what a WASTE

PLASTIC POLLUTION UPDATE

TEXT & PHOTOGRAPHS **PETER RYAN**

We're addicted to plastics, the diverse and versatile array of synthetic polymers that are essential to virtually all aspects of modern society. From food security and medicine to construction and transport, we rely on plastics to keep our technology-rich world turning. But the low cost of plastics means that we don't value waste plastics enough to re-use or recycle them. More than 100 million tonnes are used for packaging and other single-use applications every year, creating massive volumes of waste plastic. Much of this ends up in our wetlands and the sea, where it has a host of environmental and economic impacts. Peter Ryan brings us up to date on this pressing environmental concern. >

Widespread attention from the media, scientists and even politicians has made plastic pollution one of the hottest conservation issues. Much of the concern centres on the long lifespan of waste plastics, which means that more and more plastic is accumulating in the environment. Plastics degrade very slowly, especially when protected from UV light. In the absence of biological agents, it is likely they will take hundreds or even thousands of years to break down in the cold, dark environments found on the seabed.

Interestingly, there are indications that plastics might not be entirely immune to biological attack. A bacterium isolated at a Japanese recycling depot has developed a taste for polyethylene terephthalate (PET) and a mutant lab strain is reported to be able to break down plastic bottles in a matter of months. Floating plastic fragments in the mid-ocean gyres have been found with small pits that appear to have been made by bacteria. This might explain why there are fewer very small plastic fragments floating at sea than we expect, given the estimates of how much plastic enters the oceans each year. Plastic-eating bacteria might help to solve our problem with waste plastic, but would create a host of other challenges if plastics designed to last for decades, such as in aircraft or the construction industry, start to decay!

There are other possible explanations for the paucity of small floating fragments at sea. These sediment out of surface waters faster than larger items as they have a greater surface area relative to their volume on which to accumulate a 'biofilm' of marine organisms, increasing their density to the point at which they start to sink. Filter-feeding zooplankton also consume microplastic particles. Animals like copepods excrete plastic in dense faecal pellets that sink into the ocean depths. Similarly, larvaceans trap microplastics in their mucous 'nets', which are sloughed off every day and sink. It seems that most waste plastic ultimately ends up on the seabed.

When it comes to statistics, the sheer volumes of plastic are not in dispute. Around 8300 million tonnes have been manufactured since the 1950s, half of which was made after 2005. Only a quarter is still in use; the other 6300 million tonnes have been written off as waste. Of that, barely a fifth has been recycled, incinerated or converted into liquid fuels through pyrolysis; some 4400 million tonnes are either buried in landfills or floating around in the environment.

Global plastic production continues to grow at about eight per cent per year, with currently some 400 million tonnes being made each year (including roughly 50 million tonnes of synthetic fibres). About 40 per cent is manufactured for single-use applications, mainly packaging, which is typically discarded after use. Africa is responsible for only one per cent of all single-use plastics produced, but five African nations are listed in the top 20 contributors of plastic waste into the sea. South Africa is number 11 on the list of shame, thanks to its combination of a sophisticated packaging environment and poor solid-waste management practices. More than half of all solid waste in South Africa is regarded as mismanaged, compared to 11 per cent in Brazil and only two per cent in the USA. >

above *Leshia Upfold found these three Cape Gannets entangled in fishing line at Bird Island, Algoa Bay, in November 2006. The central bird was foul hooked by the fishing lure on its breast, and the other two birds were presumably snared subsequently. Such records blur the line between accidental fisheries bycatch and entanglement. It's possible that the struggles of the first gannet contributed to the other two becoming entwined; Kees Camphuysen reported seeing how four Northern Gannets struggling to free themselves from a net fragment attracted other gannets that then also became caught.*

previous spread *A White Stork competes for scraps with Kelp Gulls and Sacred Ibises at a dump site. Note the string caught in its nostril.*

above A 2015 study listed South Africa as the 11th worst nation worldwide for dumping plastic into the sea, mainly because of poor solid-waste management. The UN estimates that more than half of all solid waste in South Africa is mismanaged. Much of the plastic that arrives at landfill sites blows away. This litter-strewn veld is outside the dump in Calvinia. The problem is getting worse as many South African municipalities struggle to cope with the deluge of solid waste.

left Rivers carry a great deal of plastic waste from land into the sea, but they also intercept a lot of litter. This tree on the banks of the Jukskei River in Gauteng lies downstream from Alexandra Township and traps vast amounts of waste. One of the impacts of litter is blocking drains, exacerbating flooding during heavy rain.

Some birds incorporate plastics into their nests, usually as part of the construction process, but on occasion seemingly for decoration. The Common Noddies that breed on Inaccessible Island, Tristan da Cunha, often bring rope fragments to their nests, sometimes draping them nearby. They are very specific in their colour choice: yellow rope is used more often by the local fishery, but the noddies have only been seen to select green ropes.

Using rope and fishing line for nesting material can be dangerous. In 2012, researchers on Robben Island found a Bank Cormorant fledgling that had fallen out of its nest after becoming entangled in fishing line. The chick couldn't be reached without risking other chicks abandoning their nests, so the researchers could only document its slow death over the next four days. Gannet, osprey and crow chicks often suffer similar fates, although Cape Gannets are much less prone to including plastic items in their nests than their North Atlantic and Antipodean cousins.

DOES IT MATTER?

We've known since the 1960s that plastics are damaging to marine animals. Virtually all animals are at risk of becoming entangled in persistent plastic waste. Lost and discarded fishing gear is the main culprit, but other everyday items can cause problems, and not just at sea. In the 1980s, South Africa was proactive in banning six-pack rings, a common source of entanglement for seabirds, ducks, turtles and fish. Balloon ribbons are another largely avoidable threat, particularly when hundreds of balloons are released en masse. In addition to a host of seabirds and waterbirds, owls and even finches have been found tangled up in these ribbons.

In agricultural areas, discarded twine from hay bales often ends up in the nests of crows and ospreys; in some parts of North America they are known to kill up to 12 per cent of Western Osprey chicks. Kite strings can be equally dangerous, especially in Asia, where 'manja' kites with powdered glass glued to their strings maim or kill a host of birds, from vultures to hornbills. To date, more than 260 bird species have been recorded as being entangled in plastic litter, typically condemning the creatures to a slow death unless they are lucky enough to be rescued.

But few species are entangled often enough to compromise their populations. The ingestion of plastic items is a more pervasive threat because virtually all individuals in some species eat plastic. Plastic items can block or injure the digestive tract, while large plastic loads can reduce the effective stomach volume, shrinking meal size through a false sense of satiation. However, the most serious issue is thought to be the transfer of toxic compounds to animals. Some plastics contain chemical additives such as plasticisers and flame retardants, and all plastics gradually accumulate persistent organic pollutants as >

above *Virtually all Great Shearwaters contain some ingested plastic, but this bird trailing a piece of fishing line either was caught on fishing gear or swallowed a hook discarded with fish waste.*

left *A selection of plastic items collected from Brown Skua pellets containing the remains of Great Shearwaters on Inaccessible Island in 2004. Great Shearwaters mostly ingest hard plastic fragments, with only a few fibres and no plastic bags. The proportion of industrial pellets (bottom right) has decreased steadily since the 1980s.*

EVERY BREATH YOU TAKE...
Microfibres are everywhere

Richard Thompson from the University of Plymouth and his colleagues drew the world's attention to microplastics in the early 2000s. They found tiny pieces of plastic that are too small to see in plankton and sediment samples collected throughout the world's oceans. Many of these items were fibres from clothing – a mix of polyester (including PET), acrylics, polypropylene and polyamide ('nylon') – that get into waste water when clothes are washed. Some fibres are removed in water treatment works; a recent study found that up to 90 per cent of microplastics are retained in sewage sludge. This is often used as fertiliser, with an estimated 60 000 tonnes of plastic going onto agricultural land in Europe each year. To put this in context, the entire Pacific garbage patch contains around 70 000 tonnes of plastic! We have very little idea of what the impact of all that plastic is on soil biotas.

Microfibres are ubiquitous at sea. About 70 per cent of small pelagic fish in the Benguela upwelling region contain fibres in their guts. But fibres are continuously being released from our clothes and other materials to the extent that microplastic researchers have to take special precautions to prevent aerial contamination of their samples. Microfibres are found in most samples of tap water, beer and table salt, and we doubtless breathe them in every day.

PETE OXFORD

above *Microfibres filtered from 20 litres of the Southern Ocean during the Antarctic Circumnavigation Expedition in 2017/2018. A recent study found that polar waters have the highest concentrations of microfibres globally. Many of these fibres seem to be from natural products like cotton and wool. We surmise that even natural fibres take a long time to degrade in cold polar waters.*

they drift at sea. When ingested, these diffuse into the animals, disrupting their hormone balance and potentially triggering cancers. The magnitude of this impact depends in part on the time that plastics are retained in the digestive tract and the composition of the gut contents. Species such as petrels and phalaropes that retain plastic in their stomachs for extended periods are at greater risk than those that rapidly regurgitate (for example, gulls and skuas) or excrete ingested plastics (ducks).

Waste plastics also impact on people. They reduce the aesthetic appeal of natural areas, affecting tourism and the businesses that rely on coastal recreation. In South Africa alone, we spend more than R100-million a year cleaning beaches. Waste plastics also block storm-water drains, exacerbating flooding during rain storms. Perhaps most worryingly, they affect human health. Informal burning of plastic waste releases toxic gases such as dioxin and furan into the environment. And as top marine predators, we are exposed to the toxic compounds that plastics introduce into marine food webs.

MAKING A DIFFERENCE

Many people equate tackling the plastic problem with banning the use of plastics in high-risk applications. This can be effective; consumer pressure has pushed some manufacturers to phase out the use of microbeads in cosmetics and hopefully this year Johnson & Johnson will stop producing plastic earbuds, which are so commonly found littering many beaches. The 'Strawless in Seattle' campaign used endorsements by celebrities and professional sports franchises to have straws banned from hundreds >

above *In many urban areas, if you dive offshore you are more likely to see plastic than fish.*

left *Not all plastics float: drinks bottles (PET), disposable cutlery (polystyrene) and cable ties (polyamide) are all denser than seawater. They don't disperse as far from source areas as litter items made from less dense polymers, but are joined by other litter items that become weighed down by fouling organisms after a few weeks in the sea. This foul mess is easily overlooked as it swills around on the sea floor in bays close to urban centres, but intense upwelling occasionally pushes it ashore. This collection of more than 8000 plastic items washed ashore on just 130 metres of rocky shoreline at Muizenberg corner in November 2017. We usually only find about 300 litter items in monthly clean-ups at this site.*

ROELF DALING

above *Plastic pellets or 'nurdles' look like hail in Durban Harbour after 49 tonnes of pellets were lost from a container ship during a storm on 10 October 2017. Most of the pellets were swept out to sea and spread along the coast as far as the Western Cape and central Mozambique.*

Pellets are the first step in the plastic production chain and are shipped from manufacturers to converters, who use them to make the plethora of plastic consumer products. Numerous small spillages during shipping and handling made pellets the most abundant plastic pollutants at sea during the 1970s and 1980s, but programmes such as Operation Clean Sweep initiated by the plastics industry have greatly reduced their loss in recent years. Partly as a result of this intervention and partly because fragments of other plastic items have become more common at sea, the proportion of pellets ingested by seabirds and baby turtles has decreased sharply over the past few decades. Pellets – many of them dating back to the 20th century – remain common on some beaches, but the 2017 spill dumped roughly two billion pellets into the sea, more than the total number of pellets on all South African beaches. Despite a protracted clean-up effort, fewer than 15 tonnes were recovered.

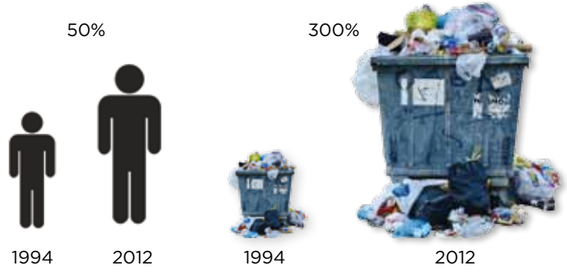
right *Litter is growing faster than the human population. The number of litter items washing up on Cape Town beaches increased by 300 per cent from 1994 to 2012. Over the same period, the human population grew by a more modest 50 per cent. Given that most litter comes from local, land-based sources, it means we're now producing more litter per person, not less. Excessive packaging is driving some of this trend, thanks to the advent of innovations like individual sweet-wrappers and sports drink bottles that have a cap on the lid.*

reduced the numbers of bags being issued by retailers, but a lack of enforcement and the failure of the price levied on bags to keep pace with inflation have resulted in a steady upward creep in carrier bag use.

Activists are calling for a complete ban on carrier bags, but these comprise only three per cent of the flexible packaging washing up on South African beaches. To make a real difference, we have to rethink the way we package products and how we manage our solid waste. Costa Rica plans to phase out all single-use plastics by 2021, but this fails to acknowledge that plastics are often the best material, even in single-use applications. For example, plastic contributes materially to food security by increasing the shelf life of fresh produce. Replacing plastics with alternative products will have an even greater environmental impact. The problem lies with people, not with plastics.

Tackling waste plastic is a 'wicked' problem; there is no simple solution. It will require concerted efforts from all sectors of society to transform. Government has a key role to play at both national and local levels to change how we deal with solid waste. Municipalities are pivotal – they need to make it easy for everyone to sort their rubbish at source for reuse and recycling and to provide strong incentives to do so. And it's in their interest to do so, as landfill becomes increasingly costly in many cities. Manufacturers need to be held responsible for their products beyond the point of sale, the so-called extended producer responsibility. Many products are very difficult to recycle because they consist of layers of different materials or are heavily inked. Consumers have the power to influence retailers by refusing to buy inappropriately packaged products.

The current focus on plastic pollution is long overdue. However, I can't help but think there's an element of displacement activity, of fiddling while Rome burns. Plastic pollution is a significant environmental problem, but it's not in the same league as human population growth, consumerism and climate change. Maybe if we can all pull together to tackle the plastic problem, we can set our sights on the really big issues confronting humanity and the future of life on earth. ◆



The gizzard or muscular hind-stomach of a White-chinned Petrel packed with plastic fragments. Petrels have a constricted pyloric sphincter between the stomach and small intestine that restricts the passage of hard prey remains and plastic. A recent study found that Northern Fulmars can regurgitate plastic from their fore-stomach and this might help to explain why ingested plastic loads in seabirds have remained more or less constant over the past few decades.

DO MORE...

If you want to get your hands dirty, start a local clean-up programme. Beach clean-ups are popular and serve two important functions. Firstly, they are a great way to sensitise people to the problem. After you've spent a few hours picking up hundreds of straws, lids, earbuds and sweet-wrappers, you are more likely to think twice before littering. But more importantly, clean-ups intercept litter before it has the chance to break down into microplastics. Once that happens, it is almost impossible to capture.

If you don't live near the coast, don't despair – you can do clean-ups anywhere and also make a difference. Adopting a stretch of river is a great idea, because river litter typically ends up in the sea. But even your local area would benefit from a regular clean-up. If left in the street, litter eventually washes down storm-water drains and into rivers. Challenge your neighbours to join you for a clean-up – you'll build a sense of community while you're helping the environment.

Peter Ryan studied the impacts of plastic ingestion on seabirds for his MSc in the 1980s, when he also started sampling plastic on South African beaches. He has continued to work on marine plastics, publishing more than 40 papers and book chapters on plastic pollution. He currently sits on international panels on plastics in the ocean: the Scientific Committee on Oceanic Research and the UN's Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection.

READ MORE...

There's a wealth of information on plastics and their environmental impacts – some good, and some decidedly sensationalised. If you want a balanced overview of the impacts and abundance of plastics in the sea, download a copy of Melanie Bergmann, Lars Gutow and Michael Klages's 2015 open-access book *Marine Anthropogenic Litter* (*https://link.springer.com/book/10.1007/978-3-319-16510-3*). Although it's already a bit dated in the fast-paced world of marine plastic research, it provides an overview of the science of plastics in the sea.

Michael Wagner and Scott Lambert's 2018 book, *Freshwater Microplastics: Emerging Environmental Contaminants?* (*https://link.springer.com/book/10.1007/978-3-319-61615-5*) summarises the much smaller amount of literature on freshwater systems.

In 2018, the UN Environment Programme released two very useful and readable reports. *Single-use Plastics: A Roadmap for Sustainability* (*http://wedocs.unep.org/handle/20.500.11822/25496*) addresses the problem of single-use plastics, pulling together case studies from around the world.

Exploring the Potential for Adopting Alternative Materials to Reduce Marine Plastic Litter (*http://wedocs.unep.org/handle/20.500.11822/25485*) examines the options for replacing plastics in litter-prone applications. It highlights exciting new packaging options derived from plant wastes, seaweed and even fungi. However, it also cautions against excessive reliance on so-called bioplastics, most of which break down slowly under environmental conditions and compromise mixed-plastic recycling efforts. They should not simply be substituted for plastics in litter-prone applications.