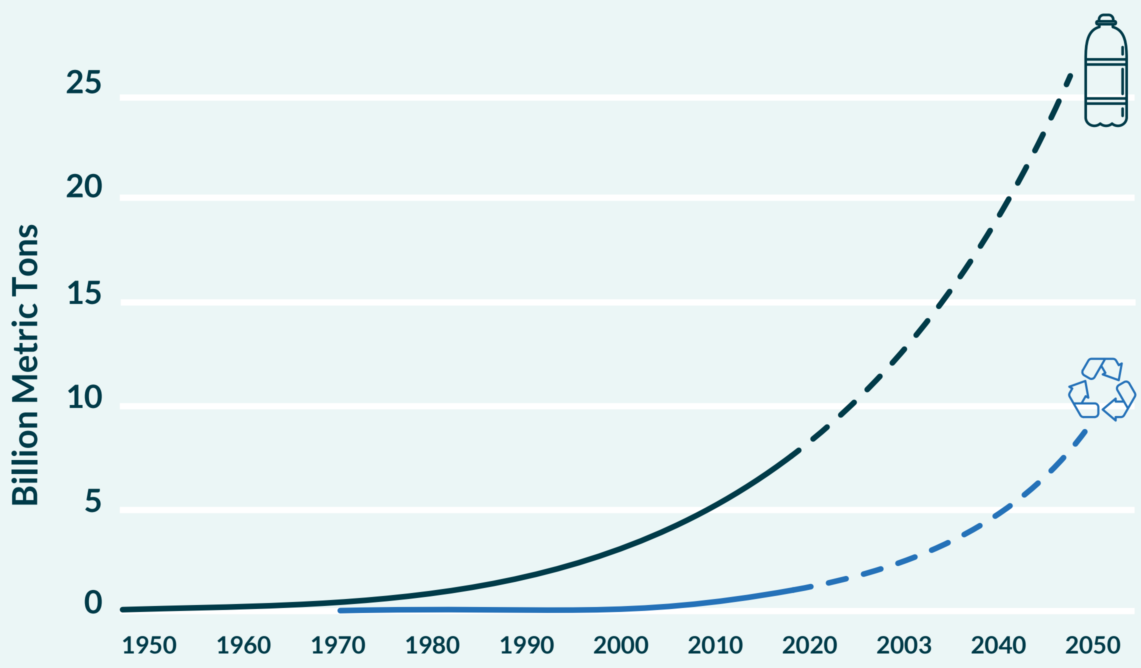
Recycling does not prevent plastic waste disposal – it only transfers responsibilities for curbing that pollution. Unlike glass and aluminum, which can be recycled endless times without losing quality – they are 100 percent recyclable – plastic can only be recycled once or twice before it becomes useless. This is because it is sensitive to heat and, when subjected to thermal and mechanical recycling processes, its long, flexible molecules break irreversibly. Therefore, most of the plastic that undergoes recycling will result in products of lower quality and less value than the original items.

The wide range of plastic products placed on the market makes the management of these materials quite complex. Both their collection and their final destination depend on the type of polymer used in manufacturing, efficiency of segregation, demand and the existence of recycling plants, recyclability limits for these materials, provision and efficiency of public urban cleaning and solid waste management services in Brazilian cities (e.g. regular collection, recyclables collection, reverse logistics), among other factors that are relevant and just as difficult to control. Factors such as lack of identification of plastic types, small dimensions, pigmentation, dirt and contaminants make it difficult to sort, segregate and recycle these materials.

If recycling rates are already low for plastic items of high interest, such as PET, for disposable products such as cutlery, bags, plates and cups, with no value for the recycling market, recycling rates are nearly zero.

While it is possible to overcome all the challenges inherent in waste management in Brazilian cities and towns, and increase recycling rates, management alone will not keep up with the pace and volume of plastic waste introduction in the consumer market (FIGURE 23). Investments in and subsidies for recycling are not on the same scale as investments in plastic production, which makes it difficult for recycled resins to compete with virgin resins.

FIGURE 23.
Projected amount of plastic generated and recycled on a global scale by 2050



Source: Geyer R, Jambeck JR and Law KL (2017).[108]

ENERGY RECOVERY

Energy recovery from municipal solid waste is provided for in Articles 3 and 9 of the National Solid Waste Policy, which considers reuse, recycling, composting, energy recovery and utilization or other destinations admitted by relevant agencies as environmentally adequate final disposal of waste, "as long as their technical and environmental feasibility has been proven and a toxic gas emission monitoring program approved by the environmental agency is in place."[109] **It is the last option among waste management priorities, when non-generation, reduction, reuse, recycling and treating have been ruled out.**

Even though it is provided for by law, energy recovery is still rare in Brazil due to difficulties related to its technical and environmental viability. The choice for this technology should follow the concept of best available technique and, above all, meet legal emission standards and make sure that there are industrial waste landfills where process waste (ashes) can be disposed of.

However, the new legal framework for basic sanitation approved in 2020 recommends its adoption as long as effectiveness and efficiency requirements are met, considering the payment capacity of populations and users involved and also observing technical and operational standards in order to avoid damage or risk to public health and safety and to minimize environmental impacts.[110]

Incineration

In direct combustion – incineration or thermo-valorization – energy is recovered from solid waste by using the heat generated in the burning process. Its full operation requires high energy consumption, so its adoption may not be viable. It also requires high technical capacity for monitoring and controlling emissions and, above all, huge scales in consumption of waste with high calorific value such as plastics.

Using this technology is controversial because pollutants may be released into the atmosphere, especially dioxins and furans, heavy metals (Hg, Pb and Cd), particulate matter and acid gases (HCl, HF, SO2 and N2O), which have been shown to affect public health and the environment.

In contrast to this concern, restrictive technologies aimed at cleaning out gases and harmful emissions can be adopted with substantial increase in the plants' investment, operation and maintenance costs.

However, not even the latest filters and equipment for controlling air pollution will prevent all pollutants from being released into the air. Therefore, energy recovery is a 'solution' whose installation, operation and maintenance costs are high, and studies show that the energy generated through this process is less cost-effective than nuclear energy (per KW). Therefore, such investments could be used to develop really renewable and sustainable solutions to curb pollution.

Plastics, which make up 16 percent of MSW, have high calorific value because they are derived from petroleum and fossil mineral gas, which makes them materials of high interest for this sector. Their large-scale – industrial scale – combustion converts plastic waste into air pollution through toxic emissions such as dioxins and furans, which are carcinogens, and heavy metals such as mercury, cadmium and lead. In addition to toxic gases, its burning also releases greenhouse gases that contribute to climate change.

The processes' limitations show that we have to move towards a system that involves waste reduction, reuse and packaging redesign or replacement, composting, in addition to significant and permanent changes in the population's consumption habits. **The most effective way to reduce the damage caused by plastic products after the end of their life cycles is to reduce their production flow at the source. The first step should be eliminating single-use plastics that are known to create problems and are unnecessary in these new times.**

BIOPLASTICS

Bioplastics or biopolymers have been 'celebrated' as a more sustainable version of plastic. Since there is no standard definition for these terms, they may cause confusion. According to European Bioplastics, they are broad terms that may refer to both the renewable origin of these materials and their degradability. Thus, **a material is considered as bioplastic if it has a renewable origin, if it is biodegradable, or both**.

Biodegradation is the process of complete or partial decomposition of a polymer, in which it is transformed into water, carbon dioxide or methane, energy and new biomass by the action of microorganisms such as bacteria or fungi. 'Compostable,' in turn, is often used to speak of the end of bioplastics' life cycles. It refers to biodegradation under specific conditions in aerobic or anaerobic environments, that is, with or without oxygen.

As no clear definition is available for minimum percentages of raw material from renewable sources contained in these materials so they can be considered bioplastics, low percentages of renewable raw materials required in their composition may lead consumers to false choices and only boost the greenwashing market rather than curbing pollution.

Distinct international standards define whether a material or product can be considered biodegradable or compostable. Typically, degradation needs to happen within a timescale measured in weeks or months. In Brazil, plastics are regulated by ABNT's (the Brazilian Association of Technical Standards) 15.448-2:2008 standard.

Non-degradable bioplastic

Some plastics are produced from renewable biomass – such as sugar cane or corn – or from a combination of renewable biomass and oil sources, but do not degrade. This is the case, for example, of the green polyethylene (PE) *I'm green™*, developed by Brazilian company Braskem. Made from sugarcane ethanol, this biopolymer is similar to conventional fossil plastic in its properties, applications and decomposition time. Thus, if not correctly used and disposed of, these plastics will cause the same pollution problems as those of fossil origin.

Biodegradable bioplastic

Biodegradable plastic can be produced from renewable and non-renewable raw materials, being designed to decompose into natural substances with help from microorganisms. The most commonly produced biopolymers are polylactic acid (PLA) and polyhydroxyalkanoate

(PHA). PLA is considered the most prominent example of biodegradable bioplastic due to its mechanical properties comparable to polystyrene (PS) and PET (poly ethylene terephthalate).

PHA (polyhydroxyalkanoate), in turn, accounts for 6 percent of the world's production of bioplastics[111] and can be used to manufacture rigid packaging, containers, bags, trays, cups, cutlery and plates.

Since the material is produced by fermentation of sugars from carbohydrates such as corn starch or sugarcane, it is biodegradable by industrial-scale composting, since its decomposition mainly requires controlled temperatures. Without these conditions, compostable plastics end up in landfills, dumps or dispersed in the environment like any other type of waste.[112]

In Brazil, industrial-scale composting plants are not yet a reality, which prevents biodegradable plastics such as PLA from being adequately treated. In the absence of large-scale plants, compostable plastics such as PHA would need to be treated by consumers in their homes, which is unlikely to occur even in the medium term, since it is not a widespread, consolidated practice and consequently it is not adopted by the population.

OXO-BIODEGRADABLE PLASTICS

Oxo-degradable polymers are sold in Brazil and in several countries around the world with an appeal to their biodegradability, which is false. These plastics receive oxo-degradable additives to accelerate their oxidative degradation (by oxygen). Their erosion is fast, but degradation is not complete, which generates microplastics that pose a threat to the oceans and other natural ecosystems. Another serious problem is that most additives contain transition metals, which can be highly toxic to the environment[1].

The European Union has banned the use of oxo-degradables. In Brazil, their use is condemned by the Brazilian Plastic Industry Association, which signed an Ellen MacArthur Foundation petition asking for a ban on their use in plastic packaging and products worldwide[2]*. According to Abiplast, there is no federal regulation prohibiting the use of these additives in the country. There are, however, laws and bills that ban specific products containing oxo-degradable additives.*

In the city of São Paulo, Law 17261, sanctioned in January 2020, prohibits supply of commercial cups, plates, cutlery, beverage stirrers and sticks for disposable plastic balloons, including oxo-degradable ones. The law was expected to come into force as of January 1, 2021 but is currently suspended by São Paulo Justice.

1 *ABIPLAST. Bioplástico, oxidegradável e biodegradável. Qual a diferença entre esses plásticos. Publicado em 11 de setembro de 2018.*

2 *VASCONCELOS, Y. Reutilizar, substituir, degradar. Revista Pesquisa Fapesp. Edição 281. Publicado em julho de 2019*

In addition, the same challenges faced when recycling small pieces of single-use plastic – such as size, low economic value and high collection costs – also apply to biodegradable or compostable materials, which require separation, collection and transportation to composting plants that provide the necessary conditions for their complete degradation. It should be noted that there are no recycling systems operating in Brazil to treat alternative types of plastic, namely biodegradable and compostable ones.

INTERNATIONAL LEGISLATION FOR REDUCING SINGLE-USE PLASTICS

Governments around the world have recognized the seriousness of pollution and passed laws and measures to reduce single-use plastics. Economic blocks and more than 40 countries have already passed laws restricting or banning them and setting high recycling targets.

These policies usually focus on the most common litter items found in beach cleanups: utensils, food packaging, plastic bottles and caps, shopping bags, other plastic bags or Styrofoam containers. Since all of these items are used once and then thrown away, a logical starting point is to target public policies for single-use plastic items.

Policies such as bans, taxes, packaging return systems and extended producer responsibility can be effective in encouraging reduction of single-use plastic. Some policies aim to encourage adequate disposal and thus change consumer behavior. Others set mandatory recycling or collection targets for producers or establish that manufacturers must ensure that their products are easily recyclable, pay the costs of cleaning the waste they produce, and raise awareness about adequate disposal and the potential harm caused by mismanaged waste.

The following are three detailed examples of adequate legislation on the use of single-use plastics (SUP):

THE EUROPEAN UNION	
Regulated SUP	Food containers, beverage cups, cotton swabs, cutlery, plates, straws, beverage stirrers, balloon sticks, beverage containers, menstrual pads, tampons and tampon applicators, wet wipes, balloons, wrappers and packaging, filter tobacco products, oxo-degradable plastic products and expanded polystyrene.
Instrument	EU Directive[113]

The European Union (EU) adopted a directive regulating certain single-use plastic products to prevent and reduce their impact on the environment, in particular aquatic environments and life, and on human health, as well as to promote the transition to a circular economy with innovative and sustainable business models, products and materials, thus also contributing to the efficient functioning of the internal market (Article 1).

This proposal appears as a complement to the efforts already undertaken by the EU in Strategy for Plastics,[114] correcting some gaps found in the various European legislations and reinforcing the systemic and innovative approach to promote substitutes of biological origin that offer new opportunities for companies and provide comfort to consumers. The European proposal establishes an obligation for Member States to take measures such as:

Consumption reduction: Reduction of at least 25 percent in consumption of food containers with or without covers, cups for beverages and other products by 2025. These measures may include ensuring that reusable products are available to final consumers at points of sale or that these products are taxed. In any case, countries must develop national plans including reduction measures and quantitative targets (Article 4).

Market restrictions: Wide ban on introduction of cotton bud sticks, cutlery (forks, knives, spoons, chopsticks), plates, straws, beverage stirrers, sticks to be attached to and to support balloons, oxo-biodegradable plastic products, containers for food and beverages made of expanded polystyrene. In addition, they must ensure that, by 2025, beverage bottles will only be marketed if they include at least 35 percent recycled content and/or are recyclable (Article 6).

Extended producer responsibility: It establishes extended producer responsibility schemes for the following products listed in Part E of Annex I to the Directive:

- Food containers, such as boxes, with or without covers, used for the purpose of storing food for immediate consumption from the receptacle, either on the spot or as takeaway, without any further preparation; for example, those used for fast food, with the exception beverage containers, plates and packaging and food wrappers.
- Wrappers and packages made of flexible material that contain food intended for immediate consumption in the wrapper itself, without any further preparation.
- Beverage containers, that is, packaging for liquids, such as beverage bottles, including their lids.
- Cups for beverages.
- Tobacco products with filters and filters marketed for use in combination with tobacco products.
- Wet wipes, pre-wetted for personal care, for domestic and industrial use.
- Balloons, except those for industrial and professional uses and applications, which are not distributed to consumers.
- Fishing gear containing plastic. Member States must guarantee the collection of at least 50 percent of fishing gear that contains plastic by 2025 and recycle at least 15 percent of that gear in the same year.

This means that manufacturers must bear the costs of collecting, transporting and treating the waste generated by these products, which will include the costs of cleaning the garbage and awareness-raising measures (Article 8).

COSTA RICA	
Regulated SUP	Plastic foam (Styrofoam) packaging, food packaging and disposable, non-recyclable, non-compostable cutlery, and straws, spoons, forks, knives, and plastic utensils.
Instrument	National Strategy

In 2017, Costa Rica published its 'National Strategy to replace single-use plastic with renewable and compostable alternatives'[115] ('the strategy'), in order to help solving the problem of pollution generated by these plastics in watersheds of the Greater Metropolitan and Pacific Area of Costa Rica. The strategy is part of the 'National Plan for Integrated Waste Management 2016-2021,' the 'National Policy for Integrated Waste Management 2010-2021' and the 'National Strategy for Waste Separation, Recovery and Valorization.'

This strategy emerged as a voluntary and collective process including the public sector (central municipal government), the private sector (industry, commerce) and civil society as a whole. Its impacts include: 1) reducing the presence of SUP in Costa Rica's rivers and beaches; 2) reducing the presence of SPU in waste recovery centers; and 3) driving economic growth in the renewable and compostable alternatives industry.

To achieve the above, the strategy aims to disseminate and monitor voluntary commitments by institutions, city governments, companies and organizations grouped around five strategic lines that, in turn, set targets to be achieved by 2021, compliance indicators and baselines to which comparisons will be made. The five lines are:

1. **Municipal incentives to replace single-use plastics with renewable and compostable alternatives** whose target is that 80 percent of cantons[4] should have their license regulations modified to include fees that discourage SPU consumption and encourage their replacement with renewable and compostable alternatives by 2021.
2. **Institutional policies and guidelines for suppliers to replace purchases of single-use plastic with renewable and compostable alternatives.** The target is that 70 percent of public institutions in Costa Rica adopt internal supply policies that discourage SPU purchases and facilitate acquisition of renewable and compostable alternatives by 2021.
3. **Promoting the replacement of single-use plastic products with renewable and compostable alternatives among traders, wholesalers and retailers across the country**, setting a target according to which 80 percent of the members of the National Chamber of Commerce and Similar Activities (Canacodea) will have replaced SPU with renewable and compostable alternatives by 2021.
4. **Encouraging research and development by specialized laboratories, private companies, universities, technical colleges and training centers to create and design packaging, bags and containers for solid and liquid products that replace SPU with renewable and compostable alternatives;** its sets the target of having at least ten new products launched on the market as renewable and compostable alternatives by 2021.
5. **Encouraging investment in productive projects that contribute to replace SPU with renewable and compostable alternatives;** it sets the target of having 20 new enterprises (or reconversions) that contribute to replace SPU with renewable or compostable alternatives by 2021.

ANTIGUA AND BARBUDA	
Regulated SUP	Expanded polystyrene containers, plastic utensils (spoons, forks, knives and straws), trays for fruit, meat and vegetables, plastic egg cartons and polystyrene foam packaging
Instrument	Law

The government of Antigua and Barbuda was one of the first to ban importation and use of polystyrene foam products for food as of July 1, 2017, under the 2017 External Trade (Import Prohibition) Order, which provided for a three-stage ban:[116]

4 A canton is a subnational territorial unit. The seven provinces of the Republic of Costa Rica are divided into 82 cantons.

Stage 1 (July 1-December 1, 2017): Styrofoam clamshell, hinge and hotdog containers and all other containers made of EPS (Expanded Polystyrene Styrofoam) to include bowls, plates, hot and cold beverage cups, lids and caps will be banned from entering the country. The government also encourages the use of PLA Cornstarch products to replace Plastic PET bowls.

Stage 2 (January 1-June 30, 2018): Ban on importation and use of utensils (plastic spoons, forks, knives and straws), fruit trays, meat trays, vegetable trays and egg cartons.

Stage 3 (July 1, 2018-1, 2019): Ban on importation and use of 'naked' Styrofoam coolers.

The law established a list of government-approved alternatives for substitution, consisting of: Bagasse (sugarcane), PLA Cornstarch (NON-GMO), Bamboo, Wheat Straw, Cardboard/Paper, Areca Palm, Potato Starch. These products will be exempt from taxes. In any case, importers must present the corresponding certificates from manufacturers and accredited laboratories. In addition, the law provided for a six-month 'phasing out' period to deplete stock of 'banned' products during each stage, to be followed by monitoring and confiscation if needed.

The Styrofoam Ban extends to all businesses within the food service industry in Antigua and Barbuda, including the catering industry, food vendors, large and small supermarkets and grocery stores. However, airline carriers, private airline charters and passenger cruise vessels shall be exempted until further notice.

Finally, an analysis of national policies shows that seven out of the 20 countries with the largest contributions to marine plastic pollution still do not have legal frameworks to significantly reduce or ban single-use plastics. They are the Philippines, Thailand, Egypt, Algeria, Myanmar, North Korea and Brazil.[117] Therefore, the Brazilian government must urgently approve robust legislation to reduce its contribution to plastic pollution in the oceans.

REDUCE, REUSE, RETURN

The problems caused by excess and misuse of fossil polymers have also led to the search for more environmentally friendly materials and changes in consumption patterns and product design. In replacing plastic to produce disposable packaging and utensils, well-known raw materials such as paper and aluminum are gaining ground, and unusual and innovative ones stand out, such as cups made from cassava pulp, seaweed-based packaging and sugarcane bagasse plates.

Companies adjust their practices, and new businesses are created to operate under a circular economy logic. **According to the Ellen MacArthur Foundation, the circular economy is an alternative to the 'take-waste-make' linear economic model. The model decouples economic activity from consumption of finite resources and eliminates waste from the system on principle. Its three basic pillars are: to eliminate waste and pollution from the beginning, to keep products and materials in use and to regenerate natural systems.**[118]

Following the principles of circular economy, an increasing number of businesses and brands offer bulk sales, that is, products that have not been prepackaged. In addition to spices, cereals, cheese and meat sold by weight, in countries like France it is possible to buy olive oil, wine, cleaning products and cosmetics in reusable containers.

The Ellen MacArthur Foundation estimates that replacing just 20 percent of single-use plastic packaging with reusable alternatives holds a business potential of US$ 10 billion.[119] By employing digital technologies, reuse models can provide consumers with better experiences, customize products according to individual needs, create brand loyalty, optimize operations and reduce costs. They allow, for example, a high-quality ice cream package that keeps the product out of the freezer for hours to be delivered and collected at consumer's homes under a subscription-based model. In addition to being convenient and pleasant, the experience can build customer loyalty.

Reuse systems also hold the potential to create jobs locally and cut public spending on waste management and cleaning. Returnable bottles were once the beverage industry's main distribution system, but companies have significantly reduced their market share in favor of disposables.

A study by Oceana calculated that a 10-percent increase in the market share of returnable soft drink bottles in coastal countries could reduce marine pollution caused by these products by 22 percent. That would mean leaving 4.5-7.6 billion PET bottles out of the oceans each year. A 20-percent increase in the market share of returnable bottles, in turn, could lead to a 39-percent decrease in marine pollution caused by these bottles, preventing 8.1-13.5 billion of them from reaching the sea every year.[120] Oceana's study points out that, although returnables have lost space for non-returnable packaging, they still hold large market shares around the world and have become more efficient and profitable.

Aiming at reducing plastic waste, products appear in new formats and materials, such as bamboo toothbrushes and solid shampoos and toothpastes. Environmental concerns also open room for the development of innovative businesses that favor packaging reuse – a crucial part of the solution for plastic pollution.

INITIATIVES

GERMANY – the national bottle deposit and return system

Germany has a national system of returnable bottles made of glass or PET, in sizes ranging from 200 ml to 1.5 liters. Almost all bottles (99 percent) are returned by consumers via machines or at points of sale. On return, they receive their deposits of € 0.08 or € 0.15 back. Glass bottles are sanitized and reused up to 50 times, while PET bottles are reused 20 times on average. Most are standard size, which allows them to be used and returned by several consumers.121

ReCup – cup deposit and return system

Recup proposes a system for reusing coffee shop cups in Germany. Consumers pay € 1 for reusable polypropylene cups in three sizes: 200 ml, 300 ml or 400 ml. They get their money back by returning empty cups to any of the 2,700-plus registered stores spread across 450 cities and towns. ReCup's business partners pay a membership fee to fund the system and access the app. Cups are designed to be used up to a thousand times.122

Loop – favorite brands' products in returnable packaging

Loop is an online platform developed by recycling company TerraCycle, which offers products from major brands in high-quality and returnable packaging. At the same time, it makes consumers' lives simpler by delivering products and collecting empty packages at their homes and helps manufacturers by taking care of reverse logistics, cleaning and redistribution of goods.

Business partners' fees are defined according to packaging's durability, cleaning difficulty and life cycle assessment. Difficult-to-wash containers have higher fees than simple-to-sanitize packaging.

Users pay no monthly or registration fees – only a small amount to use the packaging, which is refunded upon return. In partnership with companies such as P&G, Unilever, Nestlé, PepsiCo and Coca-Cola, Loop currently operates in the US East coast and in Paris. The platform is expected to expand its operations to other countries in 2020.123

ReCircle – returnable packaging in takeaway catering system

This packaging reuse system has more than 800 partner restaurants in Switzerland and 27 in Germany, with more than 70,000 containers in circulation. Businesses pay € 135 per year for 20 containers, thus saving hundreds of disposable packages. Consumers pay € 9 for takeaway packaging that can be returned to any partner restaurant where they will be refunded. The chain's restaurants are responsible for cleaning the containers.124

Algramõ 2.0 – smart refill system on wheels

In a joint enterprise with Unilever and Nestlé, this Chilean startup launched a pilot system for intelligent distribution of products at home using electric tricycles. Consumers buy reusable packaging and set up online accounts to manage refill credits and loyalty rewards that can be collected at dispensing machines. Users can schedule visits on the app at no cost. The first pilot project offers refill options for cleaning products such as Omo, and Purina animal feed. The startup is open to adding new brands to the system and installing its sales machines in supermarkets.125

Project Reutilizar #praserfeliz – bulk products at Brazil's Pão de Açúcar

Some Pão de Açúcar supermarket stores participate in Project Reutilizar #praserfeliz. Products such as grains, teas, spices and chocolates are available in specific dispensers for sale by weight. These structures guarantee food freshness and allow customers to buy the portions they want. The project contributes to reducing the use of disposables and allows consumers to pay less, since the cost of packaging is not included in the price. Stores that join the program sell reusable glass packaging.

B.O.B – bars over bottles – solid cosmetics

With its 'zero plastic' proposal, this Brazilian brand sells solid shampoos and conditioners in biodegradable packaging. The products are vegan and preservative-free.

Beegreen – reusable bamboo cutlery made in Brazil

Brazilian company Beegreen Sustentabilidade Urbana has developed a line of cutlery made of bamboo fully produced in Brazil. "It took us over a year to develop the cutlery line, since there are no proper machinery and structure to produce bamboo items Brazil. Our products are virtually handmade. Even so, we are already in the process of developing novelties," said Beegreen production engineer and owner Patricya Bezerra. Brazil has 258 species of bamboo and the largest natural reserve on the planet, but its supply chain is still being structured.

Casa Santa Luzia – groceries packed in banana leaves

São Paulo-based Casa Santa Luzia has been making efforts to reduce its waste production. The store focuses on a public with high purchasing power and has replaced part of the plastic with banana leaves to pack groceries. It plans to replace Styrofoam trays with biodegradable solutions based on banana and cassava bagasse.126

Tamoios – biodegradable packaging made from agro-industrial waste

São Paulo-based company Tamoios Tecnologia produces biodegradable packaging from industrial-scale agricultural waste. Applications include dry food and fruit trays, bottle containers, shoe fillers and auto parts packaging. The products are made of molded pulp obtained from cardboard and other vegetable fibers such as banana fiber. Recycled papers and rice hulls can also be used in the process. A distinguishing feature of the company is the machinery developed by the partners, which is able to produce various packaging formats. Unfortunately, this does not happen with egg carton manufacturers that use a similar technique (molded pulp) but work with huge machines that can only make one type of product.127

Boxed Water Is Better – water in cartons

This American company founded in 2009 provides water in beverage packages that are well known but not used for that product. Cartons are recyclable and have 92 percent content from vegetable sources, 74 percent of whichis certified paper.

Photograph: Oceana/Lara Iwanicki

6. OCEANA'S PROPOSALS FOR BRAZIL

More plastic was produced in the previous decade than in the entire past century. As a result, a truckload of plastic waste is dumped into our oceans every minute. Current projections indicate that, at this rate, 12 billion tonnes of plastic waste will have been landfilled or dispersed in the environment by 2050.

Packaging is the largest market for plastics, consuming around 36 percent of the world's production and 40 percent of Brazil's output. Single-use plastics are the cheapest option because negative externalities are not accounted for in the cost of disposable packaging or products. Taxpayers end up paying these hidden environmental and human health costs.

In recent years, flawed waste management systems have been blamed for the problem of plastic pollution. This view has transferred responsibility – and blame – to consumers, who also fail to separate what they throw out, and cities, which do not implement recyclable waste collection systems, invest little in recycling infrastructure, maintain open dumpsites, and do not build institutional capacity. Thus, policy solutions have focused on demonstrating waste recyclability and increasing recycling rates and, in some cases, promoting incineration with the energy recovered from that plastic waste.

However, a realistic assessment of recycling's potential impact shows that it is not and will not be enough to prevent plastic pollution. Even in the most optimistic estimates, recycling rates will not keep pace with the growth trend in total production of disposables and therefore will not prevent the flow of plastic into the oceans.

Consumer goods companies must go beyond recycling and recyclability commitments and offer plastic-free packaging options. Consumers who want to avoid these materials have limited choices due to the lack of alternatives and, therefore, are unable to make conscious choices.

Governments also play a key role in reducing pollution. Many countries have already implemented or are developing national policies limiting the use of disposable plastics. As governments and society become more aware, the number of those laws is increasing.

Brazil still lacks national legislation on plastics: the material is not treated differently by the National Solid Waste Policy (PNRS) or under the Sectoral Agreement for Reverse Logistics of General Packaging, nor is it the target of any restrictive rule. Norms issued by the National Health Surveillance Agency (Anvisa) do not limit the use of plastic as packaging in contact with food – they only establish specifications about quality and additives, especially for recycled plastics.

Subnationally, however, both in the legal sphere and in health surveillance, states and municipalities have distinct regulations that not always converge. Some laws require the use of oxo-degradables in plastic bags while others prohibit it; some rules ban straws while others require individual and sealed wrapping. Therefore, there is both legal void and legal confusion, in addition to lack of political will that prevent the country from effectively addressing the growing volume of plastic waste produced in its territory. The practical and concrete solution to prevent that single-use plastic keep polluting the ocean is to reduce the supply and consumption of this material.

The first step is to phase out all avoidable plastic, such as disposable products, and replace them with more sustainable alternatives that do not generate unnecessary waste.

Only clean and balanced oceans will be able to feed one billion people every day. The only practical and concrete way to prevent plastics from continuing to pollute the sea is if governments and companies commit themselves to actions that reduce their use. Oceana recommends three concrete solutions that, together, can effectively reduce marine plastic pollution:

PASS A NATIONAL LAW REDUCING SINGLE-USE PLASTICS

Brazil needs nationwide legislation regulating supply and use of all avoidable and unnecessary plastic. The country's contribution to plastic pollution in the oceans is undeniable; therefore, it has major responsibility for reducing this impact. There is an urgent need for robust legislation, inspired by policies, laws and good international experiences, to reduce the generation of preventable waste in order to:

- **i.** Harmonize dispersed regulations on the use of disposable plastics;
- **ii.** Promote non-generation of plastic waste;
- **iii.** Demand gradual elimination of disposable plastics such as Styrofoam containers, utensils, plates and glasses, etc.;
- **iv.** Set targets for reduction and reuse of single-use plastic packaging;
- **v.** Require that at least cost prices of plastic shopping bags are charged from users until they are completely replaced with returnable bags or more sustainable options;
- **vi.** Establish sanctions to producers for non-compliance with their extended responsibility for post-consumer packaging, to be applied through enforcement and suspension of commercial licenses.

Furthermore, municipalities and states must also implement local policies limiting the use of disposable plastic.

GET COMPANIES TO OFFER OF PLASTIC-FREE CHOICES

Companies should offer plastic-free options for their products and packaging, at a cost similar to or lower than that of their current packaging. This means that companies must replace disposable products with reusable options, innovate and invest in delivery systems with returnable or reusable packaging. Consumers play an important role and must demand plastic-free options of their favorite brands.

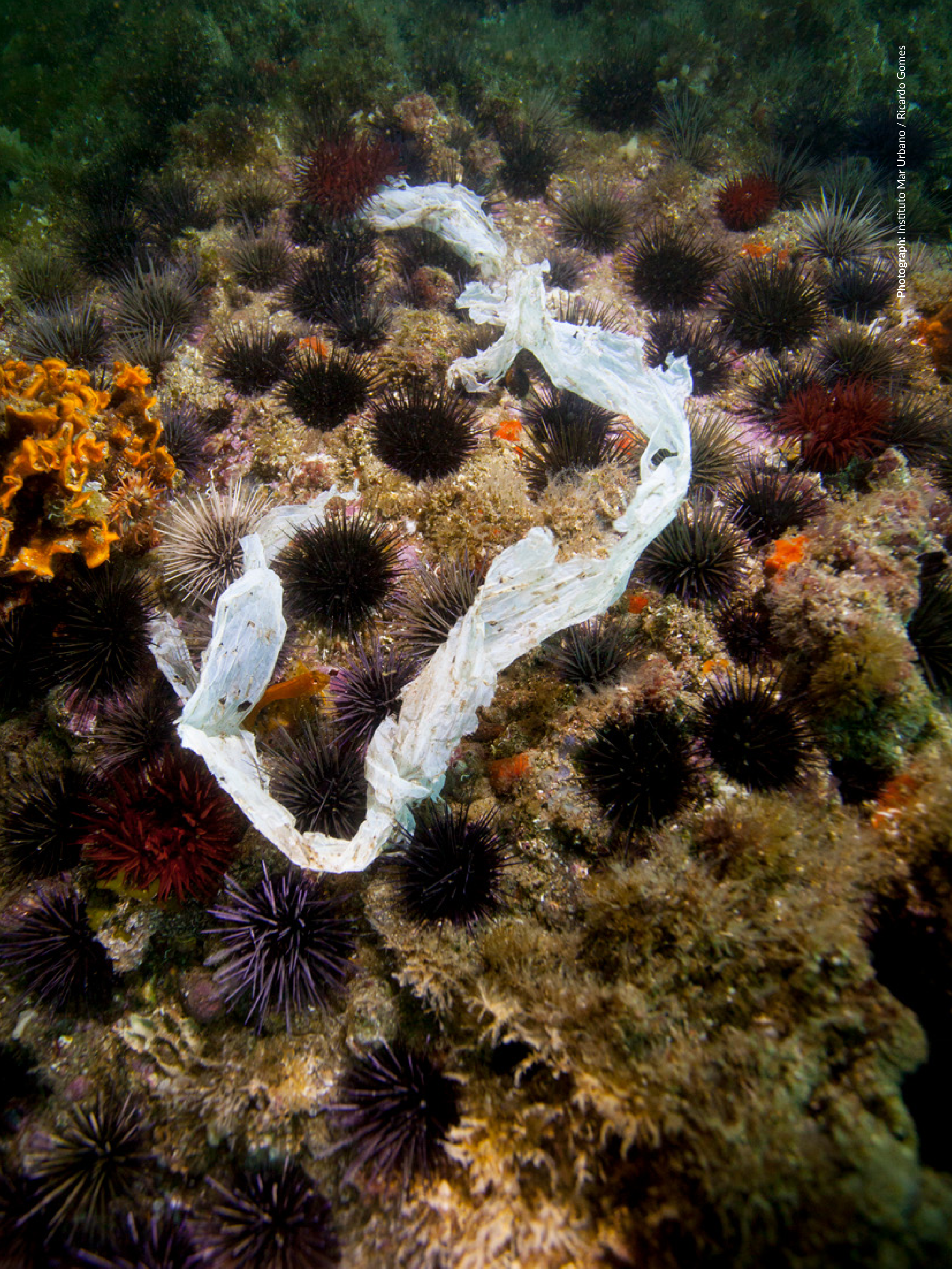
Several companies have offered alternatives, proving not only the feasibility of the transition to distinct products or packaging but also consumers' interest in these options. There are countless possibilities in Brazil:

- Products sold in bulk without plastic packaging, to be taken in customers' own containers;
- Private label products in new packaging that do not use plastic;
- Replacement of packaging – such as Styrofoam trays for cold cuts or plastic packaging for cakes and breads, or even packaged fruits and vegetables – with biodegradable alternatives;
- Development and offer of alternative packaging (in glass, aluminum or cardboard), based on product life cycle analysis;
- Offer of in-store refills upon delivery of empty packages (consumers pay only for the product; they deliver empty packages and take new products).

Changes in well-known products inspire other changes or create favorable environments for new business models that use less plastic.

IMPLEMENT PLASTIC-FREE ZONES

In order to reduce the amount of single-use plastic and raise public awareness about plastic pollution in the oceans, Oceana proposes the creation of Plastic-Free Zones where single-use plastics are not supplied, marketed or used. They may include corporate offices, airports, schools and universities, hotels, beach bars as well as festivals, events or even entire cities. These initiatives do not need to be limited to coastal areas and can be implemented by communities themselves, governments or commercial establishments, whether individually or through their networks.



Photograph: Instituto Mar Urbano / Ricardo Gomes

APPENDIX I – METHODOLOGY

This report was based on Oceana's global approach and adjusted to each country. Four specialized consultancy firms were hired to contribute to its analyzes and results. In addition to each firm's report, Oceana also conducted literature review and analysis of secondary data.

Public and official sources of information were used, such as data from the National Sanitation Information System – Solid Waste module of Brazil's Beach Monitoring Program (PMP), the Ministry of the Environment's Panel for Combating Sea Litter, export and import figures provided by the Ministry of Industry, Foreign Trade and Services, in addition to scientific articles and a database on Brazilian legislation. For specific data on production, apparent consumption and applications of single-use plastics, the consultancy Giral Viveiro de Projetos commissioned a study from Maxiquim - a company that assesses chemical industry business.

To make the report richer, interviews were conducted with the following industry associations: Abal (Brazilian Aluminum Association), Abiplast (Brazilian Plastic Industry Association) and Abividro (Brazilian Glass Industry Association).

The specific methodology for each section is detailed below. All references cited and used in this study are available for consultation.

SECTION 1. THE AGE OF PLASTIC

The information presented in Section 1 is the result of literature review as well as compilation and analysis of data available in the literature cited.

SECTION 2. SINGLE-USE PLASTICS

Methodology for measuring Brazil's single-use plastics market

Single-use plastics have been described under two categories: Disposable products and Single-use packaging. Estimates on production of single-use plastic items were based on apparent consumption of virgin resins (from second-generation petrochemicals) for single-use applications. Data on import and export of single-use plastic items were added to those estimates to obtain figures on apparent consumption of single-use plastics.

Calculation of apparent consumption of virgin thermoplastic resins was based on data on Brazilian production, import and export of each resin. They are LDPE, LLDPE, HDPE, PP, PS, PET, PVC and EPS. Data on production of virgin resins come from primary sources – producers themselves (petrochemical industries), while import and export data were obtained from Comex (Ministry of Industry, Foreign Trade and Services – MDIC). Mercosul Common Nomenclature (NCM) for the resins in question was adopted.

As for imports and exports of single-use plastics, some NCM terms for processed plastics were used. A detailed search was conducted, using NCM terms to arrive at the figures in this area.

Figures on apparent consumption of virgin thermoplastic resins for single-use applications were based on segmentation according to each resin's application and stressing uses related to packaging of non-durable consumer goods (food, beverages, personal hygiene items, household cleaning products) and disposables. Market segmentation data come from the database and intelligence of MaxiQuim – a company that evaluates business in the chemical industry. MaxiQuim provided data to consultancy firm Giral Viveiro de Projetos, which was hired by Oceana.

The calculation of apparent consumption of single-use resins did not consider production of recycled resins intended for single-use applications – only virgin resins. Furthermore, no single-use applications for engineering plastic resins were considered. In the case of PVC, the volume is negligible and Maxiquim does not have a historical series available.

Methodology for calculating the amount of disposable items and packaging (page 29)

The number of single-use items consumed, presented on page 25, was obtained by dividng the volume consumed by product by the average weight of a unit **(TABLE 9)**. As the weight of a unit may vary according to its thickness, it was used as a reference the values available in the literature, technical specifications or data about the products for sale,

for items with available information. The sum of the units totaled 482.16 billion units, and by approximation, the value of 500 billion units was considered.

TABLE 9.

Data used to convert the consumption of single-use items into units

ITEM	VOLUME CONSUMED/YEAR	WEIGHT OF 1 UNIT	TOTAL UNITS/YEAR
Bags	213,000 tonnes	3 g[1]	71,000,000,000.00
Cups	150,000 tonnes	2.2 g (200-ml cup)[2]	68,181,818,181.82
Utensils	30,000 tonnes	1.72 g[3]	17,441,860,465.12
PET bottles	537,000 tonnes	47 g (2-liter bottle)[4]	11,425,531,914.89
Styrofoam trays	52,000 tonnes	6 g[5]	8,666,666,666.67
Flexible Packaging	1317 thousand tonnes	4.9g[6]	268,775,510,204.08
Straws and mixers	11 thousand tonnes	0,3g[7]	36,666,666,666.66

References:

1 Data from the Supermarket Bag Ecoefficiency Study, available at: http://www.braskem.com.br/Portal/Principal/Arquivos/Download/Upload/SOAP_Estudo%20sacolas_FINAL%20WEBSITE_26.pdf

2 INMETRO consumer information data, available at: http://www.inmetro.gov.br/consumidor/produtos/copos_plasticos.asp

3 Market research, information available at: http://bellocopo.com.br/garfo-ref-cristal/

4 ABIPET data, available at: http://www.abipet.org.br/index.html?method=mostrarInstitucional&id=66

5 Market research, information available at: https://embalagensoriginal.com.br/produto/bandeja-de-isopor-b3-rasa-400-unidades/153

6 The weight of flexible packaging is variable. An average value was used as a calculation reference. Source: https://blog.sulprint.com.br/calculo-de-rendimento-para-embalagens-flexiveis/

7 Information available at: http://monografias.poli.ufrj.br/monografias/monopoli10030034.pdf

SECTION 3. PLASTIC WASTE MANAGEMENT

The National Sanitation Information System (SNIS) is the largest and most important information system in Brazil's sanitation sector, based on a database that includes institutional, administrative, operational, managerial, economic-financial, accounting and quality information on provision of water, sewage and municipal solid waste management services. For its Solid Waste component, SNIS-RS information is collected annually and comes from service providers or municipal agencies in charge of managing the services (primary source); the database is public and free of charge and can be assessed at *www.snis.gov.br*.

Through the data collected, the Ministry of Regional Development (MDR) produces the Municipal Solid Waste Management Assessment based on the previous year. In its 2018 edition, 3,468 cities participated in data collection (62.3 percent of the country's total), covering 85.6 percent of Brazil's urban population; 47 solid waste indicators were consolidated, including on home collection service tax, mass recovered per capita, and financial self-sufficiency of managing agencies. Currently, it is the only official source of reliable primary data and information on management of solid waste generated in the country.

Physical composition of collected solid waste

Gravimetric characterization or gravimetry is a quantitative analysis method often applied to the mass of solid waste in order to know its real composition (constituent fractions) with planning purposes. The analysis is crucial to know and monitor the waste to be planned for and/or managed, since its composition varies according to the characteristics of each municipality and/or region.

Most Brazilian cities still do not perform periodic gravimetric analysis on waste or do not make their results publicly available. For this reason, in order to know the composition of Brazil's household waste for the purposes of this study, data collected by eight State Solid Waste Plans (TABLE 10) were used, even though they used distinct methodologies and in different periods.

TABLE 10.
Physical composition of collected waste available in State Solid Waste Plans (%).

STATE	PAPER/ CARDBOARD	PLASTIC	GLASS	METAL	OTHERS	NON-RECYCLABLE WASTE	ORGANIC MATTER
Alagoas (AL)	10.49	13.19	3.97	3.28	-	-	54.08
Maranhão (MA)	21.89	32.13	3.01	39.97	10.00	-	-
Minas Gerais (MG)	9.75	8.25	2.50	3.00	11.50	-	65.00
Pernambuco (PE)	8.93	11.04	2.69	3.10	-	17.84	56.46
Piauí (PI)	12.01	13.22	2.54	0.03	-	-	-
Rio de Janeiro (RJ)	15.99	19.14	3.28	1.57	6.74	-	53.28
Rio Grande do Norte (RN)	3.50	15.30	2.00	2.54	2.75	36.34	35.54
Santa Catarina (SC)	14.40	16.38	3.63	3.06	18.67	-	43.83
Average	12.12	16.08	2.95	7.07	9.93	-	51.37

Source: State Solid Waste Plans – AL (2010), MA (2012), PE (2010), PI (2011), RJ (2013), RN (2012), SC

It is observed that the data made available by the states do not add up to 100% as expected, probably due to the fact that some states have considered the share of other unspecified waste as waste, and it is not possible to identify the inconsistency because it does not contain information about it. Thus, data from some states (MA, RN, SE is PI) that were shown to be incomplete or inaccurate were excluded since inconsistencies of this type can increase the bias (error) of the Brazil calculation.

Figures on recycling and volume of single-use plastic waste consumed to produce recycled resins were a result of statistical consolidation of data provided by recycling companies themselves. Stratifications of single-use plastics by resin were obtained from the MaxiQuim database hired by consultancy firm Giral Viveiro de Projetos, which performed the statistical analyzes.

SECTION 4. MARINE POLLUTION BY PLASTICS IN BRAZIL

Brazil's contribution to marine plastic pollution

Brazil's contribution to marine plastic pollution was calculated by the same methodology used by Jambeck et al. in *Plastic Waste Inputs from Land into the Ocean*, published in *Science* in

2014. The article estimates the total amount of plastic entering the ocean each year from waste generated by coastal populations worldwide. Brazil comes 16th among the 20 countries with the largest masses of mismanaged plastic, contributing to introduce 70,000 to 190,000 tonnes of litter in the sea every year (data from 2010). Oceana used public and official data from the Brazilian government to update the values of each parameter and thus obtain a figure for 2018 – the last year with available data. Table 11 summarizes the variables and data used by Jambeck et al (2014), as well as the data used by Oceana to update the calculation:

TABLE 11.
Variables and data used to calculate Brazil's contribution to marine plastic pollution

PARAMETERS	BRAZIL (2010)	BRAZIL (2018)	DESCRIPTION
Economic status	UMI	UMI	UMI = upper middle income; World Bank classification of Brazil's economic status according to per capita income.
Coastal population (up to 50 km from the coast)	74,696,771	**81,646,480**	The authors consider coastal population as those people living in cities within 50 km of the coast – not just in coastal cities. As we did not have access to the list of cities considered, we updated the population based on IBGE data on the growth of Brazil's general population. We calculated the population growth rate for each year between 2010-2019 and applied it to the population considered by the authors (74.69 million).
Waste generation rate [kg/person/day]	1.03	**1.03**	SNIS data indicate that 0.96 kg of waste are collected per person/day, but do not show the per capita amount of waste generated per day. A conservative option was made to maintain the 2010 value.
% of plastic in the composition of litter	15.95	**16.08**	Percentage of waste collected that is plastic. To update this figure, we calculated the weighted average of plastic's share in the physical composition of the waste collected, available in eight State Solid Waste Plans (AL/2010, MA/2012, PE/2010, PI/2011, RJ/2013, RN/2012, SC/2014).

PARAMETERS	BRAZIL (2010)	BRAZIL (2018)	DESCRIPTION
% mismanaged waste	8.52%	**24.38%**	According to the authors, mismanaged waste practices include sending waste to places without formal management, including open dumpsites or landfills where the waste is not fully controlled. In Brazil, all waste disposal in controlled dumpsites and landfills (which resemble dumpsites in many cities) is considered inadequate. SNIS data show that 24.38 percent of the collected waste has inadequate final disposal.
% waste thrown directly into the environment	2%	2%	In this methodology, for each country, the authors consider an additional volume equivalent to 2 percent of the amount of waste generated per day, which corresponds to waste inadequately disposed of on public roads, rivers, vacant lots, beach sand etc. In the absence of more recent and specific data for Brazil, the same value considered by the authors was used.
Waste generation [kg/day]	76,937,674	84,095,874	Calculated on an Excel spreadsheet, following the authors' methodology, and using 2018 data, updated.
Plastic waste generation [kg/day]	12,271,559	13,522,617	
Mismanaged plastic waste [kg/day]	1,046,087	3,296,814	
Plastic waste thrown into the environment [kg/day]]	245,431	270,452	
Mismanaged plastic waste [kg/person/day]	0.017	0.044	
Mismanaged plastic waste [tonnes] in the year	**471,404**	**1,302,052**	

The source of information used was the 17th Assessment of Municipal Solid Waste Management prepared by the Ministry of Regional Development under the National Sanitation Information System and IBGE data on the growth of Brazil's population.

According to Jambeck et al (2014), a percentage of the total mismanaged waste reaches the oceans through streams, rivers, runoff from rainwater or sewage, or taken by the wind or tides. Therefore, this percentage is highly variable and depends on specifics from each country, such as climatic conditions, topography and vegetation. Therefore, the study proposes three conversion rates (15, 25 and 40 percent), which are considered conservative, to estimate the mass of plastic that entered the sea from land-based waste. Table 12 shows the results obtained for Brazil in 2010 and those obtained by Oceana based on 2018 data.

TABLE 12.
Result of Brazil's contribution to plastic pollution in the ocean, in 2010 and 2018

PARAMETERS	2010	2018
Mass of mismanaged plastic waste (tonnes)	471,404	1,302,052
Mass of plastic that reaches the ocean (15%) tonnes	70,711	195,308
Mass of plastic that reaches the ocean (25%) tonnes	**117,851**	**325,513**
Mass of plastic that reaches the ocean (40%) tonnes	188,562	520,821

Using the same article as a reference, the Ministry of the Environment pointed out that 470,000 tonnes of plastic waste are mismanaged and that 133,000 tonnes reach the seas in Brazil per year,[5] which is approximately the weighted average between the 15- and 40-percent limits for 2010. Based on updated data, Oceana considers that Brazil's most likely contribution to marine plastic pollution is around 325,000 tonnes per year (intermediate value of 25 percent), although this figure is quite conservative.

Official government data (SNIS, 2018) indicate that 24.4 percent of the waste collected has inadequate final disposal. According to data from ABRELPE (the Brazilian Association of Public Cleaning and Special Waste Companies), this figure is even higher – 40.9 percent[6] – which would mean an even more alarming contribution to marine pollution. Furthermore, the reference methodology considers only the portion of the population living near the coast, but scientific literature stresses the role

5 https://www.mma.gov.br/agenda-ambiental-urbana/lixo-no-mar.html
6 Panorama Abrelpe 2019.

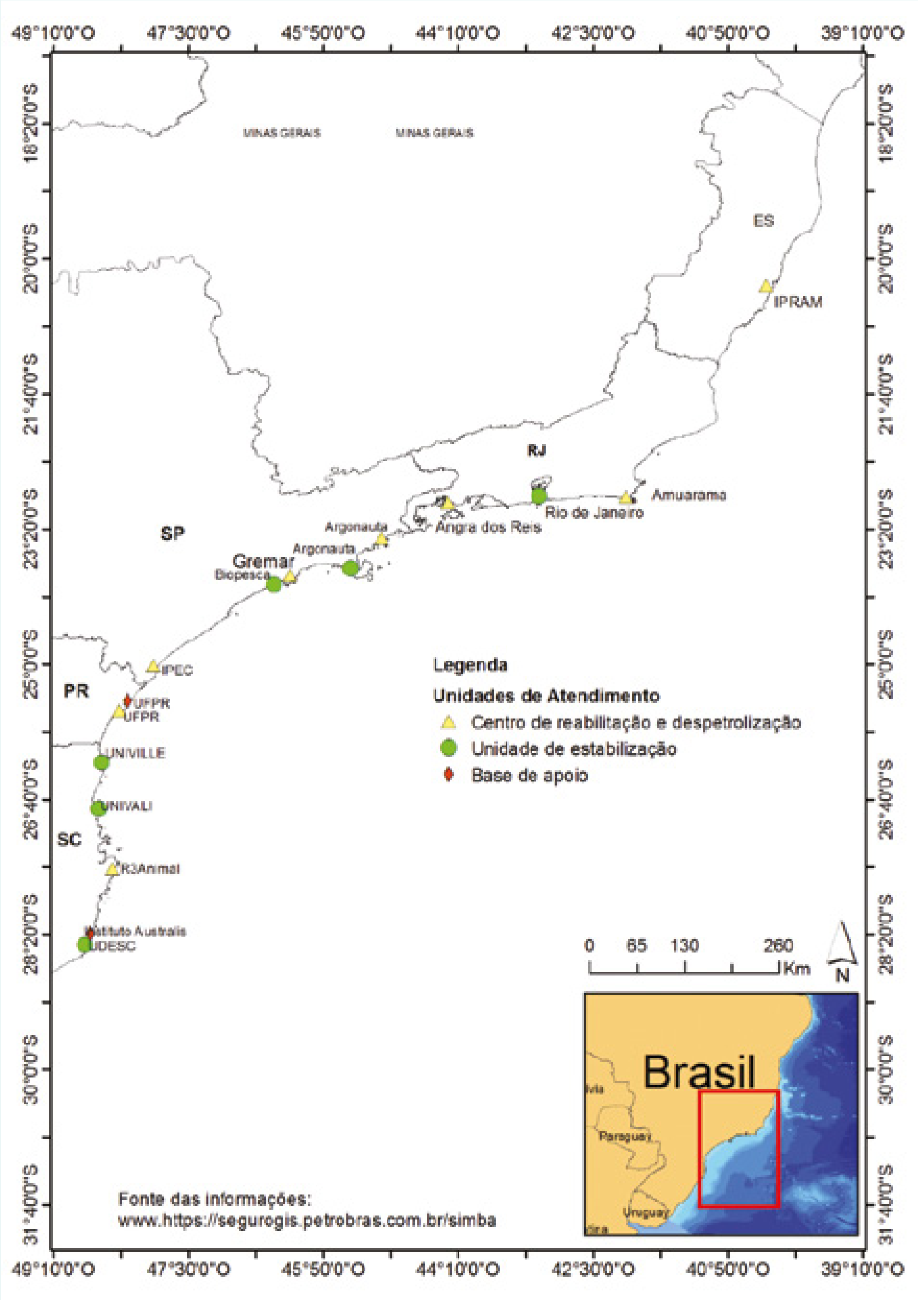
played by watersheds in taking waste to the sea. Therefore, inland cities distant more than 50 km from the coast, with inadequate waste management systems, may also contribute to marine plastic pollution through the watersheds that drain them.

Impacts on Brazilian marine fauna

The records obtained for the analyzes presented in Chapter 4 are provided by the Beach Monitoring Projects for the Santos (PMP-BS) and Campos Basins (PMP-BC), in Espírito Santo, whose purpose is to assess the interference of production and transportation of oil in the Pre-Salt layer on marine tetrapods (birds, turtles and mammals). The activities developed consist of daily monitoring of beaches and provision of medical-veterinary care to animals rescued alive and weak, as well as necropsies.

The network addressing these strandings consists of facilities distributed between Laguna, SC, and Conceição da Barra, ES, totaling 2,788 km of coastline. It includes institutions such as the State University of Santa Catarina – UDESC; Instituto Australis; The R3 Animal Association; Vale do Itajaí University – UNIVALI; Joinville Region University – UNIVILLE; Federal University of Paraná – UFPR; Cananéia Research Institute – IPEC; BIOPESCA Institute; GREMAR Institute; Argonauta Institute; CTA Environmental Consulting; and Institute for Research and Rehabilitation of Marine Animals – IPRAM; members of the Brazilian Network on Stranded Aquatic Mammals (REMAB); and the Pro-TAMAR Foundation **(FIGURE 24)**.

FIGURE 24.
Institutions that participate in Beach Monitoring Projects in the states of Espírito Santo and Santa Catarina and the locations of their respective service units.



Data were collected from publicly available information in the Occurrence Records for Individual

Target Fauna and Anatomopathological Tests on the SIMBA platform (Aquatic Biota Monitoring Information System) available at: https://segurogis.petrobras.com.br/simba/web/.

These records include information compiled since the time animals/carcasses got stranded on the beach, such as geographic location, climate conditions, as well as information about the animals themselves (species, carcass condition, physical integrity, signs of anthropic interaction, etc.). They also record all necropsy findings, including main wounds, types of anthropic interaction, as well as cause-of-death diagnosis. Additional information was found on the annual reports available on Petrobrás's online communication channel (https://www.comunicabaciadesantos.com.br/programa-ambiental/projeto-de-monitoramento-de-praias-pmp.htm l).

Animals stranded alive within each institution's operation range receive veterinary care and undergo detailed clinical examination that investigates, in addition to biological parameters, any skin trauma marks left by contact with abandoned fishing gear and/or ingestion of solid waste – even though, in most cases, the waste is observed only after the animal's death, during necropsy.

Interaction with solid waste such as plastics may or may not be linked to the cause of death. To distinguish cases, presumptive necropsy diagnoses point out natural or anthropogenic causes. The analyzes were carried out by species, sex and IUCN threat category.

The information presented in Chapter 4 is the result of the analysis of Occurrence of Individual Target Fauna and Anatomopathological Examination Records available on the SIMBA platform from August 24, 2015 to August 23, 2019. Information on stomach content recorded on necropsy reports was analyzed to check the number of animals that had ingested plastic fragments, by species, and how many had marine litter ingestion as their cause of death.

Although they are registered, not all individuals who arrive dead at the beaches are in satisfactory conditions for necropsy, since they may have died far from the coast and their carcasses may undergo postmortem autolytic enzyme action until they get stranded, naturally preventing diagnoses. Therefore, the figures presented in Chapter 4 are underestimated.

MICROPLASTICS

Sixty-two scientific studies and systematic reviews were mapped and analyzed. They had been recognized by organizations such as the World Health Organization, FAO and the European Food Safety Authority (EFSA) and other researchers that analyzed dozens of studies on the following topics:

- Sizes, shapes and types of microplastics with more potential to harm human organisms.
- Main sources of contamination through food, water and air, and what is already known about human exposure and health risks in each of these environments.
- Fish, crustaceans and bivalves where the highest concentrations and particles with potential for absorption by the human body were found.
- Potential risks of particles and their additives/components from a physical, chemical and toxicological point of view.
- Methodological limitations of studies on health risks and recommendations for improving research.
- Other initiatives that would help to better evaluate microplastics contamination in Brazilian marine species and which could interest Oceana within its scope of action.
- Recommendations for reducing contact with microplastics, according to environmental and consumers' rights organizations.

An interview was also conducted with specialists from the Oceanographic Institute of the University of São Paulo (IOUSP) and a member of the Expert Group on Scientific Aspects of Marine Environment Protection.

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Photograph: Oceana/Lara Iwanicki

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