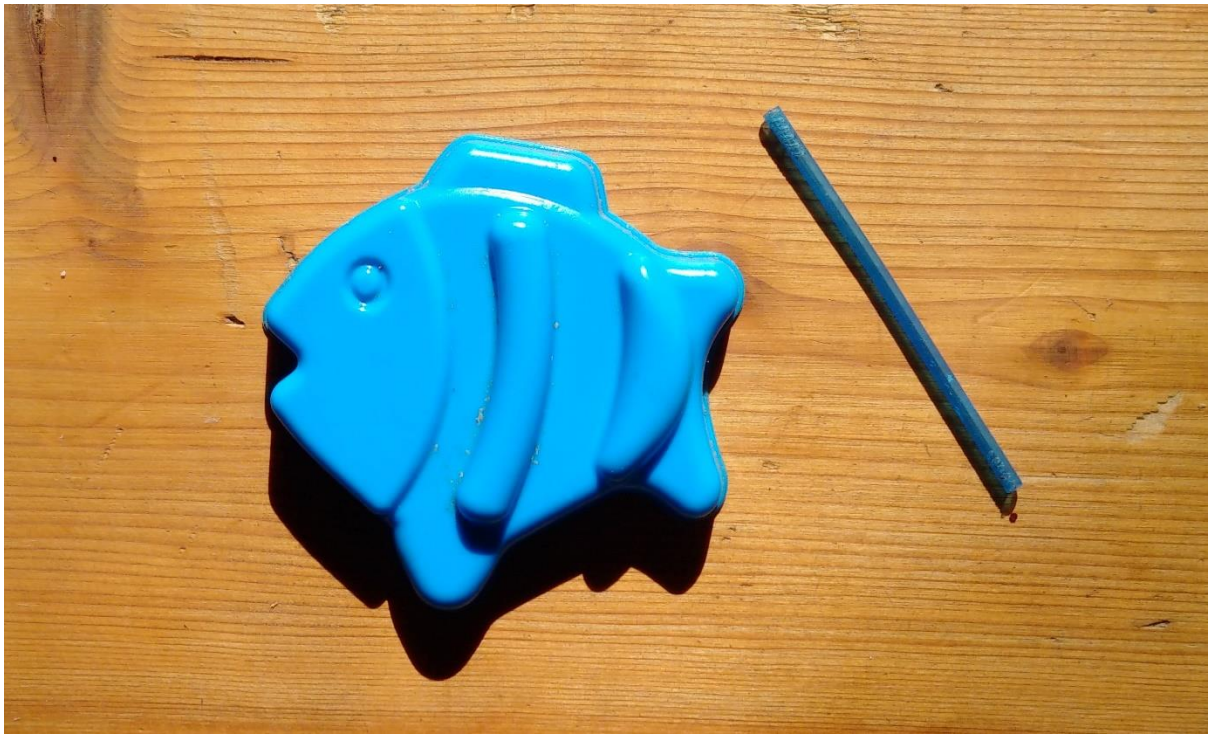
Why We Suddenly Have A Plastics Crisis

or *How Kahneman's System 1 Fast-Tracked The Plastic Crisis, and System 2 Slow-Tracked The Issue*

A Campaign Strategy Blog

Chris Rose 11 December 2017 chris@campaignstrategy.co.uk



A child's plastic fish, and a plastic cotton bud innard, both found on my local beach.

Introduction

The UN has acknowledged that we have a 'plastics crisis' and on December 6th 2017, adopted a (non-binding) resolution calling for an end to plastic entering the sea.

Many see plastic pollution as comparable in scale, threat and challenge to Climate Change. Yet if it seems to have crept up on us 'as if from nowhere', that's not for lack of earlier warning signs, dating back to the 1960s.

We've had knowledge about the key elements for a very long time but that knowledge has not been accessed or acted upon. Why not? In large part, it's because for decades, 'plastic' as pollution has been largely a 'Track Two' issue (see my previous blog for an explanation), confined to the slow-moving domain of analysis and in this case, mainly rather obscure science. It was, as my American friends might say, 'lost in the weeds'.

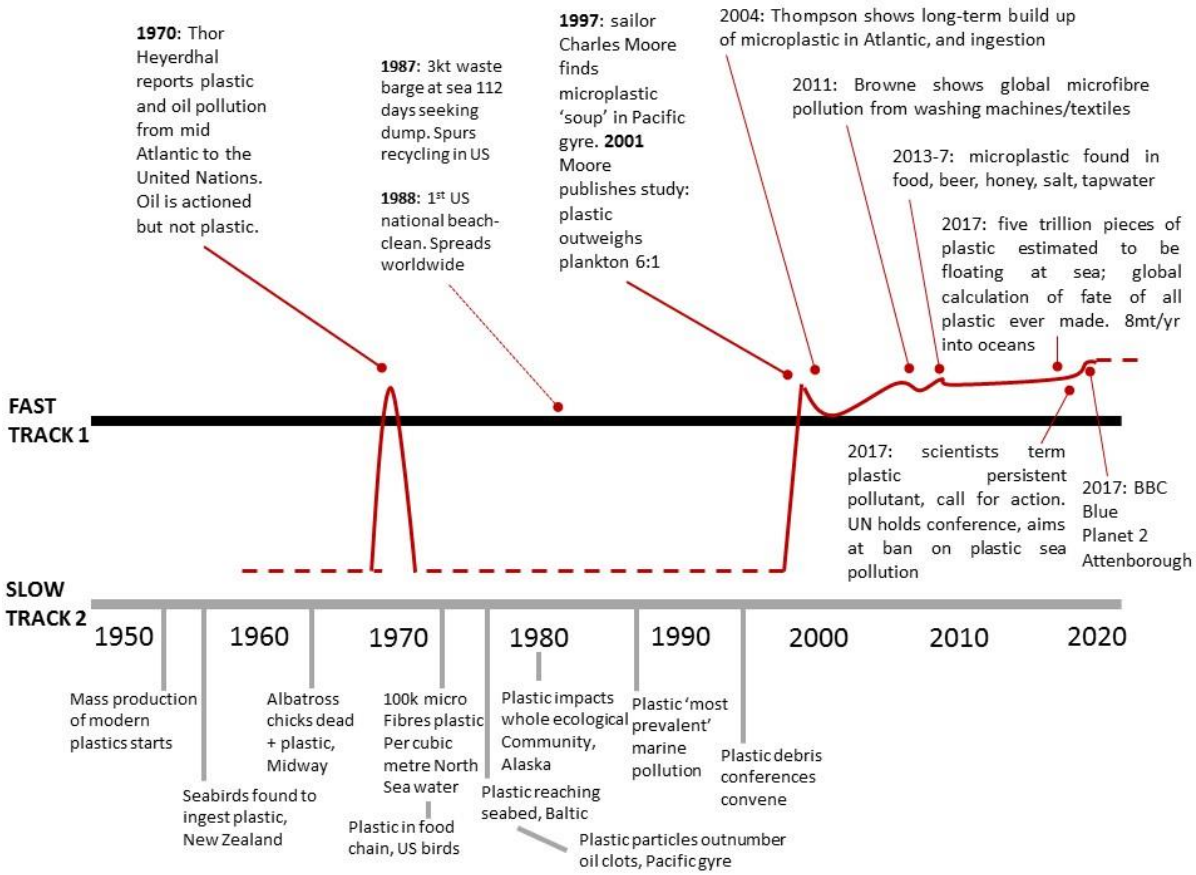
Plastic enjoyed a 'near miss' in terms of becoming a Track One mainstream issue back in 1970 when explorer Thor Heyerdahl got the world's attention with his discover of 'a sewer' of

pollution in the deep mid Atlantic but it then sank below the surface of 'general public' awareness until the chance discovery of 'Plastic Soup' in a Pacific Ocean gyre by sailor Charles Moore (see below). This gave plastic pollution its second signal 'moment' on Track One at the turn of the century.

The high degree of separation of slow Track Two from the fast moving mainstream of Track One, helped keep it plastic off the radar of major policy and campaign groups from 1970 through to the 21st century. Decades of research into plastic pollution down on Track Two effectively found no audience up on Track One.

Moore's discovery turned him into a scientist and campaigner. The publicity he gained boosted existing research efforts and began to interest the media in plastic as a global pollutant, sucking up scientific findings from Track Two, making it 'news' on Track One and feeding dramatic documentaries like the BBC's recent Blue Planet II, in which David Attenborough has admirably laid into plastic.

Here's a summary:



A summarised history of plastic as a pollutant in Track One and Two terms. See later for discussion. Communication on Track One is dominated by Kahneman's System 1, intuitive, easy, unconscious and fast, and on Track Two by System 2, slow, hard, conscious and analytical.

Moore's 1997 discovery was blessed with scientific confirmation in 2001, meaning that it's taken another sixteen years to get plastic pollution firmly onto Track One. 1970 – 2017 is most of a lifetime of wasted opportunity, leaving us with a truly monumental problem.

So as there were signs that plastic posed a pollution threat early on, how did plastic proliferation evade control from the 1960s until the present day? One significant reason is the psychological status that was conferred on plastic on Track One, through decades of everyday use. Intuitive System 1 thinking means that we take-for-granted and mainly just don't notice what is normal and repeated, and interpret new information through what we 'already know is true'. Plastic, became framed as a benign, helpful, modern convenience (cheap and disposable). This was promoted by the plastics industry even before it was actually true (early plastic items were quite durable and relatively expensive).

The 'throwaway' appeal of plastic celebrated in LIFE magazine in 1955.

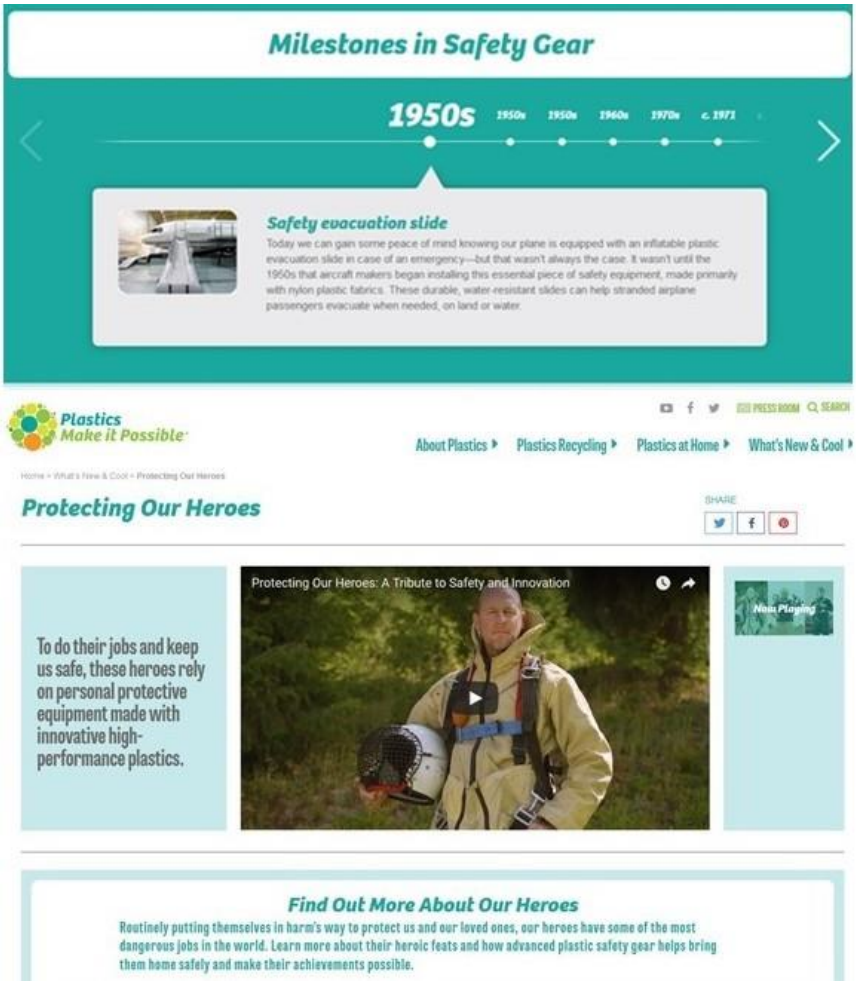
So, as noted in the previous blog, the more we saw others using plastic (social proof), the more we used it; and the more we used it, the more we accepted it (the consistency heuristic): behaviour rationalised as opinion.

It became 'common sense' and 'inevitable' that we 'rely' on plastic. Anything which did not fit with that frame had a hard time being taken seriously. So ingrained is this idea, that even science groups generating evidence to the contrary, have often accepted it as a starting point. In the Royal Society's 2009 'Theme Issue' Plastics, the environment and human health, which was mainly devoted to the problems created by plastic, the very first 'scientific' paper stated:

'Any future scenario where plastics do not play an increasingly important role in human life [therefore] seems unrealistic'.

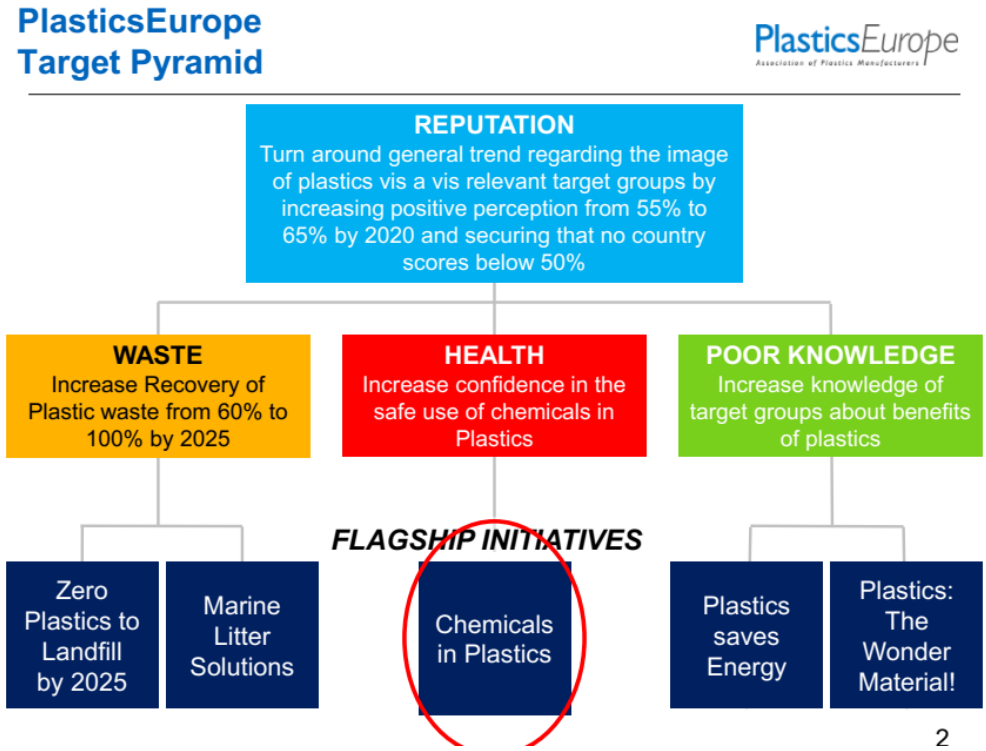
In the early 1990s I remember hearing a very senior UK government climate expert saying something similar about fossil fuels: 'no government would ever close a coal-fired power station to meet climate commitments'. I doubt he'd really thought about it, rather asked by a journalist if that's what was needed, it just seemed 'unrealistic' to imagine it.

Plastic has had some highly effective advocates in the shape of the PR and advertising industries. They made sure that mass use of plastic was helped on its way by judicious promotion to hit all the Motivational Values 'hot button's: from being safe, to fashionable, to planet-saving (eg it's lighter than glass so transporting plastics drinks bottles creates less climate changing emissions). Here are a few examples of how the industry has covered off the three values groups of Settlers, Prospectors and Pioneers:



Plastics make you safe. *Settler messages from industry group 'Plastics Make it Possible': safety slides and life saving heroes using plastic.*

Plastic is fashionable. *Prospector messaging. Vintage 1960s when vinyl became fashionable (for the first time).*



Plastics Save the Planet. *Slide from a 2015 Plastics Europe strategy workshop. Their main concern (centre) was regulation against endocrine (hormone) disrupting chemicals but bottom right you have two public communications objectives, one (saving energy, less CO2) aimed at climate-concerned Pioneers. 'The Wonder Material' is what the industry has been claiming since the 1950s and is now probably evidence of self-delusion.*

Rethinking Plastic

There's a small group (which I've done a bit of work for) called 'Rethink Plastic' and that's exactly what needs to happen.

Plastic communication strategy needs more than a bit of an overhaul. For example if scientists governments, the UN, EU and campaign groups working against plastic pollution want to make rapid and effective progress, they have to stop using the 'litter' frame for plastic, and start thinking of it as inherently dangerous stuff, and acting and communicating accordingly.

Perhaps more challenging, the reality is that 'recycling' and conventional waste strategies are not only incapable of taking plastic out of circulation to the point where plastic pollution actually declines and stops, but they, like 'litter' framed beach cleans, have been heavily co-opted by the plastics industry, whose simple objective is to maintain the flow of plastic production.

I'll return to this in a following post but now that plastic pollution has finally become a public issue, the immediate risk is that it is kicked into the 'political long grass' of Track Two, with detailed and lengthy 'studies' and 'commissions' on how to rejig the 'recycling system' and if politicians succumb to the entreaties of the plastics industry for time to come up with 'innovations', which will inevitably be reformulations of their polymers.

To begin with, we need to avoid repeating the mistakes of the past, both on issues like climate change, and in the history of plastic pollution itself.

1970: Plastic Momentarily Gets Onto Track One

Just as the mass production of plastic was really taking off, there was a moment where plastic in the 'wrong place' hit the headlines with the help explorer Thor Heyerdahl, of *Kon Tiki* fame.

In 1969, Heyerdahl had set out on a papyrus boat *Ra I* to try and show that ancient people could have made it across the Atlantic from Africa to the Americas and almost succeeded before having to abandon the voyage. On the way he had signs of noticed pollution, and arranged to make observations send a report to the UN, on his second attempt a year later. That came at a moment when the world was sensitized to news of environmental pollution, as the first 'Earth Day was to be held in April 1970.

Earth Day 1970 - http://www.lincolnandrose.com/home/photos-first-earth-day-1970

Earth Day 1970, regarded by many as the inception of 'the modern' environmental movement, took place on April 22nd 1970. It featured 'teach-in's' across the US and a rally in New York, along with demonstrations, speeches, protests and the start of the great environmentalist bombardment of 'the general public' with 'facts' (the start of a long-running attempt to change people on Track One with System 2 thinking).

Earth Day 1970 AP Photo

On 8th July 1970, after travelling some 6,100km across the Atlantic (some of it backwards as he was relying on intuition and experiment rather than knowledge of how to steer such a craft), Heyerdahl made it to Barbados. Not surprisingly, this feat created a lot of public interest but so did the revelation that he had found signs of industrial pollution far out in the ocean.

May 1970 Heyerdahl's papyrus boat Ra II proves the ancients could have crossed the Atlantic, and shocked the world with reports of mid-ocean pollution. Signed by the 8 crew members. *https://www.bajanthings.com/the-ra-expeditions-thor-heyerdahl/*

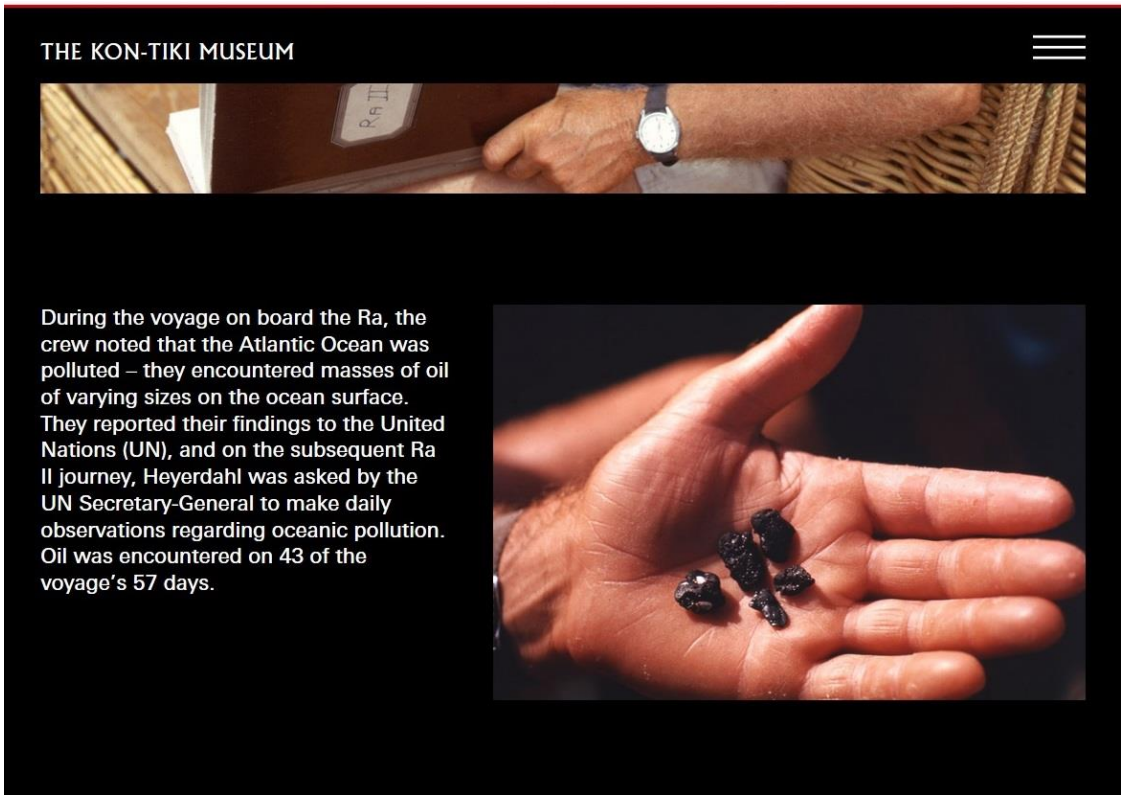
Heyerdahl's reports of nylon and other plastic containers in the 'unspoilt' mid ocean, along with many clots of oil, momentarily captured mainstream attention. He recalled two years later:

'we had hardly been to sea three days before we discovered that we were in something like a city sewer—and yet we were 100 miles or more from land … we saw plastic containers, nylon bags, empty bottles, all sorts of refuse'

But it seems he took no pictures of plastic and he counted the sightings of oil: "I decided to make a day-by-day survey, dipping down with a dipper and taking samples of the oil clots. We found oil clots on 43 days of the 57".
https://www.youtube.com/watch?v=j9ElC_luicY

Heyerdahl's report to the United Nations spurred action on oil, which was already framed as 'pollution' but plastic pollution receded from view. While far from the only factor,

Heyerdahl's oil report probably gained more political traction because he put numbers to the oil. That complied with the dictum attributed to management guru Peter Drucker: "what gets measured, gets done".



From the Kon-Tiki museum in Norway

Most of all, oil looked like pollution was expected to look. Plastic didn't, and in the following decades, a succession of oil-spill disasters such as Exxon Valdeez (1989) kept oil in the 'public eye' and on the monitor-and-manage agenda of institutions tasked with pollution control.

Sea Otters oiled by the Exxon Valdeez in 1989. After the spill Exxon kept the ship but changed the name. After being resold more than once it was scrapped under the name Oriental Nicety in 2012.

For politicians, quantifying oil also helped resolve their constant need to prioritise: let's 'do something' about the 'biggest' (and also most soluble) problem.

There's not much to be gained by dwelling on might-have-beens but we can imagine that if Heyerdahl's report to the UN had led to a surveys to check on plastic at sea elsewhere, and some examination of the emerging science, things might have turned out differently.

As it was, although by 1970, plastic was already starting to lose its sheen as a 'wonder material' and symbol of modernity (most famously captured in Dustin Hoffman's encounter with Mr McGuire "there's a great future in plastics" in the 1968 movie *The Graduate*), plastic was already established as harmless, helpful and friendly stuff.

https://www.youtube.com/watch?v=eaCHH5D74Fs

"A great future in plastics" – and there was.

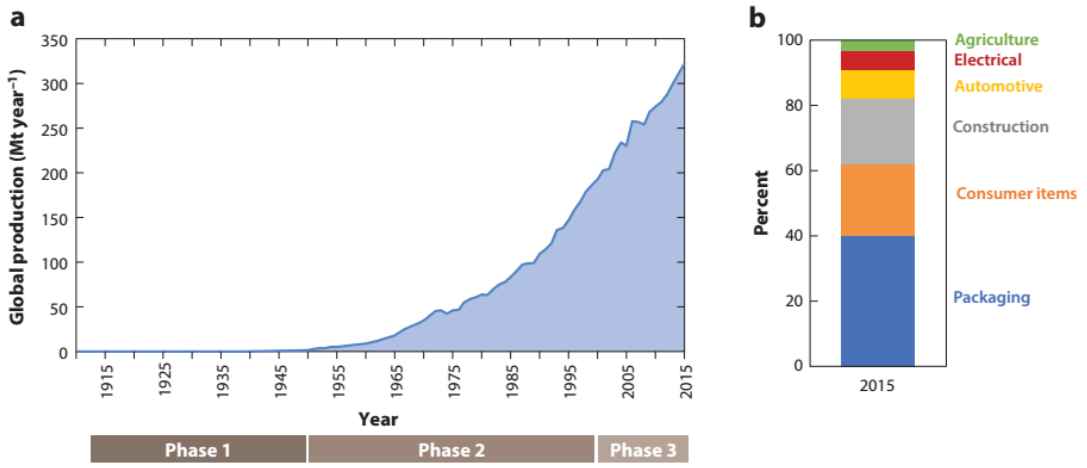


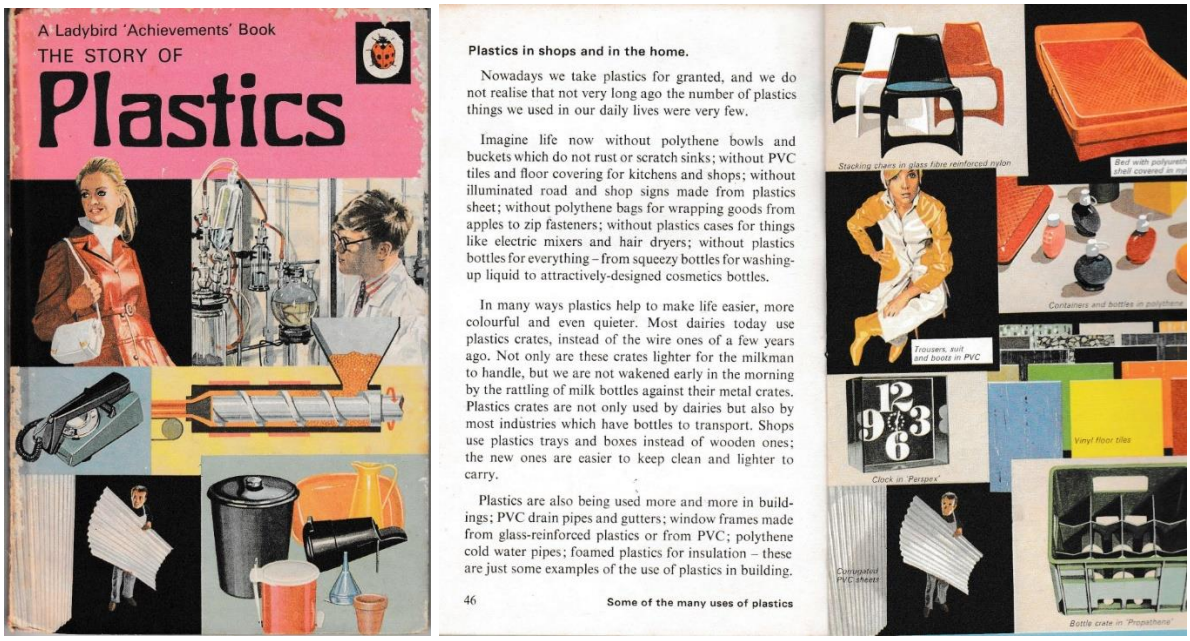
Figure 1

Time trends in total plastics production worldwide. (*a*) Global production in million metric tons per year (Mt year^{-1}). (*b*) Usage patterns of plastic in 2016 are estimated from available sources (18). Three phases are seen: Phase 1 signifies slow development and invention of most plastics commonly used today (innovation phase), Phase 2 is marked by rapid global expansion and exponential growth (growth phase), and Phase 3 shows more linear dynamics that more closely mirrors global economic growth (consolidation phase). Data compiled from References 18, 19, and 20.

Growth of plastics. From one of the best recent assessments of the problem is Plastic as a Persistent Marine Pollutant by Boris Worm, Heike K. Lotze, Isabelle Jubinville, Chris Wilcox, and Jenna Jambeck (2017)

Plastic as a pollutant was probably counter-intuitive to many. In 1974, W C Fergusson, a member of the Council of the British Plastics Federation and a Fellow of the Plastics Institute, probably felt confident when he stated:

''plastics litter is a very small proportion of all litter and causes no harm to the environment except as an eyesore".

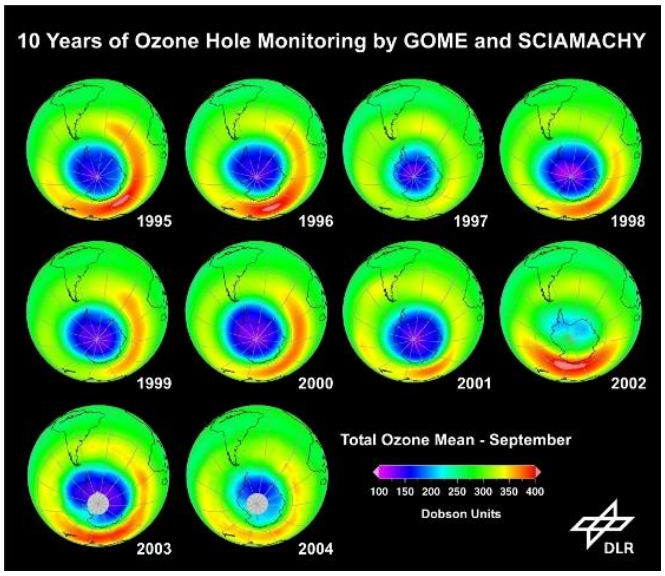


The Ladybird 'Achievements' Book on plastics, aimed at children

In 1972, the authors of the *Ladybird Story of Plastics*, painted an unremittingly positive picture, and openly acknowledged 'the co-operation of ICI Plastics Division and the Plastics Institute Information Sub-committee in preparing this work'.

Plastic Gets Overlooked

In the 1970s and 1980s a succession of other pollution 'issues' broke onto Track One because they had the necessary qualities to be processed intuitively: CFCs for example, connected the personal, such as hairspray, to the well-being of our planet. Discovered in 1985, the hole in the ozone layer over Antarctica *looked* like we'd holed the roof of the planet. It led to an unusually fast-track response.



Hole in the ozone layer *1995-2004 at the bottom of the planet – slowly healing thanks to a 1987 restriction on pollution from CFCs and other ozone depleting substances under the Montreal Protocol*

In the 1980s, 'acid rain' air pollution produced significant political action led by Germany when forests started dying, and private forest owners sided with the Greens, threatening the government. Waldsterben or forest-decline, produced dramatic pictures and dead trees from iconic forests were carried into the German Parliament. Germany led Europe into embracing the catalytic converter for cars and stricter new emission rules.

'Acid rain': dead trees in Germany, 1980s

By this time plastic production was galloping ahead and almost none of it was getting re-used. In 1991 Germany was alone in introducing a law (attached to the Green Dot scheme) extending responsibility for recovery of plastic and other packaging to the producer. Britain had just one plastics recycling officer at that time. In most countries plastic got dumped but it was regarded as an unsightly nuisance, awful to look at but harmless.

'Next time try recycling': message from Greenpeace, 1987

'Waste' made a rare appearance in the international media in 1987, when the *Mobro 4000* with 3,000 tonnes of New York waste became a real-life 'Flying Dutchman' and 'the world's most famous barge'.

Towed by the romantically named tug the *Break of Dawn* under captain Duffy St Pierre, it was originally destined for a North Carolina landfill but after 112 days and 5,000 miles, it ended up back in New York, having being turned away by ports from Louisiana to Texas, Florida and Belize. One account noted that: 'authorities in Mexico and Cuba threatened to fire artillery at the barge if it tried to dock'.

This episode caused the number of US cities with 'curbside recycling' collections to increase from 600 to 10,000 but even today, only 9% of US plastic packaging is 'recycled'. (The barge of waste was eventually burnt in a Brooklyn incinerator). The take-away lesson that lodged in the public consciousness was that 'recycling' was the answer to 'getting rid of' waste.

Then in 1988, the 'world discovered' climate change. On a sweltering 23rd June, Jim Hansen of NASA told the Senate in Washington DC that it was '99% certain' climate change was real, adding in case they didn't get it, that "it's time to stop waffling so much and say the evidence is pretty strong that the greenhouse effect is here". An international climate conference was about to get underway in Toronto and press and politicians rang the alarm on climate change.

US Presidential Candidate G W Bush declared that if he elected he would 'deal with' climate change. He didn't but the UN set up the IPCC (Intergovernmental Panel on Climate Change), and the UNFCCC (United Nations Framework Convention on Climate Change). It all sent a signal loud enough and authoritative to take hold in Track One: something must be done about climate and especially, 'carbon'.

In the cosmology of the pollution apocalypse climate change took over as threat no.1, and there it has remained. It was not the only reason that plastic got eclipsed but responding to the climate threat sucked the air from many other pollution problems, a number of which such as Persistent Organic Pollutants, themselves pose an existential threat to us, and much other life on earth.

1970 – 2000: Plastic's Long Sojourn on Track Two

Out of sight and out of mind to almost everyone except esoteric networks of marine biologists and oceanographers, the 'plastics issue' never really went away, and even pre-dates *Ra II*. It just stayed in the slow, carefully studied world of Track Two, invisible to almost everyone, and largely ignored by big-science, campaigners, politicians and the media alike.

Plastic Pollution Research: A Track Two Timeline [Ryan and other sources]

- 1960 New Zealand: stranded Prions (seabirds) found to have ingested plastic
- 1962 Newfoundland: Leach's Storm Petrels found to have ingested plastic
- 1966 Midway Island: 74 of 100 dead Laysann Albatross chicks have plastic in their stomachs
- 1968 South Africa: plastic pellets found in young loggerhead turtles
- 1969 Atlantic: Puffins with balls of plastic thread filling their gizzards
- 1969 California: a mass death of sea-living red phalarope; plastic is found in all 20 birds examined
- 1970: South Africa: plastic sheet blocks intestine of a Leather Back Turtle

- 1971 North Sea: in *'Pollution by synthetic fibres'* Buchanan finds up to 100,000 fibres /m^3 of seawater & larger fragments in plankton samples in "embarrassing proportions".
- 1971 Sargasso Sea: Carpenter and Smith find 3500 plastic particles km^2, "accumulating in the North Atlantic gyre* for some time". Suggest such particles could become a significant problem if plastic production continues, and could carry toxics such as plasticisers, PCBs into food chain
- 1971 Long Island New York: 'food' regurgitated by terns for their young, contains plastic, showing it moves up the food chain
- 1972 New England: Carpenter finds up to 14 plastic pellets (nurdles) /m^3 of seawater, and 14 species of fish eating plastic
- 1973, 1974, 1976: UK studies find three fish species eating plastic & up to 30 pieces in Flounders
- 1975 Skagerrak the Baltic: Holmström reports Swedish fishermen "almost invariably" catch plastic sheets [packaging] in their trawls, showing that plastic reached the seabed.
- 1975: a New Zealand fur seal is seen to be entangled in plastic, elsewhere sharks are entangled
- 1974 Hawaii: plastic 'pellets' in the gyre found to outnumber tar balls from oil, with up to 34,000 pellets /km^2
- 1975 Baltic: Holmström shows encrusting sealife can weigh down plastic, carrying it into the depths
- 1977 North Sea: plastic bottles found to travel over 100km/week, some reaching Germany and Denmark from the UK in 3-6 weeks
- 1980s Mediterranean, more than 100,000 items of plastic /km^2 on the seabed of the Mediterranean, and floating plastic particles and pellets recorded across the Pacific.
- 1980 Alaska: Day shows that plastics affects an entire ecological community. Of 2000 birds from 37 species studied in 1969 -1977, plastic is found in 40 % of species and 23 % of individuals.
- 1983 South Atlantic: Furness finds over 90% of Great Shearwaters contain plastic, one with 78 pieces in its gut
- 1984 Honolulu: first Workshop on the Fate and Impact of Marine Debris takes place attended by 125 people from eight countries, discusses plastic ingestion, entanglement
- 1985: Wallace estimates 100,000 marine mammals die a year from plastic ingestion or entanglement in the North Pacific Ocean alone
- 1986: California: Sixth International Ocean Disposal Symposium focuses on dumping of plastic at sea
- 1986 Alaska: Day, Clausen and Ignell find an accumulation of small plastic particles in the N Pacific gyre
- 1987 Southern Oceans: Ryan shows 40-60% of seabirds are ingesting plastic
- 1987 Florida: Azzarello and Van Vleet collate dozens of studies showing choking, reproductive failure, starvation, weight-loss and death of seabirds due to plastic. These 'profound effects on birds', are down to 'industrial and user-plastics composed of polystyrene, polypropylene, polyethylene, styrofoam, and polyvinyl chloride', the 'most prevalent forms of plastic marine pollution'

- 1987: Gregory infers that beached plastic degrades more rapidly than seaborne plastic, due to sunlight
- 1989 Honolulu: Second International Conference on Marine Debris with 170 delegates from 10 countries, discusses 'tackling the problem … solutions through technology, law and policy, and education, as well as the first estimates of the economic costs of marine litter'
- 1993: Ryan and Moloney publish *Marine litter keeps increasing* in *Nature*
- 1994 Miami: Third International Conference on Marine Debris: the report includes 10 chapters on land based sources of plastic
- 1997 Coe and Rogers edit Marine debris: sources, impacts, and solutions, a 432 page book

* gyre: ocean area where current circulation concentrates floating debris

Despite this research and much more like it, right up to the 1990s most books on 'pollution issues', hardly mentioned plastic [1]. Even in 2001 when the European Environment Agency published *Late lessons from early warnings: the precautionary principle 1896–2000* , specifically about such slow-burn unforeseen problems, plastics was mentioned just once in over 200 pages, and that only as a carrier for CFCs in styrofoam. [Nor does it feature among the dozens of problems described in the 764 page 2013 follow-up volume except for as a carrier for toxic additives such as BPA, mercury and PCE. By then, science was in fact catching up with the problem but much of the policy machinery had not caught up with the science].

1997 - 2001: Charles Moore Resurfaces Plastic Pollution

It took sailor Charles Moore, to put plastic pollution on the world's mental map, and onto Track One. When Moore's findings captured public attention, that in turn spurred greater research activity, and led to Track Two science activity being imported onto Track One by the media.

Charles Moore with samples of microplastic – from http://www.captain-charles-moore.org/about/

Moore was not thinking about plastic when he crossed the North Pacific Gyre in 1997. He was on his way back to California, after taking part in the TransPac ocean race, undertaken to test a new mast on his sailing boat.

Moving slowly across the sea, he began to notice small bits of drifting plastic such as 'shards', bottle tops and bits of plastic rope. He later recalled for Lucy Barnes of BBC Witness (2013) that at first:

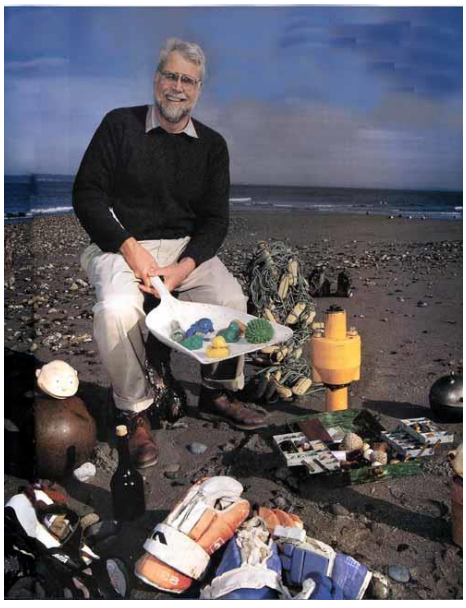
"it was just these bits and pieces of stuff there that seemed out of place … I don't know the time of the first realisation that something was wrong out there. It's more a cumulative effect. This is not an 'aha' moment, this is not a 'eureka' type of event, it's more a gradual awakening to the fact that something is amiss".

Seeing as the plastic caused no hazard to the boat, Moore didn't mention it in his ship's log but he started checking for the plastic.

"*I said to myself that as I came out on the deck and surveyed the horizon 'this time that I bet I can stay here for a few minutes and I won't see any detritus floating by but I would always lose that bet"*

"I did a kind of on the napkin calculation of a half a pound per hundred square metres and it turned out to rival you know the years deposition in the Puente Hills landfill which is the largest landfill of trash in California"

Once home, Moore started talking about what he's seen and got some System 2 back up for his discovery by contacting oceanographer Curtis Ebbesmeyer.



Curtis Ebbesmeyer with some of the flotsam used to track ocean currents

By Rick Rickman - http://vos.noaa.gov/MWL/dec2001.pdf, Public Domain, https://commons.wikimedia.org/w/index.php?curid=3675306

An expert on flotsam, Ebbesmeyer was already known to the media for his studies of how plastic ducks and Nike running shoes had made their way around the oceans after being spilt from ships in the 1990s. Moore sent Ebbesmeyer some plastic 'chips' obtained from the coastguard, to check they had not come from a passing barge. Ebbesmeyer decided they had come from many different sources. In Moore's words: Ebbesmeyer thought "it was such that a one-liter bottle could put enough plastic pieces in the ocean to put one on every square mile of beach in the entire world. He said he thought this stuff was not coming from a barge but was getting spit out from this gyre that was accumulating it".

Armed with advice from Ebbesmeyer, a scientific sampling protocol, special nets and some scientists, Moore went back in 1999 and undertook a systematic survey. The most striking finding was that by weight, their ultra-fine trawl nets captured six times more plastic than plankton.

"We were just absolutely shocked" Moore told Barnes. *"It was an explosive discovery that changed the direction of my career, it changed the focus of our marine research institute and has generated now a whole new body of research. Papers are coming out every day now by scientists around the world looking at the consequences of this detritus, which turns out is not confined to these gyres at all but just part of the world ocean"*'

Oceanographers, indeed even Jules Verne, had long known about oceanic gyres. Unknown to Moore, Alaska-based scientist Bob Day had already plastic in the gyre but Moore was the first to publicise the fact that the plastic was collecting in huge amounts of mostly small fragments in mid ocean.

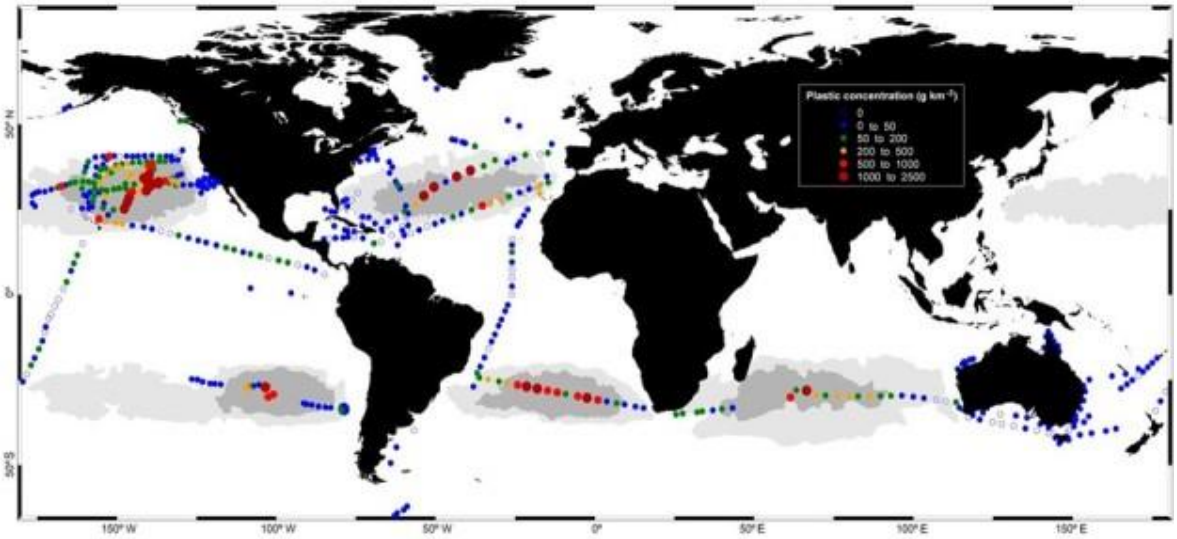
Charles Moore of the Agalita Foundation, set up with his own money

Most of all Moore had a story that was interesting, shocking, easy to understand and which he told in the popular media. Like the hole in the ozone layer within an atmospheric vortex, the oceanic gyres formed vortexes which could be visualised on a world map: pollution this big simply looked big. The Pacific 'patch' was as big as Portugal, Spain and France combined.

Moore told the BBC:

"You can sit and observe the albatross on midway island regurgitating coathangers into the baby chick, or cigarette lighters or bottle caps, when you can actually observe the tragedy of being fed rubbish. And then when you see the quantities of plastic inside these baby birds that never get to fledge, never make it off the island, that die with a full stomach"
"Whales are washing up dead full of plastic, even whales that feed on plankton and whales like the grey whales that feed on the mud at the bottom of the ocean are washing up with golf-balls and surgical gloves in their stomachs. Every trophic level, meaning every feeding stage in the ocean in the food pyramid is being affected by this polluted plastic".
… maybe we don't have a plastic island <u>now</u> out there but if we keep putting it in and it doesn't go away, we will have the surface of the planet covered in plastic."

Laysan Albatross - <u>http://ocean.si.edu/slideshow/laysan-albatrosses%E2%80%99-plastic-problem</u>



Concentration of plastic in surface waters trapped by oceanic gyres, from Plastic debris in the open ocean, Andrés Cózar, 2014, PNAS vol. 111 no. 28 10239–10244

The Eastern Pacific Garbage Patch or North Pacific Gyre (top left) described by The Independent newspaper as 'the world's rubbish dump: a tip that stretches from Hawaii to Japan'.

Like Heyerdahl, Moore gave the media a personality. This was 'System 1' communication: vivid, easy to pass on, intuitive to grasp, hard to ignore. Plus they gave it names: Ebbesmeyer coined the term 'Eastern (Pacific) Garbage Patch', and Moore the term 'plastic soup'.

The Independent reported that Ebbesmeyer 'compares the trash vortex to a living entity: "It moves around like a big animal without a leash." When that animal comes close to land, as it does at the Hawaiian archipelago, the results are dramatic. "The garbage patch barfs, and you get a beach covered with this confetti of plastic"'

Moore has been back to sea many times. In 2009 he told Earth Island Institute "We went back last year and found 46-to-1 plastic to plankton … every decade, it's getting close to 10 times worse".

In the world of science, Moore's discovery started making real waves in 2001 with the publication of a paper of which he was lead author: *A Comparison of Plastic and Plankton in the North Pacific Central Gyre*.

Not everyone was convinced that plastic posed a real and systematic ecological threat. Scientists were aware that there was still a lot to find out and some were inclined to discount any claims from 'campaigners'. As late as 2011 when Moore and Cassandra Phillips published a book called *Plastic Ocean*, Bob Holmes, a reviewer for New Scientist magazine, quoted Moore:

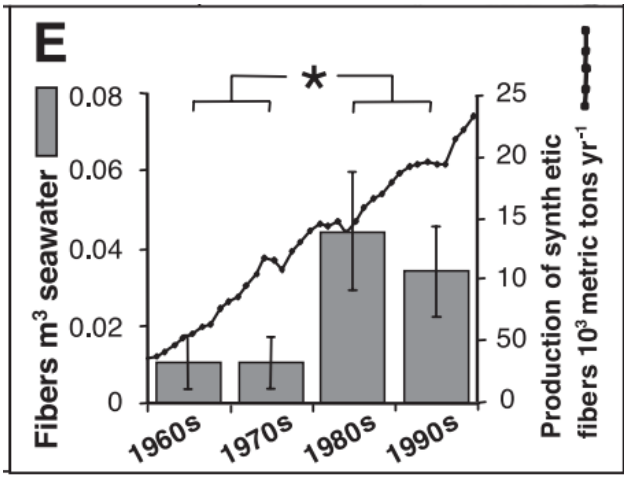
"I wasn't the first to be disturbed about plastic trash in the ocean, and I wasn't the first to study it … but maybe I was the first to freak out about it."

'Many readers' wrote Holmes, 'especially *New Scientist* readers - are likely to find Moore unpersuasive … the biggest problem is that *Plastic Ocean* comes across as a bit of a rant'. (I thought it was a pretty good book).

The Microplastic Threat Multiplier

For scientists, the threat posed by plastic pollution underwent a step change with confirmation that microplastic fragments were widespread, and were being eaten by living things at the base of the food chain, and had increased over decades.

In 2004 UK researchers led by R C Thompson from Plymouth University published a paper *Lost at Sea: Where Is All the Plastic?* which analysed microplastic on beaches, estuaries and sediments, and stored samples from Atlantic plankton surveys stretching back to the 1960s. This 'time series' was equivalent to the climate pollution record of gases trapped in ice-cores, in that it showed how the problem had changed over time, alongside increasing plastic production.



Increase in plastic in plankton, and plastic microfibre production, from Thompson et al, Lost at Sea: Where Is All the Plastic ? Science, June 2004, DOI: 10.1126/science.1094559

One third of all the very small 'micro' scale particles they analysed were plastic polymers including such familiar names as acrylic, propylene, nylon, polyester, polyethylene and polypropylene. While some microplastics were granular, most were brightly coloured fibres.

Their next step was to keep three types of small marine life in aquaria containing some microplastic as well as natural food. They found 'all three species ingested plastics within a few days'.

A 2009 review of marine plastic debris by David Barnes of British Antarctic Survey pointed out that away from surface sunlight or when covered in marine life, many plastics break down very slowly. This was illustrated by accounts 'that plastic swallowed by an albatross had originated from a plane shot down 60 years previously some 9600 km away'. In deep ocean waters plastic is thought to have a life of hundreds of thousands of years. Barnes noted that 'plastics comprise 50–80% of the waste stranded on beaches, floating on the ocean surface

and on the seabed', and 'the abundance and global distribution of micro-plastic fragments have increased over the last few decades'.

In 2011 Mark Browne and colleagues published Accumulation of microplastic on shorelines worldwide: sources and sinks showing global pollution by microfibres from textiles such as polyester, nylon and acrylic, coming from washing machines, drains and sewers. Washing machines could become the 'hairspray' of microplastic pollution: a source of global pollution in the home, and gadgets to stop that could become the 'catalytic converters' of the issue (more at this previous blog).

In the next year or so, microfibres were found in tap- water (including in Trump Towers and the US EPA), in edible fish, salt, beer, honey and other foods, as well as in houses and falling from the air over cities. One researcher calculated that someone fond of mussels might consume up to 11,000 plastic microfibres a year. The two largest microfibre sources are from clothes and wear of car tyres, as well as road markings.

In 2014 Marcus Eriksen, a co-worker of Charles Moore, headed a team who made the first 'global estimate' of floating marine plastic: *Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea*. This combined the results of 24 voyages to sample plastic in the upper two metres of seas around the world, from 2007-13.

'Five trillion pieces of plastic' caught the attention of news media and showed the mind-numbing difficulty of any retrieval operation but it only represented 0.1% of world annual plastic production. There was far less floating microplastic at the surface than expected, perhaps meaning that the huge majority was sunk well below the waves, in the water column or on the bottom, and so even harder to get back, or even more worrying, being cycled around the food-web inside living creatures.

Eriksen and colleagues pointed out that 'many recent studies also demonstrate that many more organisms ingest small plastic particles than previously thought, either directly or indirectly, i.e. via their prey organisms', and 'there is 'increasing evidence that some microbes can biodegrade microplastic particles', leading to yet smaller plastics entering marine food chains nanoplastic. Subsequent studies have confirmed that even the 0.33mm sieves used by Eriksen are indeed too large to catch the smallest particles.

In short, although it is an excellent idea to remove what plastic can be caught in the ocean gyres, like beach-cleaning, this leaves the vast majority of plastic pollution unaccounted for, and as it gets progressively mingled up with sediments along coasts and in deep waters, and gets into the bodies of wildlife and people, and into soil and freshwater systems, the problem becomes ever harder to tackle.

5.25 trillion pieces of plastic is '720 items for every person alive today' but a more recent, a follow-up study arrived at an even larger estimate of 15 - 51 trillion particles floating in the oceans in 2014.

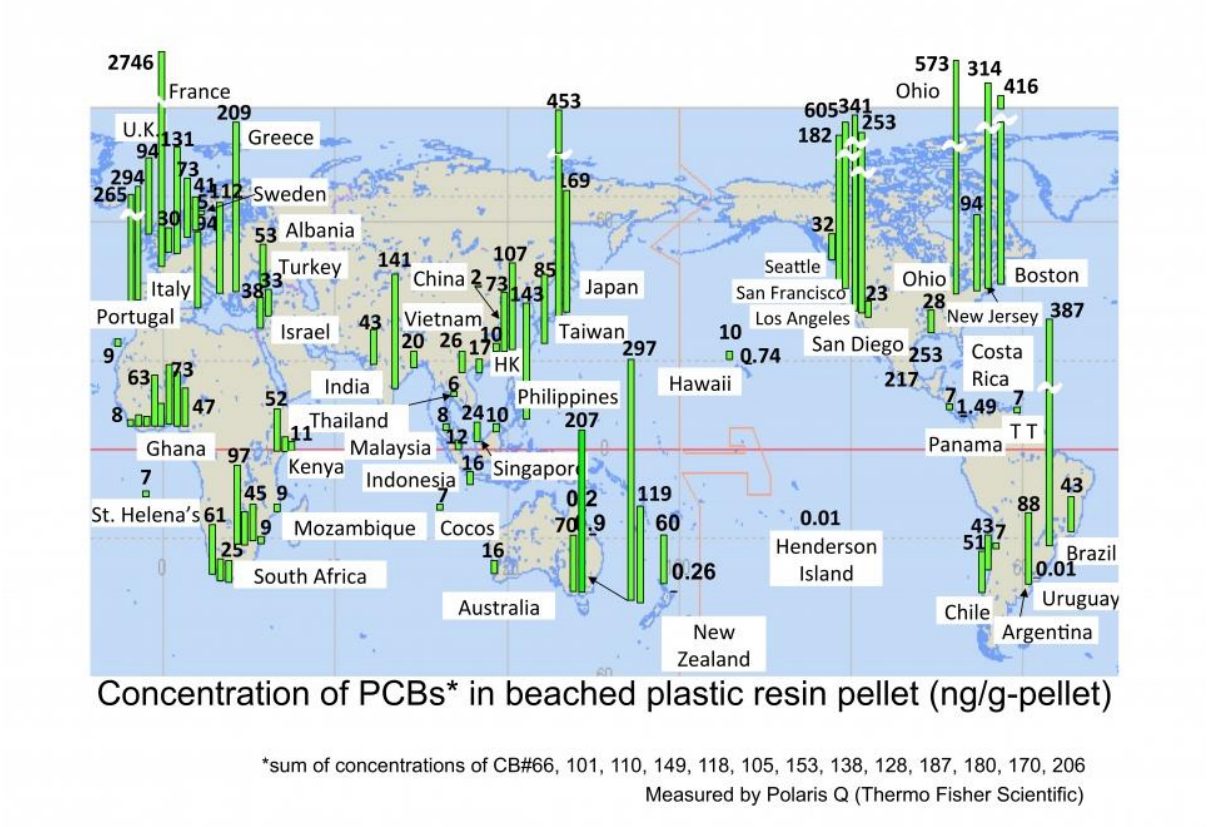
Recognizing A Different Type of Threat

Put these findings together, and plastic poses a threat far worse than 'just' entanglement or choking wildlife, or in Track Two jargon, it's a completely different class of risk from say, 'litter'.

The discovery that plastic goes on breaking down into smaller and smaller fragments, rather than 'actually going away', makes it long-lived and extremely hard to detect, let alone retrieve with current technologies.

On top of this, as with climate-changing gases, there is a future 'commitment effect' from the many millions of tonnes of plastic already in the environment and the damage it can do may increase as it breaks up.

Plastic is also known to pose a health-hazard to humans, mammals, fish and invertebrates because being made from oil, it attracts and concentrates pollutants insoluble in water, such as PCBs, long-lived insecticides, flame-retardants and other industrial pollutants. In 2001 Hideshige Takada and colleagues showed these can be concentrated a million-fold on the surface of ocean plastic particles. Such chemicals are implicated in the ill-health and reproductive failure of top-predator mammals like killer whales.



Long lived PCBs are long-banned highly toxic chemicals but still circulating in the environment. Through 'International Pellet Watch' Takada works with volunteers collecting plastic pellets from beaches, to map how much pollution is 'sponged up' by plastic particles around the world. From Microplastics and the Threat to Our Seafood , Hideshige Takada 2013

As if that isn't enough, plastics release their own cocktail of chemicals, partly by 'outgassing' from the day they are made (such as 'new car smell' and the smell of plastic printing inks), and partly as their polymers degrade and let go of single-chemical monomers like ethylene and styrene. Some of these are toxic, along with dozens of different additive chemicals used to make plastic hard, soft, heat resistant, colourful, resistant to sunlight and other things. Many of these ingredients are kept secret under the guise of commercial confidentiality.

The full implications of breathing, drinking and eating plastic pollution are not yet known: science hasn't had the resources or time to find out but they are unlikely to be positive.

For scientists and policy makers subscribing to the Precautionary Principle (a very Track Two concept enshrined in EU law), or in 'common sense' Track One terms ('when in a hole, first stop digging' or 'better safe than sorry'), this means one thing: first stop making the problem any worse.

Calls From Scientists

With many parallels to the early history of the current climate change issue, there have been an unusual number of calls from scientists global action on plastic. Some of these have even reached beyond the confines of scientific journals on Track Two.

In 2013 the journal *Nature* carried a call from ten researchers to reclassify plastics as hazardous waste, saying *'policies for managing plastic debris are outdated and threaten the health of people and wildlife'*.

In 2017 four scientists from Canada, Australia, and the US called for 'a Global Convention on Plastic Pollution' in the face of *'the unfolding plastic pollution crisis'*. Plastic, they said, is a persistent organic pollutant, akin to the toxic PCBs and pesticides covered by the Stockholm Convention on POPs or Persistent Organic Pollutants.

Also in 2017 Stephanie Borrelle from New Zealand and six others from Norway, Canada and the UK, proposed *'an international agreement with measurable reduction targets to lessen the plastic pollution in the world's oceans'*, in the Proceedings of the National Academy of Sciences in the US.

They warned:

'… international plastic pollution agreements are now where climate change agreements were in 1992, when the UN … formally recognized the climate change problem and simply encouraged voluntary, undefined support. If policies for plastic pollution maintain the same pace as international carbon emissions deliberations … an effective agreement may not happen until after 2040. By this time, emissions of plastic into the ocean are predicted to increase by an order of magnitude … To avoid waiting 25 years for an international plastics agreement with reduction targets, reporting, and signatories … the scale and pace of solutions must match the scale and pace of emissions'.

‘Plastic pollution’ they noted, ‘has received little attention in terms of international agreements—a notable contrast to carbon emissions and other global pollutants, such as chlorofluorocarbons (CFCs), and Persistent Organic Pollutants (POPs)’.

Putting Plastic Back in Pandora’s Box

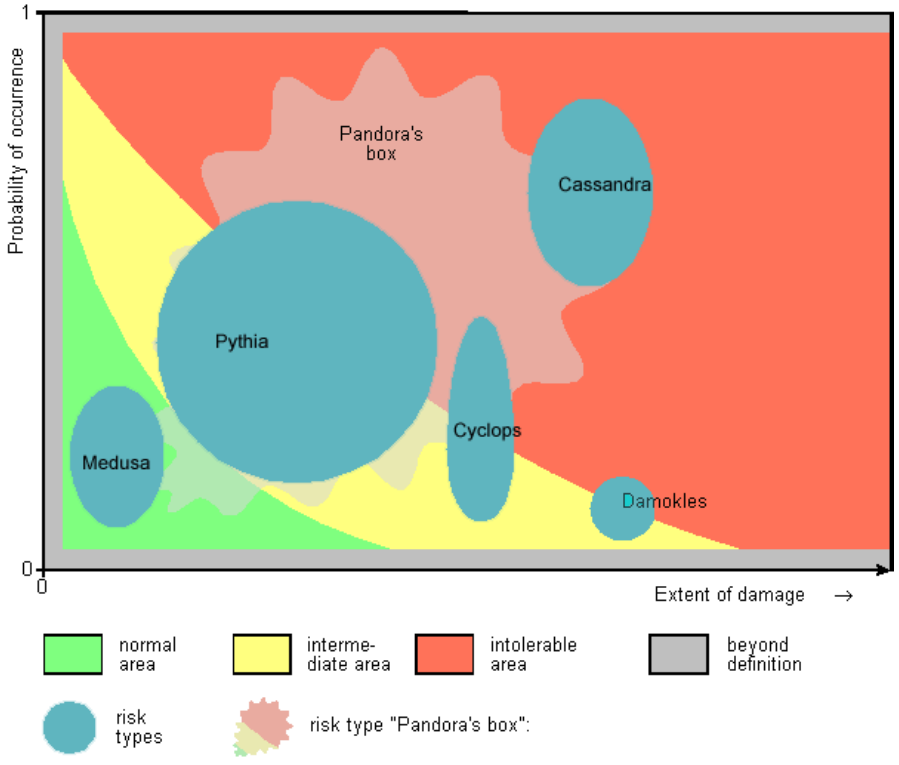
In February 2017 UN Environment ‘Declared War on Ocean Plastic’. Erik Solheim, Head of the agency said, "It is past time that we tackle the plastic problem that blights our oceans. … We’ve stood by too long as the problem has gotten worse. It must stop."

Plastic now poses a hideous problem for politicians and regulators. Vast quantities are abroad in the environment, and all of it turns out to be hazardous as it breaks into ever smaller particles. Nobody knows how to get it all back. Recycling has not contained it and existing recover, re-cycle and remanufacture practices do not make it go away (more in the next blog). Governments are not yet thinking about containing production, and only just beginning to restrict the most non-essential uses.

Back in 1999 the German Advisory Council on Global Change recognized different classes of risk problem (since refined) and gave them Greek-God names like Medusa, Cassandra and Damocles.

They assessed environmental risk against eight criteria: *Probability of occurrence*, *Extent of damage*, *Certainty of assessment, Ubiquity, Persistency, Reversibility*, *Delay effect* and *Potential of mobilisation* (political relevance). Plastics ‘ticks many of these boxes’ and has finally checked off the last one.

Plastic crosses the boundaries but it comes closest to the type of threat termed ‘Pandora’s Box’.



Here's the description of risk type Pandora's Box:

Risk class 'Pandora's box': The old Greeks explained many evils and complaints with the myth of Pandora's box – a box which was sent to the beautiful Pandora by the king of the gods Zeus. It only contained many evils and complaints. As long as the evils and complaints stayed in the box, no damage at all had to be feared. However, when the box was opened, all evils and complaints were released which then irreversibly, persistently and ubiquitously struck the earth. This risk class is characterised by both uncertainty in the criteria probability of occurrence and extent of damage (only presumptions) and high persistency. Here, persistent organic pollutants and endocrine disruptors can be quoted as examples.

A Plastic Gift Box

If plastic was sent to test us, the gods have succeeded.

[1] 'Plastic' did even not appear in the indexes Colin Moorcrafts' *Must The Seas Die ?* (1972), or K A Gourlay's *Poisoners of the Seas* (1988) or *The Ocean our Future* (1998), the Report of the Independent World Commission on the Oceans. I take my share of the blame: my own book, *The Dirty Man of Europe* published in 1990, made just two references to plastic, both about recycling

In a Future Post: What to do About The Plastic Crisis

Psychology played a role in getting us here, what does it now mean for the design of campaigns and policies to curb the problem

- How does plastic need to be re-framed?
- The visual language of the plastics problem and solution: are beach cleans and recycling now themselves part of the crisis?
- Why does the plastics industry promote beach cleans and recycling, and what real difference can they make?

- Can scientists and NGOs be persuaded to stop talking about “litter”?
- Are scientific experts on plastic pollution the right people to lead communications on getting rid of it?
- What strategy lessons can be learnt from past pollution crises so we can get on the fast track?
- What should governments do and what should be left to the market?
- What role for lifestyle campaigns?

ends