# Marine Litter

Tony Butt

2014

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# 1. Introduction

The sea covers over three quarters of the surface of the Earth, and is the origin of all life on this planet. It plays a vital role in controlling the climate and the biology of the planet, and is inextricably linked to the atmosphere, the rocks, the clouds and every very living organism. If we destroy the sea we destroy ourselves.

The coast is the interface between the land and the sea, and is one of the most delicate and least-understood parts of the environment. However, the coastline is also one of the most popular places for us humans to live or visit, and for some of us it is the very basis of our existence. If we destroy the coast, life would become very difficult for many of us.

However, despite this obvious importance of the sea and the coast, we are gradually strangling it by things like over-fishing, chemical pollution, acidification and coastal urbanization. Marine litter is also a big part of this problem – large quantities of discarded man-made objects are now being found in the sea and on the coast, in every corner of the globe.

Marine litter is uncomfortable, unsightly, smelly, and an annoying reminder of people's lack of responsibility; but it can also be dangerous. Pieces of broken glass, metal or sharp plastic on the shoreline can cause injuries, and discarded fishing nets, hooks and other large objects can be a hazard if you are in the water. Medical and sanitary waste, hypodermic needles and other dirty sharp objects or rusty metal can be a serious health risk to anybody on the beach or in the water.

Marine litter also kills and injures many other large animals that live in the ocean or on the coast, typically by being caught in fishing lines or nets, or by eating man-made objects that they mistake for their natural food. Small pieces of marine debris can act as carriers of other toxic substances to remote parts of the globe, and can even carry non-indigenous species to new locations.

While half a century ago you would have still found human debris in the sea and on the coast, you might have found wood, glass, metal, rubber and perhaps some plastic. Nowadays, the marine litter you find consists of almost nothing *but* plastic. Unlike those other materials, which eventually degrade back into the environment, plastic was invented such a short time ago that no microbe has yet evolved capable of devouring those long molecules of which plastic is made. The plastic we are manufacturing now will continue to accumulate in the environment until that microbe evolves, which could take hundreds of thousands of years.

Because plastic persists practically forever, it floats around in the ocean forever, gradually being broken up into smaller and smaller pieces, but never actually going away. Plastic is now starting to be found on remote coastlines with no human population.

If you are a surfer or other recreational water user, you will start to notice the problem of marine litter before most other people. Just walking across a beach littered with crisp packets, drinks containers and cigarette ends is annoying and depressing; and seeing pictures of marine mammals strangled by fishing lines is even more depressing. If anybody should be capable of making the link between taking home bottled water in a plastic supermarket bag, and a beach covered in litter or a dead baby albatross with its stomach full of plastic, we should be able to.

This report is primarily aimed at surfers and other coastal water users; but if you are not, you should still read it. The first part explains what we mean by marine litter and where it originates from. The second part deals with the specific problems caused by marine litter, and

why those problems are largely getting worse. Just to state that world has yet another terrible problem without offering any solution is not much use to anybody, so the third and largest section of the report goes into detail about what is currently being done about it. It splits the various solutions offered into categories from least to most hopeful. Finally, suggestions are made in the fourth part of the report of what you, the reader, can actually do to help combat marine litter. Obviously, reading this report is the first thing you should do, and if you reach section four you might already have some good ideas of your own.

# 2. What is marine litter and where does it come from?

So what do we mean when we say 'marine litter'? Marine litter consists of things that would not naturally occur in the marine environment but are nevertheless found there. We mean stuff that has been manufactured and used by humans, and then discarded into the environment where it eventually ends up in the ocean or on the coast. It might first be discarded on the land, but it ends up in the marine environment through rivers and drainage systems; for example, sewage-related debris or small items that find their way through the storm-drain system. Items such as fishing gear and ships' cargoes might have been lost at sea, end up floating around in the sea or washing up on the coast. Other items – typically cigarette butts and food containers – might have been deliberately dropped by people on the beach.

The majority of marine litter consists of items made of plastic. A recent study comparing the prevalence of different items of marine litter highlights how much more plastic there is in the marine environment than any other form of litter (Figure 1). The amount of plastic being manufactured is increasing exponentially. Plastic does not degrade; it just breaks down into smaller and smaller pieces – so it follows that the amount of plastic ending up in the environment is also increasing exponentially.

The worst culprits for plastic items that end up as marine litter are packaging materials – plastics designed to be used once and then thrown away. Here we'll have a specific look at plastic bags, plastic water bottles and bottle caps. Another big problem comes from small plastic pre-production pellets called *nurdles*, which are used as raw material for virtually everything made of plastic.

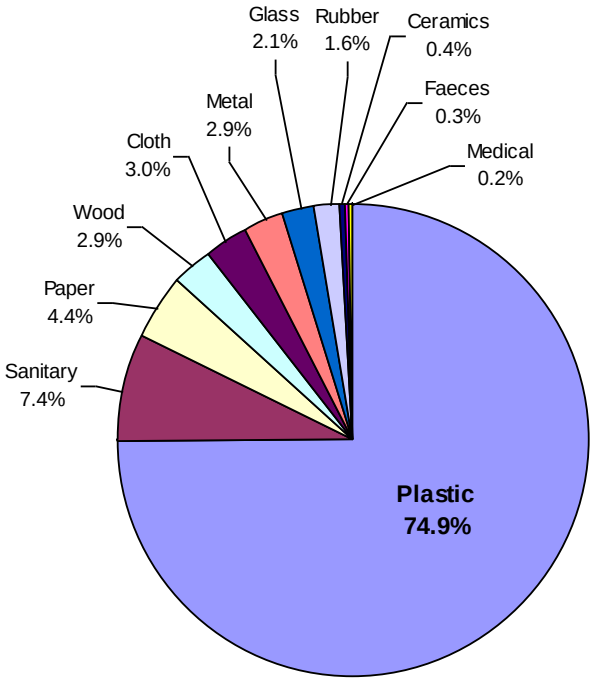


*Figure 1: The prevalence of items of different materials collected from 51 European beaches between 2001 and 2006, based on 609 surveys in eight countries[1]. Note that categories such as cloth and rubber probably also contain large amounts of plastic.*

## 2.1 How does it get into the sea?

About 20 per cent of marine litter comes from stuff thrown overboard from ships. It has been estimated that around 6.5 million tonnes of plastic are dumped from ships every year[2]. A lot of material that gets discarded from fishing vessels is nowadays almost entirely made of plastic. Fishing nets made of nylon, polyethylene and other plastics have long superseded natural materials due to their versatility and near-invisibility. The problem is that plastic doesn't degrade, so when fishing nets are discarded they turn into 'ghost-nets' and keep on 'fishing', meaninglessly snagging marine creatures for years afterwards. The stuff then often ends up on our beaches and in our line-ups, with dangerous hooks and also dangerous invisible nylon cord in the line-up – very bad if you are surfing or bathing.

The other 80 per cent of marine plastic comes from the land, and the largest proportion of that 80 per cent is from stuff that we, the consumer, throw away. This includes unwanted, worn-out or broken items, but mostly single-use packaging such as plastic bags and bottles, the number of which has been increasing at an alarming rate over the last few years. A large proportion also comes directly from the plastic manufacturers themselves. You may have seen those small, multi-coloured plastic pellets called 'nurdles' or 'mermaid's tears'. These are designed to be melted down and made into plastic items. A great many of them escape and end up floating down rivers or scattered all over the beach.

Apart from litter that beachgoers directly drop onto the coastline, the rest of the land-derived marine litter comes from inland. It washes into rivers and streams, is transported by storm water via drains and sewage systems, or is simply blown into the sea. The amount of litter getting into the sea in this way is greatly increased during strong winds and floods.

In the same way that some marine animals cannot tell the difference between their natural food and small pieces of plastic, the part of the sedimentological cycle that transports natural grains via mountain run-offs and down rivers and streams into the sea cannot 'tell the difference' between natural sediments and pieces of human litter. So it happily picks the litter up along with the other natural grains and transports them to the coast and into the sea.

## 2.2 Plastic

*This insidious debris represents man's despoilment of the earth's more pristine environment by one of its least valued materials* – Captain Charles Moore[3]

If you walked along the beach thirty years ago you would have found a fair amount of human rubbish. You would have found stuff thrown overboard by people on boats, and you would have found stuff that found its way to the coast from the land via rivers and streams. And even then, a lot of it would have been plastic. Nowadays, walk along any beach and you'll find a great deal more human rubbish, consisting of almost nothing but plastic.

Marine litter consists of a large variety of different substances, but by far the most problematical material is plastic, which will be the principal focus of this report.

It is not surprising that the majority of the litter in the sea – and everywhere else – is plastic. Our world has become totally dominated by plastic in the last few years. Almost everything we own and use is made of plastic, or at least has some plastic components, some of which you might not even realize are plastic. If you are a surfer, virtually all your equipment is plastic: your board, your leash, your wetsuit (yes, neoprene is plastic, not rubber) and most of the clothes you wear. Worse still, all the packaging that is used once and then thrown away is now almost exclusively plastic. But it doesn't have to be.

It is interesting to look back to 1941 at how Victor Yardley, an English chemist who was instrumental in the early development of plastics, saw the future. Yardley had a vision of a clean, safe, colourful world where everything would be made of plastic, maintenance free and long-lasting[4].

> *The plastic man will come into a world of colour and bright shining surfaces where childish hands find nothing to break, no sharp edges, or corners to cut or graze, no crevices to harbour dirt or germs… As he grows he cleans his teeth and brushes his hair with plastic brushes, clothes himself with plastic clothes… The windows of his school curtained with plastic cloth … and the frames, like those of his house are of moulded plastic, light and easy to open never requiring any paint*[5].

While most early visions of the future seem ridiculous now, this one has turned out to be frighteningly real. The only thing Yarsley didn't think of was another thing that was emerging at the time: the concept of a 'throwaway society'. Combine that with the development of plastic, an indestructible material, and you get what we are seeing now: a world filling up with discarded plastic.

**How much plastic is being made?**

The world is filling up with plastic. It gets manufactured, used by us and then thrown away. But of course it doesn't disappear. A lot of it ends up in the sea, where it gets gradually ground down into smaller and smaller pieces and either stays in the water or gets ingested by marine animals. Ironically, some of it eventually ends up in our own stomachs.

So how much plastic is being manufactured every year? Well, in 2008, worldwide production of plastic was estimated to be around 260 million tonnes[6]. A third of all that plastic is specifically designed for single use – that's around 90 million tonnes of plastic guaranteed to be thrown away every year.

The amount of plastic being manufactured every year is continually increasing. Not only is more and more plastic accumulating all the time, but the *rate* at which it is accumulating is accelerating. Worldwide plastic production continues to grow at about nine percent a year (Figure 2).

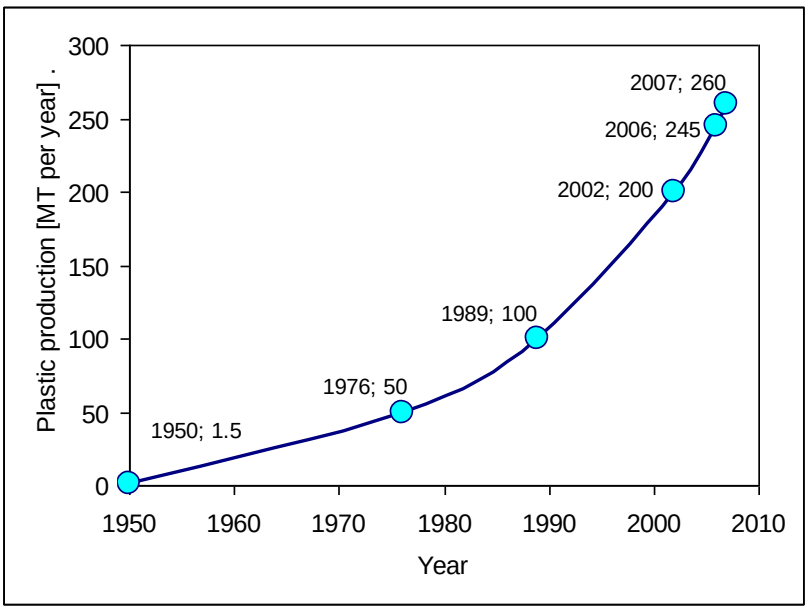


*Figure 2: Approximate increase in plastic production every year*[7]*. Note that this is the increase in the* rate *that plastic is being added to the environment, not the actual amount of plastic in existence.*

So how much of that plastic ends up in the sea and how much are we pumping in every year? The most recent estimate from the United Nations Environmental Program (UNEP) states that the ocean contains about 615 million tonnes of plastic, with an average of about 13,000 pieces of plastic for every square kilometre of ocean surface and five million pieces of plastic entering the oceans every day. As you can imagine, these figures are very hard to estimate with proper scientific rigor, but nonetheless are alarming even if you take them as the roughest order-of-magnitude estimates.

On the coast, an average of about 2000 pieces of human-generated litter – almost all plastic of course – washes up onto every kilometre of shoreline every year in the northern hemisphere, and an average of about 500 pieces in the southern hemisphere. Enclosed and semi-enclosed seas near to highly-populated areas like the English Channel, the North Sea and the Mediterranean are worse than open coasts of large oceans. In the Mediterranean, it has been estimated that, on average, 18,000 pieces of litter per kilometre end up on the shoreline every year[8].

The amount of plastic present in the sea is constantly increasing because we are putting more in than we are taking out. And, you won't be surprised to hear, the *rate* at which we are putting plastic in the sea is also increasing. In other words, the sea is filling up with plastic, but faster and faster every year. This is despite efforts to clean it up and despite legislation designed to stop people dumping stuff into the sea.

The amount of plastic is increasing on the coastline as well. A 2009 study on the amount of plastic lids and bottles on South African beaches showed a ten-fold increase over a 20-year period[9]. In the UK, an older study showed that the amount of litter present on the coast approximately doubled during a four-year period between 1994 and 1998[10].

Plastic does not go away, so even if we stopped throwing it away now and devised a way of recycling and re-using every piece of plastic that already exists, we would still have to get all the plastic out of the sea that we have already put in there.

### The Great Pacific Garbage Patch

Perhaps the most important event to bring the problem of marine litter into the public eye was the discovery of the Great Pacific Garbage Patch by Captain Charles Moore and his crew in 1997. It deserves a brief mention here.

While returning to California from Hawaii aboard his 50-foot catamaran, Moore passed through an area of relatively calm winds called the North Pacific Anticyclone. Three years earlier Moore had founded the Agalita Marine Research Institute and was working on kelp forest and wetland restoration. However, on this particular journey, the focus of his research suddenly changed when he found a vast sea of floating debris, almost entirely made of plastic:

*As I gazed from the deck at the surface of what ought to have been a pristine ocean, I was confronted, as far as the eye could see, with the sight of plastic. It seemed unbelievable, but I never found a clear spot. In the week it took to cross the subtropical high, no matter what time of day I looked, plastic debris was floating everywhere*.

He found large intact items such as bottles, cups, bags, boxes and fishing nets, but also millions of multi-coloured, unidentifiable smaller pieces of plastic.

Even though NOAA scientists had predicted in 1988 that there would be a lot of marine debris in this area, Moore's first-hand account firmly brought it to the public's attention. Shortly afterwards, the term 'Great Pacific Garbage Patch' was coined – a name which has now become well known the world over.

The Great Pacific Garbage Patch is not the only place in the world's oceans where you will find a concentration of plastic. It just happens to be the most well-known and the most intensely studied. 'Garbage patches' also exist in the other four major gyres of the oceans: in the North Atlantic, South Atlantic, South Pacific and Indian Oceans, and in several smaller gyres. There is no reason to believe that the concentration of plastics in these other gyres is much different from the one in the Pacific.

## 2.3 Specific sources of marine plastics

Below I am going to focus on the most prolific items that become plastic litter and then end up in the sea. First, the non-single-use items, i.e. stuff that breaks or stuff that you get bored with and throw away; then, single-use items, i.e. stuff that is actually designed to be used once and thrown away. The latter is mostly packaging: for example plastic bags, plastic water bottles and bottle caps. Then I am going to talk a bit about Nurdles or Mermaid's tears – plastics that don't even get a chance to be made into single-use or non-single-use items, a raw material that short-cuts its way into the sea almost immediately after it has been converted from oil into plastic.

A proportion of the litter found in the sea and on the coast is derived from items that have been thrown away at the end of what we consider to be their useful life. We are keeping stuff for much less time than we used to, either because we can't repair it when it breaks or simply because we think we need the latest design. The two things often go hand-in-hand, as manufacturers purposely design things to break, and then persuade us to buy the new improved model. This is a well-known strategy called *planned obsolescence*.

The most obvious examples are electronic items like mobile phones and computers which are rapidly advancing technologically, but it also applies to clothes which go out of fashion and,

over the past few years, wetsuits. Most of these things are made of plastic or at least contain a huge proportion of plastic. They are heavily packaged in plastic and most of them are not recycled.

Throwing away a mobile phone, computer, pair of shorts or a wetsuit because it either goes out of fashion or breaks and you can't repair it is bad; but at least we have had some use out of the item. If we are clever enough, we can make it last a bit longer by trying to repair it or ignoring fashion. However, single-use plastics are much worse. Single-use plastics are absurd if you think about it: considering that plastic is a material designed to last virtually forever, and which never degrades back into the environment, who in their right mind would want to design something made of plastic that you use once and then throw away?

When I say single-use plastics I'm talking about packaging: plastics that are used to package food and drinks, or to package other things made of plastic, that we throw away at some later date. Food packaging is designed to keep food fresh and to protect it, and packaging of other products is also designed to protect it. However, packaging has also developed another purpose: to lure the shopper into buying that product. The colour, size, shape and design of a package might mean that the customer goes for that brand instead of another one, even though the product inside is just the same. Companies have whole teams working on this, including specialized psychologists.

Packaging is a massive industry. In fact, the packaging industry is the third largest industry in the world, after food and energy. And, you won't be surprised to hear, the packaging industry is growing, pumping out more single-use plastics every year at an ever-increasing rate. The famous industrial market research group, Freedonia[11], produced a number of studies in 2013 estimating how much more packaging we would be producing in the following years. For example:

> "Global cup and lid demand will rise 5.0 percent per year to $25.9 billion in 2017"
>
> "US demand for beverage containers will rise 1.7 percent annually through 2017 to 265 billion units, valued at $29.1 billion"
>
> "Global demand for drug packaging products will increase 6.4 percent annually to $90 billion in 2017"
>
> "US food container demand will rise 2.9 percent per year to $27.6 billion in 2017"
>
> "Global demand for caps and closures is projected to rise 5.3 percent per year to $46 billion in 2016"

Probably the most famous icons of the single-use plastics are the plastic water bottle and the plastic shopping bag. They by no means represent the only single-use items found on beaches and in the ocean, but they are the most potentially problematical, along with plastic caps and closures (bottle tops) and those tiny plastic pellets called nurdles or mermaid's tears. Below I am going to outline a few details of each.

## Plastic bags

Those wafer-thin plastic bags that you get every time you go to the supermarket are a convenient way to carry your shopping home – a journey that might last anywhere from about five minutes to a couple of hours. Then what happens to the bags? Some of the luckier ones might end up being given another trip to the shops, or a second use, perhaps to contain food or to be used as bin liners. But then most of them will end up being thrown away, a proportion of which will end up in the sea and on the coast.

Even though governments are beginning to recognize the problem of plastic bags, they are still being manufactured in their billions, and their use is still increasing in places where there is no ban or charge. Estimates vary, but some suggest[12] that up to a trillion ($10^{12}$) plastic bags are manufactured every year, which equates to well over a million a minute, over 90 percent of which are discarded.

**Bottled water**

Unless you happen to be somewhere where tap water is unavailable or not potable, there is not one reason on earth why you should ever buy bottled water. There is no evidence that bottled water is better for you or tastes any better than tap water. What is more, a large proportion of bottled water is just tap water anyway. Yet it costs hundreds or even thousands of times more than tap water. And, incredibly, we keep on buying it.

So, bottled water is less than useless. It is also highly damaging to the environment: through the manufacture, transport and disposal of the plastic bottles, bottled water is a major contributor to environmental pollution.

One reason you wouldn't have seen all those plastic water bottles on the beach 30 years ago is that the oil-based plastic to make them, polyethylene terephthalate or PET, had only just been invented.

The bottles take a lot of resources to make. To manufacture a one-litre bottle takes three to five litres of water and the equivalent energy of about a quarter of a litre of oil. When you multiply that by the number of bottles made per year, it adds up to a lot. For example, in 2006, sixty billion (60,000,000,000) plastic water bottles were sold in the U.S. alone. If you cannot imagine what 60 billion water bottles look like, think about this: assuming each one is 20 cm tall, put end to end they would reach the Moon and back about 16 times.

So where do the bottles go after we throw them away? The manufacturers would like us to think that they just disappear into the ether. But of course they don't. Some of the lucky ones might get reused or recycled, but most of them end up in the environment – on the roadside, in landfill sites and in the sea.

Even if they are recycled, a lot of the bottles in the recycling bins are shipped all the way to places like India and Pakistan – right back where many of them were manufactured in the first place. The people living there get all the pollution from the manufacture, the pollution from the recycling plants, and all the bottles that couldn't be recycled. Ironically, their tap water is even less drinkable because of the contamination associated with the bottles. However, unlike us, they can't afford bottled water.

In summary, bottled water is a moral and environmental crime. The companies that make it are stealing the water, which belongs to everybody, and they are selling it back us at extortionate prices in throw-away containers made of a toxic substance that never degrades. As always, the people most affected are those in the poorer nations who get the brunt of all the pollution.

**Bottle caps**

Perhaps more prevalent on beaches and in the sea than the bottles themselves, are the caps, nowadays mostly made of plastic. A much smaller proportion of plastic bottle caps are being recycled than the bottles and containers themselves. According to Charles Moore[13] bottle caps are the number one intact item of trash found in the open ocean, and, according to

documentary filmmaker Chris Jordan, around 56 percent of non-edible material found in dead albatross chicks' stomachs, consists of bottle caps[14].

Again, just like other plastic throwaway products, worldwide production of what is referred to in the business as 'caps and closures' is a growing multi-billion-dollar industry, with a greater number of caps being produced every year. In other words, the number of bottle caps in existence in the world is increasing exponentially. In 2011 the Freedonia Group produced a report[15] confirming that the caps and closures market was expanding by around 4.6 percent a year and expected to be worth about 40 billion dollars by 2014. The demand for non-plastic caps is disappearing fast as old-fashioned glass bottles and jars, aluminium toothpaste tubes and other non-plastic containers are also vanishing. Here are some quotes from the Freedonia report:

> "World demand for caps and closures is projected to rise 4.6 percent per year to $40 billion in 2014".
>
> "Some of the best opportunities for caps and closures will be found in the Asia/Pacific region"
>
> "Cap and closure demand in the food market will benefit from trends toward convenience-oriented packaged food. This will especially boost demand for plastic."

Figures on the actual number of individual caps and closures being produced worldwide every year are hard to come by. However, according to Freedonia, around 370 billion caps are produced every year in China alone. Just to visualize how large a number that is, assuming each cap is 1 cm high, stacked up they would produce a pile 3.7 million kilometres high (to the Moon and back about four times). And don't forget, that is not the total number of caps in existence, it is the amount *added* to the total every year. And that is just from China – the total number produced worldwide must be considerably more than that.

**Nurdles or mermaid's tears**

An important item on the list of the most problematical items found on the coast and in the sea is not a product that has been used by us and then discarded; instead it is an item that is at the other extreme of the life-cycle of a product. Small plastic pellets called 'Nurdles' or 'Mermaid's Tears' are used as pre-production raw material for melting down and producing practically every item of plastic that exists.

Nurdles, or pre-production pellets, are spherical, ovoid, or cylindrical in shape and range in size from one to five millimetres in diameter. They are milled from a crystallized polymer called 'fluff' that comes straight out of the oil refinery. They are then transported from centralized chemical plants to all corners of the world to the factories that make the actual plastic products. The number of nurdles manufactured per year, worldwide, has been estimated to be around five quadrillion ($5 \times 10^{15}$) – a number unimaginably large and getting larger every year.

Nurdles are not supposed to be seen by us or anyone not involved in the industry, but of course they tend to escape the distribution system and end up in the environment. Apart from specific accidents, for example where container-loads of nurdles fall into the sea from ships, most nurdles end up on the coast and in the sea because a certain percentage of them get spilled as a routine part of the transport process. For example, trucks and trains are often pumped full with nurdles via large hoses connected to the pellet bins. If the tubes are connected and disconnected manually, there will always be a certain amount of spillage. The nurdles on the floor will then be washed away by rain, down drains, into rivers and eventually

onto the coast and into the sea. The workers are probably not given time to be careful, and the managers are either unaware or uninterested in the problem.

Nurdles constitute about ten percent of plastics found on beaches, most of which are washed onto the coast from the land, not from the sea.

*Nurdles*

# 3. Why is marine litter a problem?

Apart from the fact that being surrounded by things that other people have thrown away is simply unpleasant and extremely annoying, marine litter is dangerous to us and to other species. Large marine animals such as turtles, seals and seabirds can become tangled in fishing nets or other debris, and die from suffocation or starvation. Marine animals eat marine litter instead of their normal food, and hence end up dying from starvation or by being poisoned by the toxins carried by the litter.

As I mentioned in the previous section, plastic does not degrade. Apart from the small proportion that has been incinerated, every gram of plastic ever made still exists. In the marine environment, large pieces of plastic slowly break down into smaller and smaller particles, called microplastics. These are not only dangerous in themselves but they act as carriers for other toxins. The microplastics are ingested by every marine animal from the smallest zooplankton upwards. This leads to *biomagnification*, whereby each member of the food chain not only ingests the microplastics itself, but also through eating animals below it in the food chain, ingests all the toxins that have accumulated in all the levels below.

## 3.1 Plastic is forever

### Plastic won't biodegrade

A direct consequence of our incessant consumerism and throw-away culture is the accumulation of human rubbish, particularly plastic. We can't keep on manufacturing stuff and then just throwing it away, because it is accumulating much faster than the Earth can absorb it back. The extraction of raw materials and the fabrication of plastics to make products that will just be thrown away is a one-way, unsustainable process. It is altering the chemical composition of the Earth, interfering with biodiversity, and causing changes in the atmosphere and ocean, whose effects are just feeding back right onto us.

As far as plastic is concerned, once the manufacturing process has gone over that threshold of turning oil into a crystallized polymer called 'fluff' then into the pre-production pellets called nurdles or mermaid's tears, there is no going back. The plastic that has just been created is there to stay. It will outlive us, our children, their children and hundreds of generations into the future. It gets broken down into smaller and smaller pieces, but it never really goes away. Apart from a small amount that has been incinerated, every piece of plastic ever made still exists. It includes all your old wetsuits, surfboards and leashes, your old clothes and shoes and every piece of plastic packaging that you tore off every item you have ever bought.

Why won't plastic go away? The reason is that, unlike wood or any other organic material used to build stuff we use, plastic won't biodegrade. In other words, no microbe has yet evolved that can eat plastic, because plastic is too new. Plastic was invented such a short time ago (we only started introducing it into the environment about 50 years ago) that no biological process exists yet to degrade it. The bacteria that gobble up everything from wood to rocks just haven't had time to evolve a species capable of devouring those long, complicated molecules that, ironically, make plastic such a useful material. Eventually, there will be a plastic-eating microbe, but it could take hundreds of thousands of years to evolve[16]. Or plastics might begin to disappear due to *geodegradation*, when the forces of geology, the

pressure from rock fluid movement, squash and distort the molecules into something else. But that is such an academic question that it doesn't help us.

You may have heard of photodegradation, where sunlight breaks plastic down. Well, yes, plastic can break down slowly if it is exposed to strong sunlight. The ultraviolet light breaks up the long molecule chains, and the plastic starts to become weak and become more susceptible to other forces breaking it up into smaller and smaller pieces (of plastic).

But there are two problems with photodegradation:

First, even if the molecules are broken up, the plastic still remains a plastic. It would be very difficult to break the molecule chains up so much that the chemical nature of the material is changed into something else: this would take thousands of years of intense UV radiation.

The other problem is that plastic on the land is exposed to a lot of UV, but plastic in the water isn't, because it doesn't need to be very far under the surface and the UV doesn't get through, making photodegradation meaningless.

Because plastic marine litter doesn't go away, it continues to wander around the planet at the mercy of the fluid motions in the atmosphere and ocean, particularly the ocean currents. Even before it gets a chance to be broken down into tiny pieces, it gets transported thousands of kilometres around the globe and sometimes ends up in places uninhabited by humans.

For example, a piece of plastic found in the stomach of an albatross around 2005 contained a serial number that was subsequently traced to a World War II seaplane shot down in 1944. The trajectory of the object was simulated using ocean current models, which showed it spent a decade circulating just south of Japan, and then drifted almost 10,000 km to near the west coast of the United States, where it circulated for another 50 years[17].

**Plastic just keeps on accumulating**

Assuming every bit of plastic ever made still exists, how much plastic is there on the planet, and how much will there be in the future? Referring back to Figure 2, to find out how much plastic there actually is, you would have to integrate the curve in the figure.

So we need to add up all the plastic manufactured every year since 1950. If we assume a nine percent increase every year since 1950, then add the amount produced every year to the amount previously accumulated, we end up with a formula like this (a bit like calculating compound interest):

$$\text{Total plastic in the year 2014 (MT)} = 1.5 \times (1.09 + 1.09^2 + 1.09^3 + \ldots + 1.09^{64})$$

According to this simple estimate, it turns out that there are approximately five billion tonnes of plastic in existence as of 2014 (see Figure 3). It is frightening to note that more plastic has been produced since 2005 than all the plastic produced before 2005 since the beginning of time.

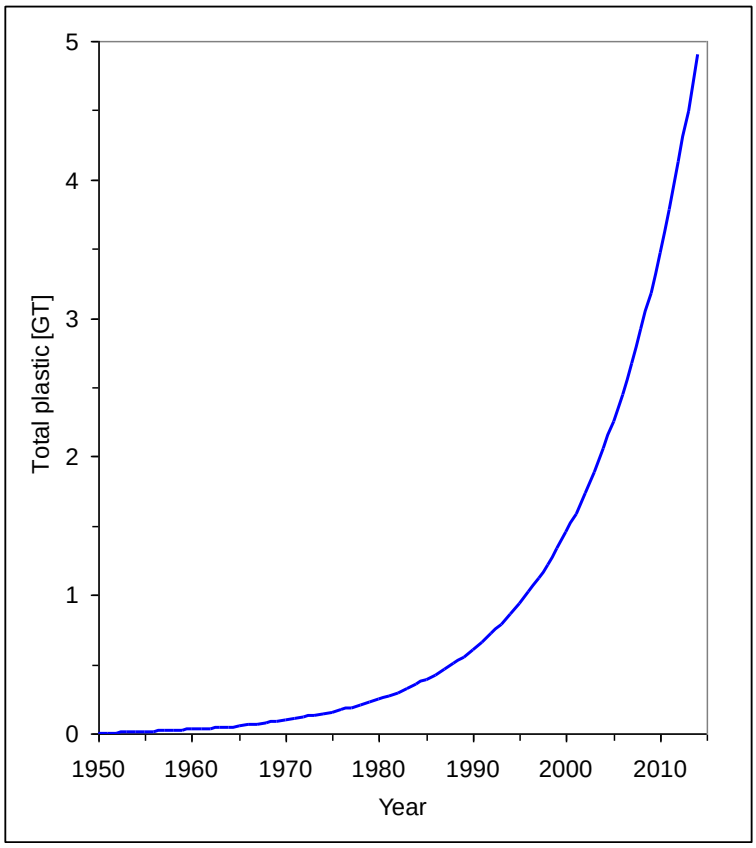


*Figure 3: total plastic in existence (billions of tonnes or GT) assuming a nine percent increase per year in the manufacture of plastic since 1950*

Now, it has been estimated, based on the manufacture of PET water bottles, that it takes about 19 barrels of oil to make one tonne of plastic[18]. The amount of oil left on the planet is practically impossible to estimate and a vast subject in itself, but just to get an order-of-magnitude idea, a recent OPEC claim was around 1.5 trillion barrels[19]. Even if we used all that oil for manufacturing plastic and for no other purpose, the extrapolation tells us that will have used up all that oil by 2047.

I know that any oil-reserve estimate is probably little more than just a wild guess, and that we keep being told that more and more oil is being found. So, just to make sure, let us assume that the oil reserves are ten trillion ($10^{13}$) barrels. Even assuming this highly-unlikely scenario, and again assuming that oil is used exclusively for the manufacture of plastic, we can see that all the oil will still be gone by 2069 (Figure 4).

The year 2069 is not very far off; in fact it is around the time when your grandchildren will be about the same age as you are now.

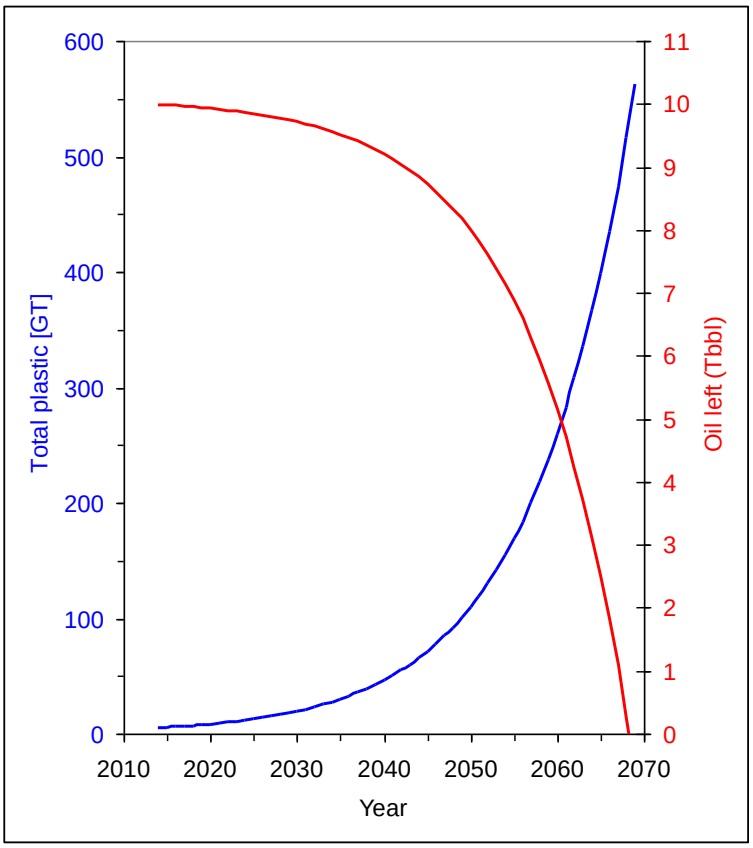


*Figure 4: Extrapolating the amount of plastic created from 2014 onwards (billions of tonnes or GT), and the amount of oil left (trillions of barrels or Tbbl) assuming that there is about six times as much oil left as OPEC said in 2012, and that oil is used exclusively for making plastic*

## 3.2 Direct effect of marine litter on us

Before we get onto the toxicity of marine litter on large animals, small animals and the rest of the ecosystem, and the way those effects filter through to eventually reach us, we will have a look at the more direct effects of marine litter on us humans.

For a start, marine litter is simply annoying. Sitting on a beach, walking along the coast, swimming or surfing in the sea surrounded by litter is simply not a very pleasant experience, just like sitting in a park or walking through a forest with the floor covered in cigarette butts, crisp packets, plastic bottles and beer cans. Not only is it uncomfortable, but the thought of somebody else throwing their rubbish on the floor is at the same time infuriating and depressing. It suggests a society full of irresponsible, selfish or, at best, ignorant people. It is even more exasperating when one thinks of the people who are in control of the large corporations that manufacture the stuff in the first place, knowing that it will end up in the environment as litter.

Before plastics were invented, and before the concept of a 'throwaway society' existed, people in cities produced almost as much waste as they do now. The waste consisted of things like horse manure, human excrement, food scraps and animal carcases. The unhygienic conditions contaminated rivers and coastal waters and produced diseases such as cholera, typhoid and hepatitis. But the waste was all natural and biodegradable and, even though people died, it didn't have the same long-term, latent effect on the wider ecosystem that we

are now discovering with plastics. And the waste certainly didn't find itself landing on remote, uninhabited islands thousands of kilometres away.

Through thousands of years of evolution, we are genetically programmed to be nauseated by the sight and smells of rotting food, excrement and rotting animal carcases. This is because they carry potentially dangerous bacteria, and so the unpleasant reaction causes us to automatically avoid them. Plastics, on the other hand, have been around for such a short time that we haven't built up a natural tendency to reject them. They seem clean, tidy and harmless to us. But in the long run plastics can be just as dangerous, if not more so, than raw sewage.

The bottled water industry is probably the best example to show that plastics are actually poisoning us, and are not the nice, clean, inert substances that they seem. Plastic water bottle manufacturing plants, many of which are in the Far East, can cause a lot of problems with local contamination. Ironically, the manufacture of the plastic bottles themselves is a major contributor to the contamination of drinking water in those areas. Of course, the people who live there and work in those factories can't afford to buy bottled water.

The smaller bottles are mostly made of PET but the larger water bottles, along with other plastic food and drinks containers, are made of plastics containing or Bisphenol-A or BPA. Bisphenol-A is what is known as an *endocrine disruptor*, and has been found to cause multiple negative effects in humans by altering the body's natural hormones[20]. High levels of BPA have also been highly correlated with cardiovascular disease, diabetes and liver abnormalities[21].

Surfers and other recreational water users are a kind of 'indicator species' among social groups. Compared with other people we are more sensitive to changes in our environment, because changes in the coastal and ocean environment directly affect our experience, often very quickly and in a negative way. The problem of marine litter is no exception – before anybody starts noticing the long-term biological or chemical effects, we can't help but notice all that stuff on our beaches and in our line-ups.

## 3.3 Effects on large non-human animals

Probably the most effective way of convincing the general public that our litter, particularly plastic, doesn't belong in the sea is to show photos of large sea animals that have been killed or seriously debilitated due to plastics. For example, seals and turtles tangled up in fishing lines, seagulls being strangled by six-pack rings, or the stomachs of dead whales and albatrosses filled with plastic bags and plastic bottle caps instead of food.

According to a study published in 1997, at least 267 different species were known to have suffered from entanglement or ingestion of marine debris[22]. The species affected included 86 percent of all sea turtles, 44 percent of all seabird species, 43 percent of all marine mammal species, plus numerous fish and crustacean species.

### Entanglement and suffocation

Once entangled in marine debris, large animals can die from suffocation, strangulation or from drowning. One particularly gruesome death is when a young animal gets a piece of plastic such as nylon fishing line, stuck around them, and the plastic tightens around them as they grow, gradually strangling the animal or causing infection as the plastic cuts into it.

Sometimes the plastic impedes the animal's movement so that it cannot feed or escape predators, leading to death by starvation or predation.

**Ingestion of plastic objects**

In April 2002, a dead whale washed up on the coast of Normandy in France. Later it was found to contain around 800 kg of plastic bags in its stomach[23]. Perhaps the whale thought the plastic bags were jellyfish or schools of small fish; nobody knows. But what we do know is that this behaviour is very common – marine species mistaking plastic for food.

When animals eat plastic instead of their normal food, the plastic can block their airway, causing them to suffocate; it can block their digestive system causing them to starve to death, or it can simply fill up their stomach and make them think they are full, in which case they also starve to death.

Plastic bags are a big problem because they look like jellyfish, squid or schools of small fish. But smaller items and broken-up pieces of plastic are also being mistaken for fish or crustaceans by turtles, seals and many other species of marine animals, including a large number of seabirds.

Probably the most comprehensive ongoing work being done on the effect of plastics on seabirds is by filmmaker Chris Jordan, studying albatrosses on Midway Island in the Pacific[24]. In the stomachs of dead baby albatrosses, Jordan and his team have found items such as bottle caps, pieces of fish nets, toothbrushes, cigarette lighters and those pre-production pellets called nurdles. The parents feed their young by gathering food at sea and then regurgitating that food into the throats of the young birds. The 'food' they gather from the ocean surface, is plastic, mistaken for real food.

**Poisoning**

In his book *Plastic Oceans*[25] Charles Moore points out that many marine mammals are being poisoned by chemicals associated with marine plastics, and that they are suffering from diseases usually specifically associated with humans. The animals either directly ingest PCBs, pesticides and other toxics after ingesting microscopic pieces of plastic (see below) or after eating other contaminated species lower in the food chain. In addition to weakened defences leading to vulnerability to disease and low reproductive rates, mammals such as whales and seals have been found to suffer from thyroid disorders and cancer.

## 3.4 Microplastics

A lot of the litter found on the coast and in the ocean consists of whole objects and largish pieces of broken plastic. But the majority is made up of very small, almost invisible particles, called microplastics. Microplastics are normally defined as less than 5 mm in diameter, with some of the smallest particles detected as small as 2 μm (one five-hundredth of a millimetre)[26]. Nurdles or mermaid's tears, being generally less than 5 mm, would also fall under the category of microplastics.

A lot of microplastics come from the continuous breaking up of larger pieces due to wave, wind and current action, and after being weakened by UV light. They can also come from various other more direct sources, such as particles used as abrasive scrubbers in domestic

cleaning products, plastic granules added to hand lotions and face creams as exfoliants. All these products are washed down the sink, where they eventually end up being flushed into rivers and into the sea. The plastic particles are too small to be stopped by any filters so they also end up in the sea.

The physical effects of plastic if it is mistaken for food by marine animals can be bad, as I described earlier. But there is another problem: toxic chemicals are attracted to the tiny plastic particles. Among many other nasties, these include polychlorinated biphenyls (PCBs) and pesticides like DDT. These are still in the environment even though they were banned in most countries several years ago, because, just like the plastics themselves, they do not go away.

It has been found that, if plastic is left in seawater containing these pollutants for one or two weeks, the concentration of these substances on the surface of the plastic can become many times greater than that in the surrounding water. For example, in a classic 2001 study on the attraction of pollutants to nurdles, it was found that nurdles taken from industrial shorelines in Japan, had toxic loads a million times stronger than toxic levels in nearby coastal waters.[27]

Those tiny plastic particles in the ocean, a large proportion of which are covered with highly-poisonous substances, are accumulating exponentially just as the amount of plastic on the planet is accumulating. It is not surprising then, that a huge amount of microplastics ends up being ingested by almost every creature living in the ocean, from the smallest plankton to the largest whales.

**Bioaccumulation and biomagnification**

The smaller the pieces, the greater number of species of animals can ingest those pieces. For example, a 50-cm chunk of plastic might find its way into food chain only at the very top, via, say, a shark; but a sub-micrometre grain of plastic can enter the food chain through every creature from the smallest zooplankton upwards.

*Bioaccumulation* refers to the accumulation of toxics in the body of a particular animal as that animal keeps ingesting toxic chemicals, in this case via microplastics. The chemicals are not expelled by the body and simply keep building up.

*Biomagnification* is one step worse. It is when a species occupying a particular level (called a *trophic level*) in the food chain not only gets the contaminants from the microplastics that it ingests directly, but also gets all the contaminants that have accumulated in all the trophic levels below it. On the first level, right at the bottom of the food chain, are the primary producers – phytoplankton and algae – which live from photosynthesis. It is from the second layer up that biomagnification starts, with creatures such as zooplankton ingesting microplastics instead of phytoplankton and algae. Species occupying the third layer ingest microplastics plus contaminated zooplankton; and those in the fourth layer ingest their own microplastics plus contaminated third-layer occupants plus the contaminated zooplankton ingested by the second-layer occupants. And so on. The top predators, including us humans, get all the poison that has accumulated in every level of the food chain.

The results of Moore's studies show how easy it is for animals that would normally eat plankton to be eating microplastics instead. A lot of Moore and colleagues' experiments have been based on measuring the ratio of plankton to plastic in the water, comparing this ratio between locations, and over time. In 1999 they found six times as much plastic as plankton at a particular location in the Garbage Patch. In 2008 they went back to exactly the same location and found a staggering 46 times as much plastic as plankton[28].

# 4. What is being done about it?

Despite the fact that marine litter is an immense problem which is getting worse all the time, a lot is actually being done to address the problem. In order to have at least some chance of making headway against it, we need to focus our efforts in the right direction. This means recognizing which 'solutions' are useful and which are not.

In this section I have attempted to organize the solutions people are offering for marine litter into four categories, from least useful to most useful:

To start with, there are a lot of ideas and proposals put forward by government and industry that are really not worth the effort pursuing. Some of these are just so hindered with bureaucracy that they will take forever to get off the ground, and others are deliberately designed to fool us.

Next, there are things that are useful as symbolic gestures, but will never solve the problem on their own. The best example is actually trying to clean up the litter from beaches and from the ocean. While this is a good way to make the public aware of the problem, the rate of production of marine litter is so high compared with the rate at which we could remove it, that our efforts are little more than insignificant.

Then there are some very good ideas that people have come up with, such as *cradle-to-cradle*. These are idealistic final goals to aim for, essential to recognize but very difficult to put into practice at the moment. Before we can come anywhere near those goals we need to work out all the intermediate steps.

Lastly, there are the most practical ideas which can easily be developed right now, or which have already been proved to be highly successful. These include things that the public will find easy to understand and easy to get used to, such as not using plastic shopping bags or not buying bottled water – things that everybody accepted as normal up to only a few decades ago.

## 4.1 Things that are just not working or that are designed to fool us

We need to remember that the people running the industries responsible for producing the material that ends up as marine litter are extremely clever and immensely resourceful. They are very good at convincing us that they are genuinely interested in reducing contamination of the natural environment, when in fact, the primary reason they exist is to make a profit.

This is summed up superbly by Derrick Jensen[29]:

"*The specific and explicit function of for-profit corporations is to amass wealth. The function is not to guarantee that children are raised in environments free of toxic chemicals, nor to respect the autonomy or existence of indigenous peoples, not to protect the vocational or personal integrity of workers, nor to support life on this planet. Nor is the function to serve communities… We may as well expect a clock to cook, a car to give birth, or a gun to plant flowers… Limited-liability corporations are institutions created explicitly to separate humans from the effects of their actions – making them, by definition, inhuman and inhumane."*

**International treaties not worth the paper they are written on**

We need to be very careful not to be taken in by the promises from politicians that we read about in international frameworks, objectives, directives, treaties, conferences proceedings and agreements, mostly not worth the paper they are written on. These are drawn up perhaps to make the politicians feel like they are doing the right thing, and to make the public think that the politicians are doing the right thing. It is a good way of continually delaying actually having to do something.

Even if proper laws are eventually put into place, actually enforcing those laws is another matter. One of the best examples is the Marine Pollution Treaty (MARPOL). Way back in 1970, Thor Heyerdahl did a report for the UN on marine pollution[30], which led to the drawing up of MARPOL. Heyerdahl's report stated:

> *The present report has no other object than to call attention to the alarming fact that the Atlantic Ocean is becoming seriously polluted and that a continued indiscriminate use of the world's oceans as an international dumping ground for imperishable human refuse may have irreparable effects on the productivity and very survival of plant and animal species.*

Ten years later, MARPOL came into action, with laws mostly dealing with oil spills and similar problems. It wasn't until another eight years later in 1988 that the treaty brought out 'Annex V' which dealt with marine litter and plastics. Ten years later MARPOL was still being 'widely ignored' with ships still estimated to dump over six million tonnes of plastic a year[31].

Don't get me wrong: legislation works perfectly as long as it is enforced. The important thing to realize is that it is no good just making laws and then sitting back and assuming they will enforce themselves. When complicated treaties like MARPOL are signed, one might be forgiven for thinking that the politicians and bureaucrats, continually pressurized by industry, pass these laws just to calm the public down, but with little intention of actually enforcing them.

In 2012 the European Commission stated:

> *At the Rio +20 Earth Summit, World Leaders committed to achieving a significant reduction in marine litter by 2025. The European Commission intends to be at the forefront of this effort, working closely with Member States, Regional Sea Conventions and stakeholders to identify and develop concerted initiatives to tackle the problem[32].*

How can we trust a bunch of politicians whose decisions are often influenced by the interests of multinational industries, to reduce marine litter by the year 2025? Especially since it goes directly against their main interests, which are economic growth, more jobs and more production? The same people, at the same time, send out messages that economic growth and increased consumption of resources can only be good, and it would be unthinkable to promote anything but those things[33].

**Greenwashing and half-hearted efforts by industry**

We also need to be very careful not to be fooled by companies that tell us they are creating 'green' products and doing everything else they can to 'save the planet' when, in actual fact, all they are still primarily concerned about profit. Of course, the people who run one or two companies are genuinely concerned, but it is very difficult for us to tell which.

One of the latest buzz-statements you might see is the 'decoupling of growth and environmental impact'. Just like the more well-known 'sustainable growth', it is an oxymoron. How can you have 'growth' without using more and more resources, and how can you be sustainable if you are using more and more resources?

Here is a typical statement by Paul Polman, the CEO of Unilever (a company specializing in cleaning and hygiene products all sold in plastic bottles), who asserts that becoming more sustainable will result in higher profits:

> *We are already finding that tacking sustainability challenges provides new opportunities for sustainable growth: it creates preference for our brands, builds business with our retail customers, drives our innovation, grows our markets and, in many cases, generates cost savings*[34].

Charles Moore[35] paraphrases this statement as follows:

> *Hey stockholders! This sustainability thing is a marketing bonanza! When our customers hear we are sustainable, they'll love us even more and buy more of our products. ... Plus – and this is the best thing of all – when you use less raw material, less energy and water to make thinner packages and containers (and quite possibly fewer human workers ...), you lower costs and beef up profit margin.*

Here is a statement from Coca-Cola:

> *Through the world's largest beverage distribution systems, consumers in more than 200 countries enjoy the company's beverages at a rate of 1.5 billion servings a day. With an enduring commitment to building sustainable communities, the company is focused on initiatives that protect the environment, conserve resources and enhance the economic development of the communities where we operate.*

A quick look at the Coca-Cola website[36] shows that they have one of the most impressive and convincing environmental programs of all multinational companies, and you would be hard-pressed to believe that they are not genuine. But whatever they do, short of stopping manufacture altogether of plastic bottles, Coca-cola will still be helping to fill the environment with plastic. Even if 99 percent of those 1.5 billion servings were completely recycled, that would still mean fifteen million plastic bottles entering the environment every day.

**Putting the responsibility on the consumer**

There is no excuse for throwing litter on the ground when you could take it home and reuse it, or recycle it in the nearest recycling bin. When I see a car park or beach in summer covered in plastic bottles, crisp packets and cigarette ends I immediately think of how selfish and nasty those people are. Only afterwards do I realize that, if those packages were not manufactured specifically to be thrown away, or if they were made of completely organic, biodegradable material, a large part of the problem would immediately disappear.

The fact that most of us put all the blame on the consumer and not at least part of the blame on the manufacturing industry is, of course, a huge bonus for the industry itself. Perhaps this

is not even an accident, because the plastics industry has been campaigning covertly for decades to shift any possible blame away from them and onto us.

It all started in 1953 when throwaway containers were first starting to become popular in the United States. An organization called Keep America Beautiful (KAB) was founded, enlisting support right from the beginning from companies like Coca-Cola. Using slogans like *People start pollution, people can stop it*, and *Don't be a litterbug*, KAB succeeded in shifting attention away from those who design, produce, market and profit from single-use containers. According the them, the new throwaway containers weren't the problem; the problem was shameful people who didn't responsibly dispose of them. They even produced an 'educational' film starring Ronald Reagan, who said 'trash becomes litter only after people thoughtlessly discard it'[37].

Nowadays, KAB is still alive and kicking, with million-dollar support from a wide range of multinational companies, including the world's leading single-use plastics advocates like Coca-Cola, Nestlé and McDonald's, and a mission statement that says: *Engaging individuals to take greater responsibility for improving their community's environment*[38].

## 4.2 Things we should keep doing but that will never work on their own

Unlike the examples in the section above, which we could happily live without, there are other things that people are doing which are potentially very useful, but cannot be thought of as a solution on their own. These things should be continued and developed further but, at the same time, we must realize that their usefulness will always be limited.

### Clean up all the plastic?

Beach cleans are becoming popular in a big way. In the UK, for example, Surfers Against Sewage organise over 100 beach cleans a year, mobilizing thousands of volunteers and removing many tonnes of marine litter. In 2013, SAS organized the biggest ever UK beach clean, setting an unofficial UK record of 314 beach clean volunteers.

Cleaning the beach of all that litter is a great way to make people realize the enormity of the problem – not just those who participate but also those who read about them. It makes people realize that marine litter is a big problem; especially if they witness 300 volunteers cleaning their local beach on a Sunday, to leave it almost totally free of litter and then see the beach covered in litter again on Monday.

Looking at the wider picture and not just coastal beach litter, calculations by Charles Moore show that, even if the input of plastic into the oceans stopped today, it would still take an absurd amount of time to remove all the plastic that is in there already.

*For the cleanup we start with the 145 million square kilometres that comprise the sub-tropical gyres. And, to be generous, let us say an advanced clean-up vessel can do 5 square kilometres per day (a 10m-wide net travelling at 20 km/h, wider and faster than anything in use today). It will take that vessel 29 million days, or 79 thousand years to do the job, or, a thousand boats 79 years working 24 hrs a day.*

Manuel Maqueda, from the Midway Project[39], likens the task of cleaning up all the litter to the story of Sisyphus in Greek mythology. Sisyphus was cursed into rolling a huge boulder up a hill and then to watch it roll down again, over and over again for eternity:

*A beach clean-up on Midway Atoll made us feel just like Sisyphus. Even if all the boats in the world were put to the task somehow, the clean-up would not only remove the plastics but also the plankton, which is the base of the food chain, and is responsible for capturing half of the CO2 of our atmosphere and generating half of the oxygen we need to breathe. But even if this problem was solved too somehow, the amount of plastic that we could capture, at an immense cost, would be a drop in the bucket* [sic] *as compared to the amount that flows into the ocean every day. No matter how hard we push, in terms of technology or money, the boulder will be rolling back down the hill, throughout eternity, unless we stop putting more plastics into our environment.*

So, just to reiterate, beach cleans are a great idea, and we should keep doing more and more of them, because it raises public awareness. But we should also realize that beach cleans alone will never be able to remove all the marine litter. The rate at which litter is entering the marine environment is millions of times faster than the rate at which we could possibly hope to remove it.

**Recycling**

All the waste that is collected during a beach clean is removed from the marine environment; but then where does it go? It doesn't just vanish or get jettisoned off the planet into outer space, and it doesn't get converted back into the organic material from which we made it because we don't know how to do that yet. In the worst case it might get thrown away into rubbish bins, end up on a landfill site and then get blown back onto the coast and into the sea. Some of the luckier pieces might be used for plastic art or perhaps sent back to the company that produced them. But a lot of the stuff will be put into recycle bins and sent to recycling facilities.

Recycling is a great thing and there is no way we should stop doing it. But it will not solve the problem of marine litter on its own. The reason is simple: we are still producing hundreds of millions of tonnes of plastic a year, and the amount of plastic ending up in the environment is continually increasing. Alright, perhaps it is increasing at a slower rate than it would be if we didn't recycle, but that is not good enough. The amount of plastic ending up in the environment and the amount of new plastic created every year needs to *decrease*.

At the moment, most of what we call recycling is more like 'downcycling' – the raw material extracted from items that we have thrown away is made into a lower-grade material which cannot be used to make the same items again. For example, a toy tractor might end up as a plastic crate, and a plastic crate might end up as some sort of filling material. All the material in a toy tractor does not normally end up being used to make another toy tractor.

So, at the moment, recycling is a linear process, with the life of the plastics being temporarily prolonged, but with the material eventually ending up in the environment. Scientists are working towards making recycling more of what the word suggests – re-*cycling*, a circular process, where more and more material is fed back into making the items from which it originally came, and less and less escapes into the environment. However, that ideal goal is a long way off.

The other problem with recycling, of course, is that it uses a lot of energy, not just for the processing and sorting, but also for collecting and transporting. And that energy often comes from fossil fuels. In the end, if we didn't have as much stuff to throw away in the first place, we wouldn't need to waste so much energy on recycling it all.

**Scientific research**

Even though the general public might not be totally aware of the enormity of the problem of marine plastics and marine litter, most governments and multinationals such as Nestlé, Coca-Cola and McDonalds – in other words, those who have the most power to change things – are fully aware. Of course, doing something about it for the right reasons is usually not in their interest. They need to be threatened with a short-term detrimental effect on their own lives, such as losing money or power, or looking stupid.

A recent *Nature* paper states:

> *We believe that if countries classified the most harmful plastics as hazardous, their environmental agencies would have the power to restore affected habitats and prevent more dangerous debris from accumulating… the biggest producers of plastic waste – the United States, Europe and China – must act now*.[40]

Pretty obvious stuff; but if it were written by you or me it would be easy for politicians and CEOs to ignore. But it was written by a team of ten world experts and published in the world's most prestigious scientific journal. Scientific reports that prove the obvious (e.g. plastic is hazardous)[41] but with unequivocal statistical rigor, published in peer-reviewed journals by a scientists with a string of qualifications, are a little more difficult for politicians and CEOs to argue with. If they are bombarded with statements by the cleverest people in the world suggesting that their actions are bad, they might feel under pressure to be seen to be doing something.

The problem is that, even when this kind of pressure results in new laws being passed, you invariably end up with something like the MARPOL treaty; which tells people what they should not do but is not very effective at stopping them doing it. And even when companies are pressurized into becoming 'greener' you normally end up with greenwashing. On the other hand, you might be lucky and end up with a return to bottle deposits bottled water bans or plastic bag charges.

So, scientific research and the publication of results in peer-reviewed journals is a useful tool for putting pressure on those with a lot of power, but we mustn't rely on it always working. Scientific research is also essential for the ongoing development of novel ideas in a more general context – ways of giving us what we think we need by causing less damage to the environment. Again, with a lot more scientific research and a lot of luck, we might end up achieving the ideal goal of a totally circular system in which our existence on this planet is sustainable.

## 4.3 Idealistic ideas to aim for

I am sure you have heard of the hydrological cycle. Basically, the hydrological cycle describes how the planet's water goes from the sea, to the clouds to rain, to the mountains to the rivers and back to the sea again. What is absolutely essential to understand about the hydrological cycle is that it is the *same water*; the same water that has been around for at least two billion years, just going round and round.

Now imagine if we lived on a planet where vast amounts of water were continually being generated as a by-product of some natural process, and we all knew that, in about 50 years' time there would be so much water that we would all drown. Sounds absurd, but that is what we have done – we have created a linear system where once before there was a circular one. We are converting organic material into plastic and not converting it back again.

As I just mentioned in the previous section, an ideal situation would be if our society could go back to a circular system instead of a linear one, where the systematic changes we as a species are causing to our own habitat are zero or insignificant; where we are converting organic material into stuff that we use in our lives, then converting it back again at the same rate. Sustainability. That would be ideal.

To work towards that ideal we need ideas, and that is why we should never give up on scientific research. But those ideas then need to be developed and accepted, and put into practice by people. If the ideas catch on, and spread from individuals to small communities to larger communities, to some sort of critical mass where politicians and CEOs of multinationals can't ignore them any longer, then we have a chance.

## Cradle to Cradle

In 2009, chemist Michael Braungart along with architect William McDonough caused a sensation when they published *Cradle to Cradle. Remaking the Way We Make Things*.[42] The concept of cradle-to-cradle is that products should be designed right from the start to be totally recyclable, with the birth and life of each product culminating in the birth of another product. In other words, it means a totally closed-loop system of production and consumption, with no trash[43].

Products made from natural resources should end up being permanently used by us, or should end up being absorbed back into the natural environment, but should never end up as trash. But cradle-to-cradle goes a bit further and puts the emphasis on industrial design rather than putting all the responsibility on the consumer. The authors hypothesise that, in the near future, as resources become more and more difficult to get out of the ground, and hence more expensive, this will act as an incentive for industrial designers to start making products that last longer and that are recyclable.

One thing that must also be done is to make packaging totally recyclable just like the products inside it. The concept of throwaway packaging needs to be eliminated altogether, and the amount of packaging needs to be vastly reduced. Then, an infrastructure needs to be created so that products at the end of their life get reabsorbed into the manufacturing process. This would have to be far more advanced than the recycling facilities currently in existence, and would not be feasible until all products (and their packages) are specifically designed to be totally recyclable.

Finally, this is perhaps the most difficult problem. At the moment, having as much money and material goods as possible, and not having to be worried about throwing stuff away, is what most people aspire to in our society. Our culture needs to change so that being wasteful is no longer associated with being prosperous. People need to realize that they will benefit in the long-run by buying a better product that lasts longer.

The idea of 'becoming attached' to something you possess needs to be re-introduced into people's philosophies. For example, a pair of shoes that have become so comfortable over the years that you dread the thought of them one day wearing out and you having to put on a stiff new pair. Or perhaps, for those who are into status symbols, a really good quality watch that you can be proud of, but which also lasts a few decades. This idea is softer on the consumer lifestyle, but still reduces resource depletion.

## Zero Waste

Part of the concept of cradle-to-cradle is *zero-waste*. If all products are made to be recycled and all the stuff we make is either fed back into manufacturing new stuff or absorbed back into the ground – in other words if we achieve a closed-loop system – the concept of rubbish automatically becomes meaningless. But there is nothing stopping us aiming towards zero-waste, even if manufacturing companies are not making stuff totally recyclable yet. We can start as individuals, and then try to convince local communities to take part, and then aim for larger communities.

The Global Alliance for Incinerator Alternatives (GAIA)[44] has suggested the 'nine commandments' of zero-waste: a list of basic components some of which are pretty obvious, some of which are more idealistic than others and some of which require more infrastructure than others. But the list gives you a general idea of what to work towards, and it can be adjusted or increased in order to suit a vast range of different types and sizes of community. They are:

1. Reducing consumption
2. Reusing discards
3. Extended producer responsibility (EPR) see below
4. Comprehensive recycling
5. Comprehensive composting or biodigestion of organic materials
6. Citizen participation
7. Ban on waste incineration
8. Improving product design upstream to eliminate toxics and instead design for durability and repair
9. Effective policies, regulations, incentives, and financing structures to support these systems

Some people are already making a lot of progress towards zero-waste without really any new technology or revolutionary thinking. For example, in the coastal resort town of Kovalam, in Southern India, local residents have made an impressive list of changes which make a mockery of some beach resorts in Europe or North America[45].

Concerned about the increase in litter due to the sudden expansion of the Kovalam as a tourist resort, culminating in the proposal of the tourism department to build an incinerator, local activists organized an international e-mail campaign in which thousands of potential visitors worldwide told the tourism department that they would not go there if an incinerator were built. This prompted the tourist department to work closely with the environmental group Zero-Waste Kovalam, by setting up stations for people to refill water bottles with boiled and filtered water instead of buying bottled water, and setting up worker cooperatives to train local people to make reusable cloth bags from leftovers from tailor shops, instead of having disposable plastic bags.

## Biodegradable plastics

Earlier in this report I explained that plastic, once converted from oil, stays plastic. Every piece of plastic ever produced still exists today. The reason plastic won't go away is because plastic won't biodegrade. And it won't biodegrade because it has been around such a relatively short time that no microbe has yet evolved to eat it.

Now, why not turn the problem on its head? If there is no microbe to eat the plastic, then maybe we should invent a plastic that can be eaten by the microbes that currently exist. This is the concept of *bioplastics* or biodegradable plastics. Perhaps if we could make a plastic that gets absorbed back into the environment in the same way as, say, wood, we might be a bit nearer to achieving a closed-loop society.

However, there is a lot of controversy behind bioplastics[46]. Most so-called biodegradable plastics do not fully break down, and might leave non-degradable components that are just as toxic as normal plastic. And most need special environmental conditions in order to break down properly. The ocean is cold and relatively lifeless compared with the land, and it would be much more difficult to make a plastic that would biodegrade in the sea in a reasonable length of time, than to make one that would degrade on the land.

Even if a true biodegradable plastic were invented, consumers might have a hard time accepting it for food and beverage containers. We currently believe (albeit falsely) that plastic used for food and beverage containers is totally clean, inert and never diffuses into the food itself. 'Organic' food containers, are generally considered unhygienic (although a few years ago we never had a problem with fish-and-chip wrappers made of old newspapers).

Currently, bioplastic containers are not like apple-cores, where you can just throw them on the ground to rot away. There is a danger that both consumers and manufacturers will get the wrong idea, thinking that items made of bioplastics can just be thrown anywhere, and that we can go back to a proliferation of single-use plastics that we are just beginning to reduce.

## 4.4 Practical things that should be developed strongly

This section describes some campaigns and schemes that have already been put into practice and that have been highly successful; schemes that we should follow up and keep expanding. If we keep going in the right direction, starting with these campaigns, the closer we will be to reaching a closed-loop system before it is too late.

Ironically, many current schemes being put into place at the moment are aiming to take us back partly to the way things worked decades ago. In other words, in the past few decades we seem to have gone backwards. For example, 40 years ago drinking water in plastic bottles didn't exist, people had no choice but to take their own shopping bags to the supermarket, and it was normal to pay a deposit for canned and bottled drinks containers. With the knowledge and technology that we have today, we could very quickly go back to operating the way we did then, but in an even better, more efficient way.

### Bottled water bans

As I pointed out before, drinking water sold in disposable plastic bottles is, perhaps our worst enemy. It is, or soon will be, the worst contributor to marine litter and general environmental and humanitarian abuse, on many levels. Luckily, people are beginning to wake up to the fact, and bottled water is starting to be banned in more and more places around the world.

The United States is probably the guiltiest country in the world for anything associated with a 'throwaway society', including the consumption of bottled water. But there is also quite a lot of resistance springing up there, such as the Ban the Bottle campaign, whose initial focus is eliminating bottled water from schools, universities and public events[47].

A few towns in the US have introduced sanctions against the sale of bottled water. Concord, Massachusetts, for example, starts with a first time warning, then $25, then $50 etc.[48]. Hardly enough to break the bank, but perhaps more useful as a precedent for other towns to follow on, and for people to eventually get the message that bottled water is bad. National 'monuments of Nature' such as the Grand Canyon National Park in Arizona, where the problem of litter is bad for publicity, have also introduced a ban on bottled water.

Elsewhere in the world, people are slowly catching on. In Australia, there is the famous case of Bundanoon in New South Wales where, since 2009, the selling or dispensing of bottled water within that town precinct has been prohibited[49]. And in the UK, bottled water is starting to disappear from university campuses and from some council office buildings[50]. Canada is also doing well, with a growing number of universities and colleges, and at least 75 town councils having ended the sale and distribution of bottled water[51].

We seem to be on the right track, but we still have a long way to go before a tipping point is reached where enough people around the world realize how stupid bottled water is. Only then will it seriously start to disappear from the supermarket shelves, as companies such as Coca-Cola and Nestlé start to think twice about its profitability.

**Banning or charging for plastic bags**

Forty years ago, shops and supermarkets did not have a pile of wafer-thin plastic bags at the checkout ready to be filled with shopping. Instead you might have got a paper bag, and you would certainly have felt silly if you had left your own shopping bag at home. As a child in the 1960s and 1970s I distinctly remember "the shopping bag" – the same bag used by my mother since before I had been borne and until after I had left school.

Then, the plastic bag revolution came about and we took a step backwards. Billions of bags suddenly appeared at the checkouts, in our dustbins, in landfills, in rivers, in the sea and in marine mammals' stomachs. There is no doubt that, along with plastic water bottles, plastic shopping bags are one of the worst offenders as far as marine litter is concerned.

Now people around the world are realizing that we need to reverse the trend and start to reduce the proliferation of plastic bags. Again, we have an awful long way to go, but at least people are beginning to get the idea. In the last decade or so, some countries in the world have started banning plastic shopping bags, or at least the wafer-thin ones; and other countries have started charging money for them. The results are quite encouraging, with many poorer nations taking the lead. For example:

- In 2002 Bangladesh banned the use, production and marketing of polyethylene shopping bags.
- In 2003 the Indian state of Himachal Pradesh banned the production, storage, sale, distribution and use of polythene bags[52]. Since then many other Indian states have followed suit.
- African countries such as Kenya, Uganda, Botswana Tanzania and Zanzibar have introduced bans or partial bans on plastic bag manufacture and use, since around 2007. In Rwanda, for example, visitors are warned that any visible plastic bags will be confiscated at the airport[53]. In South Africa, a range of measures were introduced in 2003 including a minimum thickness for plastic bags and a fixed levy on bags. Results of a recent study suggest that, since these measures have been in place, the consumption of plastic bags has fallen by 44 percent[54].

- In North America, in 2007 large supermarkets and pharmacies in San Francisco were prohibited from giving out plastic bags. In 2009 Toronto introduced a charge for bags, with an estimated 53 percent decrease in plastic bag use within the first year[55]. Since then both Toronto and Seattle have introduced outright bans on plastic shopping bags. Many other states and cities in the USA and Canada have implemented plastic bag bans or fees[56].
- In Europe, Italy banned the distribution of polyethylene to shoppers in 2011[57]. Many other European countries including France, Germany, Belgium, Netherlands, Denmark, Spain, Portugal, Hungary and Bulgaria are beginning to introduce charges for plastic bags. In Ireland, a plastic bag charge introduced in 2002 had spectacular results, with plastic bag use estimated to drop by 98 percent in the first week[58].
- In the UK a minimum charge of 5p was introduced for single-use bags, in Wales in 2011 and in Northern Ireland in 2013. Studies show that plastic bag use has dropped by around 80 percent in both countries. And, probably by the time you read this, England and Scotland should have followed suit by the end of 2015[59].

**Extended Producer Responsibility**

In the last few years it has become more and more difficult to find products that can be re-used or recycled – products that don't contain plastic packaging that will one day end up in a landfill, on the coast or in the sea. A few years ago, for a while, you might have be able to choose milk in a glass bottle instead of in a 'tetrabrik' carton, or you might have been able to choose a more expensive electronic gadget that lasts ten years instead of a cheaper one that lasts six months. But nowadays, most people just give up. It is simply too much effort to shop around. We buy what is available and, in the end, the plastic packaging and the product itself ends up in the environment.

So it is not all our fault, like the people behind the KAB scheme would like us to think. If we simply cannot find anything else but products packaged in non-recyclable plastic, or stuff that breaks after three months because the manufacturer has simply decided it will make him more profit, why should it be our responsibility to dispose of it?

Ideally, the manufacturer should be made responsible for the entire life-cycle of his products, not just up to the point where those products are handed over to us, the consumer. If the manufacturers were made responsible for the disposure of the product, and penalized for stuff ending up in the environment, they might be more inclined to design longer-lasting or recyclable products. This would put us on a step towards the closed-loop idea described above.

That might seem a bit far-fetched to you. Large multinational companies would never in a million years be interested in such a scheme. And governments, who are of course influenced by those companies, might pass laws, treaties and directives, but might be reluctant to enforce those laws.

Well, not quite. In Germany, in 1991, the Duales System Deutschland (DSD) packaging collection and recycling program was set up, whereby companies are required to pay according to the volume and type of packaging they use; in other words, the more volume and the nastier the package, the more they pay. This has two advantages: firstly, the worse the packaging, the more money there is to get rid of it, and, secondly, it gives those companies a financial incentive to design the products and their packaging to be less toxic and more easily recyclable[60].

The pioneering system introduced in Germany is called Extended Producer Responsibility (EPR), defined as *a mandatory type of product stewardship that includes, at a minimum, the requirement that the producer's responsibility for their product extends to post-consumer management of that product and its packaging*[61].

Under an EPR program the producers, manufacturers, brand owners and importers of products and packaging are given the legal responsibility for collection, recycling and end-of-life management.

Since 1991, the EPR system in Germany has been fairly successful, and in the rest of Europe it is catching on. PRO Europe, the organization formed in response to EPR legislation, claims 'significant changes' in packaging design, reduced material use and easier recycling since 1991[62].

The EPR program is not without problems, and is only catching on very slowly, while poorly-designed products, packaging and single-use plastics continue to get worse. But the fact that it has actually been put into practice in Germany means that it will be that much easier for other European countries to follow suit.

**Bottle deposits**

In Europe and North America, the replacement of glass bottles with disposable drinks containers, and the disappearance of a deposit system, has been a relatively gradual process. But in some other parts of the world it happened overnight, and the effects were that much more noticeable.

For example, in 1989 I travelled to Peru. If you were thirsty you would walk into a shop, ask for a drink in a glass bottle, drink it right there, pay the shopkeeper and give him the bottle back. Once I asked if I could take the bottle away and he looked at me as if I were crazy, explaining that I would have to pay a bottle deposit of about eight times the value of the drink.

Then, sometime between 1989 and 1992, single use plastic drinks containers were introduced into Peru by Coca Cola and Pepsi. When I went back to Peru in 1992 I was shocked by the amount of plastic bottles piled up along the side of the road, in the streets and along the coastline. Peru had made a sudden late entry into the culture of convenience. Even then, when I knew little about sustainability or environmental campaigning, I couldn't help thinking they had taken a step backwards.

Nowadays, people are beginning to realize that the old system was better, and are beginning to re-introduce deposits on drinks containers. This gives the user a simple choice: throw it away and lose the deposit or return it and get the deposit back. Modern schemes have been highly successful, and even with deposits as low as ten percent of the product value, big differences in container recovery rates have been found. In North America, in states without container deposit programmes, around two thirds of all beverage containers end up as litter; whereas this is much less in those states with deposit programmes. For example, in Ontario, in 2008, it was found that 94 percent of all glass and aluminium beer containers, and 67 percent of wine and spirit containers were returned[63].

Deposit schemes have been re-introduced in many parts of the world. Here are a few examples:

*Southwest Australia*: A deposit scheme has been in place since 2003. The deposit is 5c (about 0.03€) and return rates are around 75 percent for plastic bottles and 90 percent for cans.

*Denmark*: Deposit scheme since 2002. Plastic bottles and cans carry a deposit of 1.25 DK (about 0.15€).

*Germany*: Deposit scheme in place since 2003, with 25c (about 0.25€) deposit on drinks bottles and cans.

*Netherlands*: A 0.25€ deposit on drinks bottles. The bottles are returned to 'reverse-vending' machines in supermarkets: you put the bottle in and the machine gives you the money.

*Sweden*: A scheme has been in place since way back in 1984, with a 0.50 SEK (about 0.06€) deposit on cans, and a 1 SEK (about 0.10€) deposit on plastic bottles. Return rates are around 85 percent[64].

## 4.5 Campaigns by NGOs

A number of non-profit organizations around the world are working hard to increase public awareness about marine litter. If these groups can at least make a large sector of the public aware of the problem, we will be on our way to eventually reaching a point where most people would consider it unthinkable to vote for a politician who didn't want to ban plastic bags or introduce bottle deposits.

Public pressure driven by campaign groups is a good way to narrow down the choices available to the CEOs of companies such as Coca-Cola; so that they either reduce their packaging (even better, take part in EPR schemes) or make less profit because people won't buy their product.

There are many charities, NGOs and environmental groups working around the world to combat marine litter. Here are a few examples:

- In the UK, Surfers Against Sewage are involved in several high-profile and original campaigns to raise public awareness about marine litter around the UK coast. These campaigns go way beyond simple beach cleans and are designed to make people aware of specific aspects and to address the root causes of marine litter.
- In Europe, the Surfrider Foundation has been fighting against marine litter since the organization was founded. They have a comprehensive program of high-profile events under the *Ocean Initiatives* program which are designed to 'raise awareness among the general public on aquatic waste found in the sea, where it comes from, responsible consumption, recycling, etc. in order to change the way we think and act in our daily life'[65]. Surfrider Europe are also working hard to try to change European law which presently does not properly define marine litter, and therefore makes it even more difficult to provide effective legislation[66].
- On the other side of the Atlantic, Surfrider International has a program called *Rise Above Plastics* (RAP) whose mission is 'to reduce the impacts of plastics in the marine environment by raising awareness about the dangers of plastic pollution and by advocating for a reduction of single-use plastics and the recycling of all plastics.' The RAP program encourages local action by providing a 'toolkit': 'A step by step guide to creating positive change in your community through reducing single-use plastics, the RAP toolkit is focused on establishing a plastic bag ban or similar ordinance and it also offers insight on increasing awareness of plastic pollution issues through education and outreach'[67].
- The Algalita Marine Research Institute[68], founded by Captain Charles Moore, the world's most famous expert on marine plastics, is one of the most important organizations in the

world for combating marine litter. Algalita's mission is to 'work toward a plastic pollution-free world through research, analysis and education'. Specifically, they are dedicated to: (a) conducting research and collaborative studies on distribution, abundance and fate of marine plastic pollution, the potential harmful effects of plastics in the marine environment and the transference of toxicants and their impact on human health; (b) providing authoritative, educational findings to students, scientists, the general public, governmental agencies, and the private sector; and (c) collaborating with organizations working toward restoring the aquatic environment by reducing and ultimately eliminating plastic pollution.

– Working closely with the Algalita Institute is the Five Gyres Project[69], another very important worldwide organization dedicated to the elimination of plastic pollution in the oceans. The Five Gyres project organizes research expeditions inviting scientists and journalists to sail through the five subtropical gyres (the 'great garbage patches') to understand the impacts of plastic pollution. Results are published through multimedia outlets and peer-reviewed publications, including print and television media, websites and blogs, lectures and school outreach, and a travelling exhibition about plastic pollution to museums, science centres and aquariums.

## 4.6 Plastic art

A lot of people have been using art to raise public awareness about just how much plastic debris is out there[70]. If people's attention is first drawn to something striking and unique such as a giant fish made from pieces of plastic collected from the beach, they should then be more receptive to further information about the problem.

Plastic art turns the idea of litter on its head. It conveys the message that, if useful things can be made of something that has already been considered litter (i.e. the plastic is 'up-cycled'), then perhaps those things should not have been thrown away in the first place. More specific messages can also be incorporated into the art itself, such as the *(S)Hell* piece by Luis de Dios, shown here. The piece was made almost entirely from small plastic disks and bottle-tops, collected from the coastline.


*(S)Hell* by Luis de Dios[71]

# 5. What you and I can do

If we really want to help rid the world of marine litter, we need to dig deep and target the root causes. As I already mentioned, we shouldn't stop doing beach cleans or we shouldn't lose faith in recycling; but these are only *proximate causes* and will not solve the problem on their own. We need to get to the *ultimate causes*. For example, if plastic is being manufactured, made into packaging, thrown away and arrives on the coastline twice as fast as we could possibly clean it up, we need to slow down the manufacture in the first place.

### Get to the people who have the real power

To get to the root of the problem we need to reach the people who have the power to change things, namely politicians and people in control of multinational companies. These people have the power to provide funding for research towards ideals such as those I mentioned in section 4.4, and they have the power to develop practical ideas such as those I mentioned in section 4.5. Obviously, this is not an easy task: most of the time these people are not interested in anything that benefits the overall population if it doesn't increase their own wealth, status and power.

We need to find efficient ways of getting to the people who have the power to change things, and then use them as leverage to force the changes that are required.

To reach the politicians, in theory we have a system of democracy which allows us to vote for the good ones and put them in power. To choose which ones are the right ones is the difficult part, and to convince enough other people to vote for them is even more difficult.

So, what is a 'good' politician? Well, perhaps it is one who is not afraid to admit that the premise upon which our society is based – that the more we consume the better off we are – is absurd and wrong. Perhaps a good politician is one who measures the success of a people by its potential to survive through future generations, not by its gross domestic product or by the amount of new cars being sold every year. Unfortunately, at the moment, any politician who remotely subscribes to this way of thinking is usually considered a crazy environmental extremist, and not taken seriously.

The people who hold even more power than the politicians are the people in charge of large multinational companies. They have a hold over the politicians, because they control the resources upon which the consuming public depends. The decisions that politicians make are therefore principally in the interests of the large multinationals.

As far as marine litter is concerned, large companies are in control of the manufacture of all the plastic packaging that is bought by us and that eventually ends up on the coast or in the sea. They are generally not interested in anything to do with sustainability, ecology or the environment; all they want to do is make money. So how can we change their behaviour so that they stop filling the environment with plastic?

If we tried to plead with them, bombard them with scientific evidence or send them petitions with thousands of signatures, it just would not work. They need to be threatened with something that will make them lose money. For example, if enough people stopped buying

bottled water, there would be no demand and the companies would make less profit. Therefore, they would have less money to spend on advertising, less influence on the people, sell even less, make even less profit, and so on until bottled water eventually disappears.

But how do you make enough people stop buying bottled water?

Or how do you make enough people vote for a politician that most people think is mad?

### Bottom-up, top-down approach

To reach these people, and to make them change things so that problems such as marine litter really start to be solved, is all about tipping points and critical masses (the sort of thing that happens on the internet when suddenly a video or some message goes 'viral').

Once enough members of the general public are convinced to, say, stop buying bottled water, a lot more people will quickly follow suit. And once a large enough number of people stop buying bottled water, the demand will go down, and so will the supply.

It is a kind of 'bottom-up-top-down' approach. The effect of killing the demand filters upwards from the consumers to the manufacturers, who have no choice but to reduce the supply; and the reduction in supply filters back down to consumer level, where people won't be able to throw away plastic water bottles, plastic bags and bottle-tops, because those items simply won't exist.

### Increase public awareness

Before a critical mass of consumers can be reached, a smaller mass of people needs to really understand the problem so that they can propagate the message out to the general public. People like us – surfers and coastal water users – should find it easy to understand the problem. We should be able to appreciate that the satisfaction of being able to walk across a pristine beach into clean water doesn't compare with the satisfaction of being seen walking around the city with some stupid plastic bottle.

However, there is still a lot of ignorance, even among surfers and coastal water users. For example, some people don't realize that their wetsuits, boards and most of the clothes they wear are made of plastic; and a lot of people are surprised when they learn that plastic never degrades. Even some surfers and coastal water users don't realize that when they throw away something made of plastic, it will eventually, inevitably, end up in the environment, and may come back to haunt us on the coastline and in sea. Sometimes I cringe when I see surfers buying water in plastic bottles; and when I explain to them why they shouldn't, they usually tell me that they just didn't think about it.

So, the first thing you can do, now that you have got this far into this report, is to tell as many people as possible to read the report, spread it around on your social media, put it on your website, maybe even print it out leave a few copies in strategic places.

Now, how do we convince the general public who are not surfers or coastal water users, and who are not likely to read this report? How do we get people 'on the street' to stop buying bottled water, refuse to use plastic bags, buy stuff with less packaging, and vote for the politician who doesn't advocate infinite growth?

First, we can get them to support some of the campaigns I mentioned in section 4.5. The more people support organizations like SAS or the Surfrider Foundation, the more people will have access to information and be aware of the problem.

We can try to choose the most efficient and strategic methods of getting the information out there. Professor Richard Thompson and colleagues in a recent report[72] suggest the following methods to increase public awareness and spread the message:

- Increase public awareness through public education and communication campaigns linked to waste reduction and recycling promotion programs
- Information accurately disseminated via local media support, print advertising and signage in key public areas
- Campaigns built around creative use of social media
- A focus on children and schools

The last one on the list is extremely important and absolutely crucial. Children are infinitely more receptive to any social message, (good ones but unfortunately bad ones too, as we constantly see with branding marketeers targeting children to buy their products). If we used all the methods we could think of to get the message out there but only focused on informing the adult population, our efforts would be wasted. Not only would the message be less heard, but it would die with the present generation.

If an environmental message telling people to do or not to do something seems boring, or alludes to some future scenario too far removed for them to be able to imagine, people can be convinced in a less direct ways; 'through the back door' as it were.

For example, many people buy bottled water because the branding marketeers have conned them into associated it with some kind of social status and healthy living. But there is another part of our culture that we can easily appeal to. Bottled water costs up to 2000 times as much as tap water. People, especially tend to be very sensitive about paying over the odds for something – if your friends find out you got ripped-off you will look a fool. In contrast, if you manage to get a real bargain you will make your friends jealous and they will admire you for being crafty and clever. So, it wouldn't be too difficult to mount a campaign against bottled water on the basis that people who buy it must be stupid.

**Practice what you preach, and preach what you practice**

It should be fairly easy for us to practice what we preach, be a good example to the rest of the population, by not buying bottled water, not using plastic bags or showing everybody how little household waste can be produced. Richard and Rachelle Green from Gloucestershire, England have done just that. They are the family who famously filled only one bag of rubbish in a year[73]. They are not only living examples of what can be done, but they are also doing a lot to convince other people, through their own website and with a growing number of followers[74].

However, it is important to realize that, while you need to be a good example and practice what you preach, you also need to be able to preach what you practice. You need to do everything right as far as possible, but not go to such extremes that you won't be able to get the message out there. For example, to be absolutely sure we were using as little resources as possible and producing as little waste as possible, critics might tell us that we should be living as hunter-gatherers and totally rejecting everything to do with modern society. But if we did that we would not be able to get around and spread the message. It is more efficient to use a computer or mobile phone to persuade 1000 people to vote for the right politician or to join a powerful campaign group, than to refuse to use a computer or mobile phone yourself because it is made of plastic.

# Conclusions

Here are some of the most important points from this report:

- Human debris on the coast and in the sea goes much further than being just an aesthetic problem: it is a serious health risk to humans and other large animals, and its toxicity affects the entire ecosystem from the smallest zooplankton right up the largest predators.
- The problem of marine litter is growing exponentially, much faster than we could possibly remove it.
- The majority of marine litter is plastic. Once plastic has been manufactured it stays in the environment forever. The worst problem is from plastic packaging, designed to be used once and then thrown away almost immediately.
- Marine litter lies within the larger issue of human debris, particularly plastic. The extraction of raw materials and the fabrication of plastics to make products that will just be thrown away is a one-way, unsustainable process.
- To solve the problem we need to work towards a closed-loop system, where nothing is made that does not get absorbed back into the environment at the same rate. Ideally, material that never degrades should be continually recycled.
- Initially we need to reverse some of the trends that have been introduced in the last few decades; for example, eliminate as much plastic packaging as possible, particularly things like disposable plastic bags and plastic water bottles. Re-usable food and beverage containers, with a deposit payable by the user, need to be re-introduced.
- To achieve these initial goals and to have a chance at eventually reaching the ideal of a closed-loop system, we need to get to the people with the power to change things: politicians and the heads of multinational companies.
- Politicians can be made to change things if the public give the right politicians the power by voting for them. The heads of multinational companies can be persuaded to change things if the public choose not to buy their products.
- To get to these people requires a ‘bottom-up-top-down’ approach. For example, you, the reader of this report, if you are a surfer or other coastal water user, propagate the message to other water users, who tell others to join large campaign groups such as SAS or the Surfrider Foundation, who have the power to propagate the message out to the general public. Once a critical mass has been reached of people who understand the problem and are prepared to do something about it, others will follow much more quickly. Eventually, there will be enough public support to reach the people with the real power, who will have no choice but to make changes.
- It is important to preach what you practice as well as practice what you preach. It is no good producing zero waste or becoming an ideal example of sustainability if nobody knows you are doing it. It is more effective to reduce your own waste by 10 percent and persuade another nine people to do the same, than to silently reduce your own waste by 90 percent.
- Lastly, don’t forget that, if you are a surfer, many people secretly wish they could be as cool as you. We manage to keep fit and avoid stress-related illnesses all the way through

our lives, without the need for too many material comforts. Surfing brings us close to Nature and can give us immense enjoyment without burning fossil fuels or generating by-products. Now that surfing is more in the public eye than ever before, we should take advantage of that and show we can be happy and sustainable at the same time.

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