PLASTIC SOUP: POLLUTION IN THE PACIFIC OCEAN

by Olly Phillipson

OVER 20 YEARS AGO the USA's National Oceanic and Atmospheric Administration (NOAA) discovered a huge amount of rubbish, mainly plastic, floating in the north of the Pacific Ocean. It was nicknamed the 'Eastern Garbage Patch' by oceanographer Curtis Ebbesmeyer (the world's leading expert on flotsam – the name given to rubbish floating on water). Its existence gained wider publicity in 1997 through Charles Moore, the skipper of the *Algalita*, who sailed through this rarely visited area of ocean on his way back home to California. Thousands of kilometres from land, he spent a week sailing through a seemingly endless mass of plastic rubbish. On his return, concerned about what he had seen, he wrote widely about the problem of plastic pollution in the Pacific Ocean and set up the Algalita Marine Research Foundation (AMRF).

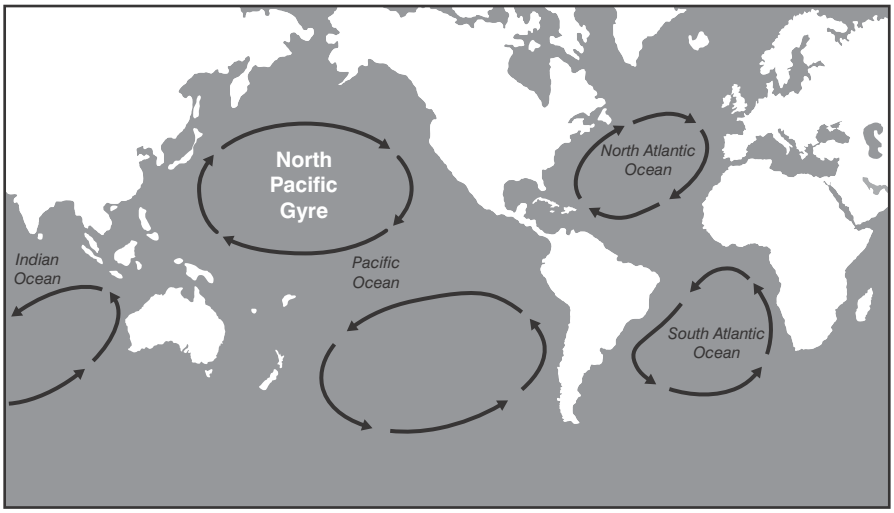

Figure 1: **The world's ocean gyres**

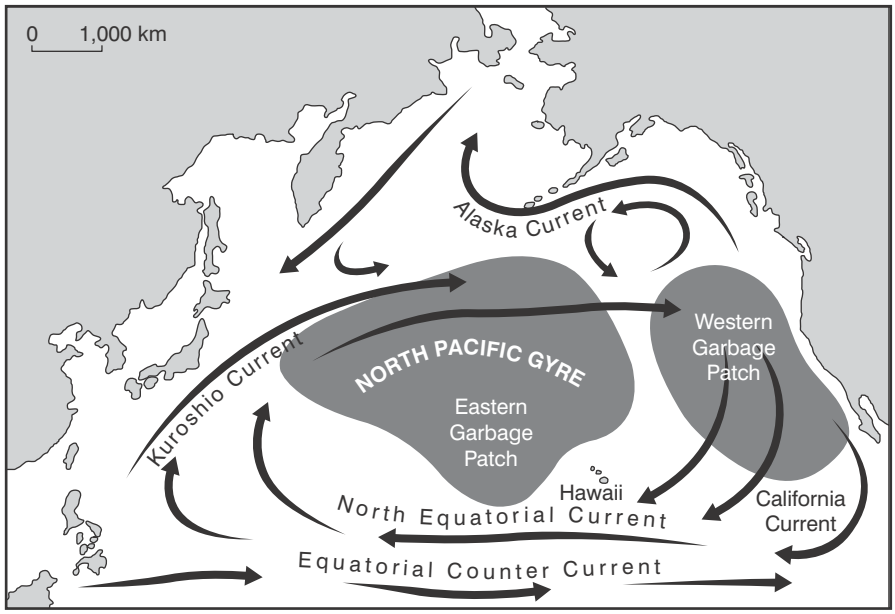

Figure 2: **The North Pacific gyre**

The North Pacific gyre

The part of the Pacific that Moore sailed through is one of the world's five major ocean gyres (Figure 1), known as the North Pacific gyre. It covers most of the northern Pacific Ocean (almost 35 million km^2 – about twice the size of continental USA) and includes the North Equatorial, North Pacific, Kuroshio and California currents (Figure 2). This large, swirling mass of ocean moves in a spiral, clockwise direction, resulting in the accumulation of plastic garbage from the western USA, Japan and the Pacific Rim in the centre of the gyre. The dominant weather here is high pressure (from warm air heated at the Equator) with gentle winds causing the spiralling water to circulate very slowly in convergence zones.

The garbage that scientists now call plastic soup is thought to be found in two separate areas on either side of the Hawaiian Islands – the Eastern and Western Pacific Garbage Patches (sometimes called the 'trash vortex'). The two are joined together by the Sub-tropical Convergence Zone current. This part of the Pacific Ocean

is nutrient poor, and although plankton and other small marine creatures are found here, the water doesn't support larger marine life and fish, so is not used by commercial fishing fleets. The lack of strong winds means that yachts and sailing ships also avoid it. With so few ships passing through the gyre and most of the translucent plastic soup invisible from the air, few observations or studies have been made until recent years.

Where do the ingredients for plastic soup come from?

We manufacture over 100 million tonnes of plastic each year. About 10% will end up in our seas and oceans. Whilst 20% of this comes from ships and offshore platforms, the rest originates from the land. A vast range of plastic goods are washed into our sewers and rivers, ending up in seas or on beaches. Large items including plastic drums and containers, fishing nets, polystyrene foam and packaging float out to sea, moved by tides and currents. These may travel vast distances, for example to the middle of the North Pacific gyre and/or are washed up along beaches. During their journeys, long or short, they gradually break into smaller pieces to form plastic soup.

Plastic goods from cigarette lighters to bags and bottles, are some of the most easily recognised items found floating in the plastic soup mix, but the tiny pellets from which they are made are another important ingredient frequently found within the mix. These may be washed out from factories into rivers and then seas or oceans, or from consignments lost overboard from ships at sea.

Why is plastic soup a problem?

Rubbish and waste materials have always found their way into

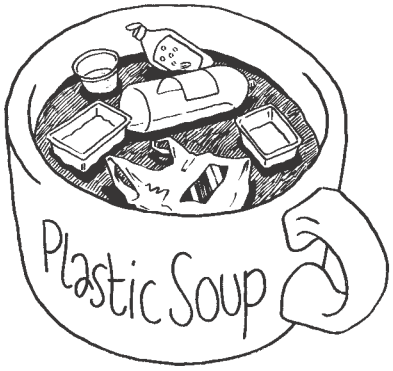

Figure 3: **Cuppa Pacific Soup**

our seas and oceans, whether by accident or deliberately. However, in the past much of this was biodegradable and quickly rotted away. Most plastics are specifically made to be hard-wearing and long-lasting. Items made over 50 years ago are regularly found as part of the Pacific's plastic soup mix. Plastics do not biodegrade as natural materials do, but break down gradually into smaller plastic fragments, taking 100 years or even more. Some plastics are worn down by abrasion by rubbing against other flotsam or the sea bed. Others photodegrade into smaller pieces (called nurdles or mermaid tears) through the action of sunlight.

As the pieces get smaller they form a moving mass of plastic soup on or just below the surface of the water (Figure 3).

The amount of plastic soup is increasing every year – Moore fears that the amount in the North Pacific gyre could double over the next ten years. The United Nations Environment Programme (UNEP) estimates that there are 18,000 pieces of floating plastic for every square kilometre of ocean. Plastics may account for as much as 90% of the total amount of rubbish floating in the world's oceans. Much of this cannot be easily seen or measured. Charles Moore could see it as he sailed through it, but most plastic soup is translucent so cannot be seen from the air or easily be monitored by satellites.

On the surface, plastic soup can provide a new superhighway for living organisms to travel and be transported around the world, invading areas previously outside their reach, with potentially harmful consequences to existing habitats. Apart from these vast quantities of plastic soup near the surface, over 70% of the plastic garbage in our seas and oceans sinks to the bottom, covering the sea bed and affecting the

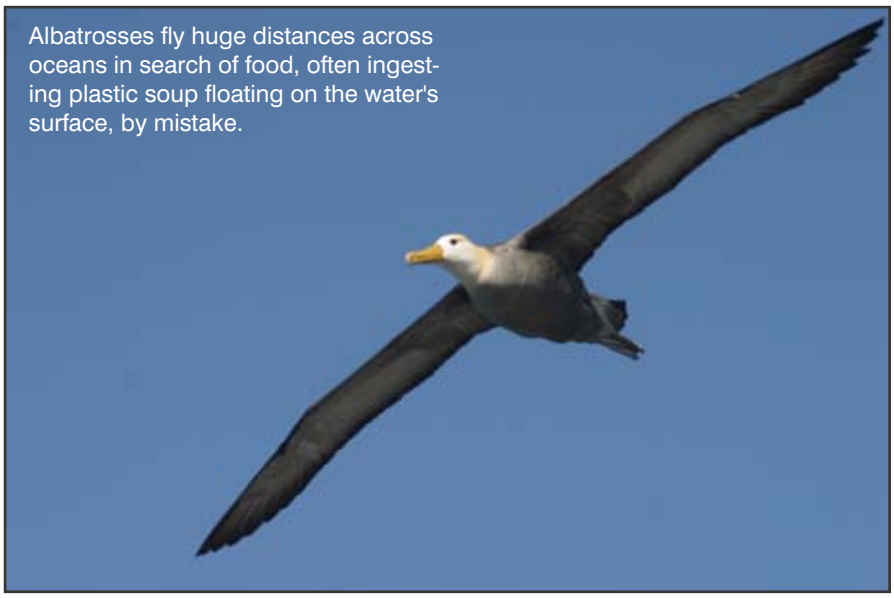

Figure 4: **Albatross in flight**

Species	No. of species worldwide	No. of species entangled	No. of species ingested
Sea turtles	7	6 (86%)	6 (86%)
Seabirds	312	51 (16%)	111 (36%)
Other birds	–	5	0
Marine mammals	115	32 (28%)	26 (23%)
Fish	–	34	33
Crustaceans	–	8	0
Squid	–	0	1
Total	**–**	**136**	**177**

Figure 5: **Some species experiencing plastic entanglement and ingestion**

Source: Greenpeace Report, *Plastic Debris in the World's Oceans*

creatures that live there. Dutch scientists have found an average of 110 pieces of plastic litter per square kilometre on the bed of the North Sea.

In the North Pacific gyre there are now thought to be 6 or 7 kg of plastic for every kilogram of plankton. It is plankton that forms the base of the marine food chain. Small marine creatures feed on the plankton, ingesting large amounts of the plastic soup around it. Larger birds, typically albatrosses, feed on these and sometimes directly on plastic rubbish which they mistake for food like squid (Figure 4). Studies have found hundreds of items of plastic inside individual corpses of birds and turtles throughout the region. These include cigarette lighters, torches, toys, syringes, toothbrushes, bottle tops, plastic bags and balloons. On Midway Island, within the North Pacific gyre, over half a million albatross chicks hatch every year. Over 40% of these die, many through eating plastic unknowingly fed to them by their parents. Researchers are convinced that *all* birds contain at least some items of plastic in their digestive systems.

Old plastic netting and fishing lines trap, kill and injure birds and mammals. Jellyfish are often seen with long streams of plastic caught around them. UNEP estimates that over 1 million seabirds and 100,000 marine mammals and turtles die every year either by swallowing plastic or becoming fatally entangled in it (Figure 5).

Small amounts of plastics found at sea can initiate chemical changes. Recent studies in the UK have shown that some chemicals, e.g. PCBs, can be absorbed by small pieces of plastic:

> 'They can become magnified in concentration and maybe in a different chemical environment, perhaps the guts of organisms, those chemicals might be released.'
>
> Dr Richard Thompson, University of Plymouth

This could result in the release of highly toxic materials into the water, and into the marine food chain. Researchers in Tokyo have discovered that plastic pellets act like sponges, building up very high concentrations of toxins such as PCBs and DDT. They can also disrupt hormone levels in living organisms.

The future

Whilst studies of plastic pollution in the North Pacific gyre are increasing and scientists are beginning to find out more about it, similar areas within the other four major ocean gyres are also likely to see the build-up of plastic soup. Scientists in Chile have recently reported sightings in the Southern Ocean near Antarctica. Others are concerned about the Sargasso Sea in the Atlantic.

As more plastic builds up in our oceans, it may move right through the food chain. Scientists studying filter feeders like barnacles and lugworms, near the bottom of the marine food chain, have found that they can easily ingest plastics. The plastic, and any toxins within them, could pass right through the food chain to humans.

Given the sheer size of the oceans and the amount of plastic already in use, cleaning up this soup would be an almost impossible task. Charles Moore believes that:

> 'Only elimination of the source of the problem can result in an ocean nearly free from plastic, and the desired result will only be seen by citizens of the third millennium AD. The battle to change the way we produce and consume plastics has just begun, but I believe it is essential that it be fought now.'

If his (and others') predictions are correct, we will continue to see the build-up of plastic soup not only in the North Pacific gyres, but in other oceans too, for the foreseeable future. Scientists may help in finding plastics or other substances that do break down safely and quickly, but this will take time. Far stricter regulations on the disposal of plastic may be needed whilst such research takes place.

Activities

1 Write brief definitions to explain the following:
- gyre
- biodegradable
- photodegradable
- flotsam
- plankton.

2 Study Figure 2. How does this map help explain why the plastic soup forming the Eastern and Western Garbage Patches is found here?

3 (a) List the 'ingredients' for plastic soup.
(b) Where do the various ingredients come from?

4 Copy and complete Figure 6. You will probably need a full page (A4) for it.

5 (a) What do you think about Charles Moore's statement about the problem of getting rid of plastic soup? Are you optimistic or pessimistic?
(b) Discuss your answer to (a) with someone else in your class / in a small group. What would your group suggest is done about the problem of plastic waste / plastic soup?

Extension activity

6 Look at Figure 7. It lists 12 key facts taken from the UNEP's list of 50 published in 2004.
(a) Which facts did you know about / were you aware of?
(b) Which facts are related to plastic debris / plastic soup?
(c) Which facts surprised you? Explain why.
(d) Look up the complete document at: www.unep.org/wed/2004/Downloads/PDFs/Key_Facts_E.pdf

Problem	Description/explanation
Degradable?	
Amount	
Superhighway	
Ingestion	
Entanglement	
Food chain	
Chemical changes	
Other	

Figure 6: **Why plastic soup is a problem**

1	Oceans cover 70% of the Earth's surface.
2	More than 90% of the planet's living biomass is found in the oceans.
3	Eighty per cent of all pollution in seas and oceans comes from land-based activities.
7	Death and disease caused by polluted coastal waters costs the global economy US$12.8 billion a year. The annual economic impact of hepatitis from tainted seafood alone is US$7.2 billion.
8	Plastic waste kills up to 1 million sea birds, 100,000 sea mammals and countless fish each year.
9	Sea creatures killed by plastic decompose; the plastic does not. Plastic remains in the ecosystem to kill again and again.
30	Less than 0.5% of marine habitats are protected, compared with 11.5% of global land area.
31	The High Seas – areas of the ocean beyond national jurisdiction – cover almost 50% of the Earth's surface. They are the least protected part of the world.
36	More than 3.5 billion people depend on the ocean for their primary source of food. In 20 years, this number could double to 7 billion.
43	Destructive fishing practices are killing hundreds of thousands of marine species each year and helping to destroy important undersea habitats.
44	Each year, illegal longline fishing, which involves lines up to 130 km long, with thousands of baited hooks, kills over 300,000 seabirds, including 100,000 albatrosses.
46	Global by-catch – unintended destruction caused by the use of non-selective fishing gear, such as trawl nets, longlines and gillnets – amounts to 20 million tonnes a year.

Figure 7: Selection from **50 key facts about seas and oceans**

Source: UNEP

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