The North Pacific Subtropical Gyre (NPSG) & Plastic Pollution FAQs

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Where is the gyre? How much of it is the "Garbage Patch"?

The North Pacific Subtropical Gyre (NPSG) is one of several areas where ocean currents form a swirling vortex. There are subtropical and sub-polar gyres in every ocean in the world. In this case, the gyre is bounded by the North Pacific current, the California current, the North Equatorial current, and the Kuroshio current. Algalita has sampled along the following two transects: 35 45.8 N, 138 30.7 W to 36 04.9 N, 42 04.6 W and 36 04.9 N – 142 04.6 S to 34 04.0 N. To our knowledge, most of the rest of the gyre has not been sampled. We can say with certainty that the areas where we collected samples are a "garbage patch." We suspect that the contamination is much more widespread, and in future research voyages we will collect data to confirm or deny this hypothesis.

Captain Moore says, "With regard to the size of the debris-impacted area of the North Pacific subtropical gyre, loosely referred to as the Eastern "Garbage Patch", I now believe that such a dubious distinction belongs to the whole of the gyre we are surveying. Ocean Surface Current models (OSCURS) by Jim Ingraham show Texas-scale areas nicknamed garbage patches in the eastern and western North Pacific where much of the debris resides for decades. We have found that millions of square miles of ocean from 20N to 40N and from 135W to near the international date line, where we have done limited but extensive trawl sampling are significantly impacted, though outside the loose geographical limits of the EGP. In fact, the highest levels yet found by our team have been in the area bounded by 30-33N and 160-170W, an area not considered part of the EGP."

(from the ORV Alguita blog, Feb 2008)

Dr Marcus Eriksen, the director of education and research at AMRF, further explains the distinction between the gyre and the garbage patch: "The North Pacific Gyre is roughly twice the size of the United States, occupying much of the North Pacific Ocean. We begin to see evidence that we are in the Eastern Patch 500 miles off the California coast. Others have found what is believed to be a Western Garbage Patch a few hundred miles off the coast of Japan. It's dimensions and location shift seasonally, and the density of debris varies. Our first investigation of plastic density in the North Pacific Gyre in 1999 found an average of .002g/m2, with the dry weight of plankton outweighed by plastic 6 times. In 2008 we replicated the same study and found an average of .004g/m2 plastic density, doubling in 9 years. The ratio of plastic to plankton was 46 to 1, likely a representation the spatial and temporal variability in plankton production, but alarming when considering the many filter feeding pelagic species that are impacted."

If you would like to learn more about oceanic gyres in general, please refer to: http://en.wikipedia.org/wiki/Gyre.

Why aren't there any satellite photos of the "Garbage Patch"?

Rather than picturing a floating "island" of debris, it is more helpful to think of the "Garbage Patch" as a plastic soup. The smallest size class of plastic we have been able to measure (.355-.499mm) is smaller than the head of a sewing pin. When seen from the ocean's surface, it appears as confetti, with the occasional large piece of derelict fishing gear. This is not picked up in satellite photos. The plastic is distributed throughout the water column as well as in the sediment on the sea floor. In an effort to capture this idea, Algalita associate Manuel Maqueda is working with Google Earth to show a layer on the map of the Pacific Ocean at the coordinates of the gyre that will show, using photographs of debris collected in the gyre, what we would see if all of the pieces were floating on the surface.

Where is the plastic coming from?

The United Nations Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) estimated that land-based sources are responsible for up to 80% of marine debris (Sheavly 2005). Land-based point sources include plastic manufacturers and fabricators (spilled nurdles). Non-point sources, or diffuse sources, include litter from beach goers and litter further inland that finds is carried by wind or streams to the sea. Destructive storms contribute to the problem as well. Think of the debris that you have seen carried in flood waters. In coastal areas, much of this is washed into the sea.

In addition, plastic is sometimes lost (intentionally or unintentionally) from cargo and passenger ships. If you are curious about how flotsam (floating debris) can help us monitor the ocean's currents, you can read more at Dr. Curtis C. Ebbesmeyer's website http://beachcombersalert.org/index.htm.

Where and how does Captain Moore collect the samples?

The crew dragged a manta trawl (rollover: a device that captures surface debris in a fine mesh net) and a Bongo trawl (a device lowered to depths up to 100 meters to capture debris in the water column) behind the *Alguita* (Captain Moore's 50-foot research vessel*)* as she (rollover: maritime superstition has it that it is unlucky not to refer to a boat as a woman) sailed through the gyre.

In order to make fair comparisons over time, Captain Moore and the crew of the *Alguita* took into account not only the precise coordinates of the spots to be sampled and the depths of the Bongo trawls, but also the times of day (to determine whether the feeding time of fish correlated to any variation in the abundance of particular size classes of plastic debris), the season of the year, and the effects of wind and ocean currents.

If you would like more details on the protocols that Captain Moore and his crew followed in collecting the samples, please refer to his published work.

What types of plastic are causing the problem?

The majority of our samples, which are collected at one, ten, and one hundred meter depths, contain primarily low-density polyethylene, expanded styrene (Styrofoam), polypropylene, and PET (polyethylene terephthalate). We suspect that they are so abundant in our trawls because they are buoyant (unless the pieces of plastic are large enough to be colonized by fouling organisms, such as barnacles, in which case the weight of the organisms causes it to sink).

Polyvinyl chloride (PVC), acrylonitrile butadiene styrene (ABS), high-density polyethylene (HDPE), polystyrene (non-expanded PS), nylon and rubber debris tend to sink (US EPA 2002). We look forward to sampling deeper in the water column and the sediment to ascertain the abundance of other types of polymers.

(Low-density or linear low-density polyethylene, like single-use plastic shopping bags, has the resin code #4. Polypropylene has a resin code of #5, and is a common material for bottle caps. Most disposable water bottles are made of PET, which has a resin code of #1.)

What about "compostable" plastics?

It is difficult to make a blanket statement about compostable and biodegradable plastics. The technology is changing so quickly that new products are being introduced constantly. Some of these compost only under certain conditions (temperature, pressure, moisture, presence of particular species of microorganisms, etc.) that can not be achieved in the marine environment. Others show promise, but even when products do biodegrade, questions remain about the toxicity of the additives that are left behind.

Some products that are marketed as "biodegradable" are actually a combination of regular plastic and cornstarch. The cornstarch breaks down, leaving pieces of plastic too small to notice. However, the plastic does not break down any further on an appreciable time scale.

We are aware that other concerns have been raised in regards to the social and environmental impact of using food crops to manufacture plastics. Hopefully, further research and product development will lead to better and better replacements for petroleum-based plastics.

Why does Algalita consider plastic marine debris to be an urgent problem?

With the exception of the plastic that has been incinerated (a disposal method we do not recommend because of the release of toxicants into the air), all the plastic ever manufactured is still with us. The quantity of plastic in the ocean is increasing very rapidly, paralleling the rapid rise in the volume of global polymer production. The amount of debris around the coastline of the UK doubled between 1994 and 1998, and in parts of the Southern Ocean it increased 100-fold (Barnes 2002). One study reported plastic debris stranded on shores as far north at Spitsbergen in the Arctic (Barnes and Milner 2005). Each time the *Alguita* crew samples the gyre, we find that the abundance of plastic has increased since our previous visit. Since plastic already swirling in the gyre will not go away, we urgently call for the prevention of further pollution of our oceans.

What is a nurdle?

A nurdle is a pre-production plastic pellet. It is also sometimes called a "mermaid's tear." Nurdles are chemically produced in one facility then taken to factories where they are melted and shaped into consumer products, like a plastic water bottle or a computer keyboard. You might think of the nurdles as something like the thread that must be taken to looms that weave it into cloth before you can make clothing.

About 250 billion pounds of nurdles are produced every year (Wired News, June 5, 2005). One pound of nurdles costs about $1 U.S. and contains about 25,000 pellets.

Nurdles are about the size of a lentil, usually between 0.1 and 0.5 cm in diameter. (Just smaller than the tapioca pearls in Thai iced tea, which are about 0.6 cm in diameter.) Because they are so small and lightweight, they easily slip through the cracks in the boxes that transport them. They might be carried on a light wind, finding their way into the street, then into the sewer drains. They are so tiny they wash right through the filter screens at storm water treatment plants. Many nurdles end up in the ocean.

What are POPs?

The term "persistent organic pollutant" (POP) is a way of describing any synthetic poison that meets a particular set of characteristics:

- POPs are *persistent* in the environment. They resist decomposition.
- POPs are *organic*, which in this usage of the word simply means contains carbon.
- They are *pollutants*, that is, they have harmful effects.

Twelve POPs were regulated in an international treaty called the Stockholm Convention. This "dirty dozen" includes Aldrin, Chlordane, Dieldrin, Endrin, Heptachlor, Hexachlorobenzene, Mirex, Toxaphene, Polychlorinated Biphenyls (PCBs), DDT, dioxins (a class of contaminants of which there are many individual species) and furans (like dioxins, there are many furans). However, these are not the only POPs.

POPs are lipophilic, which means that they are attracted to fatty or oily substances. Because of this property, they tend to bioaccumulate in living tissue and resist excretion, which means that an animal or person retains and adds to their stores of poison over their lifetime. The older one is and the higher up one is on the food chain, generally the more POPs one has in their body. Remember that the top of the food chain is nursing infants. For more information, visit the Stockholm Convention's website at http://chm.pops.int/.

How long does it take plastic to break down? What is the difference between photodegradation and biodegradation?

Photodegradation refers to the action of ultraviolet radiation and solar heat on plastic. In the absence of special additives (many plastics contain UV-filters specifically designed to resist this process), the plastic weakens and breaks into pieces. This is a physical change, not a chemical change.

Biodegradation happens when living organisms transform the chemical bonds of the plastic. In current scientific understanding, biodegradation plays a very limited role in the environmental fate of plastics. While there have been preliminary isolated reports of specific (terrestrial) microorganisms that can “digest” certain types of plastic, in general, plastic is not “digestible.” In fact, some researchers have promoted the idea of replacing cattle's roughage with plastic, precisely because it doesn't break down in their stomach and can even be removed after slaughter and given to another cow. In a similar way, plastic consumed by marine life appears to either pass through the digestive tract intact (if it is small enough), or remains in the animal. When the animal dies, the plastic is either released, to be eaten again, or is swallowed by a predator eating the plastic-ridden prey.

No one can say with certainty how long plastics will last in the environment. We will just have to wait and see. The first synthetic plastic, Bakelite, was invented in 1907. Pieces of Bakelite are still structurally sound after more than a century. Our best guess is that, like diamonds, plastic is forever.

What effects is plastic having on wildlife?

Large pieces of plastic, especially derelict fishing gear, can kill by entrapment, suffocation, and drowning. Smaller pieces can be ingested, cause choking or intestinal blockage. In some cases, starvation occurs because the plastic makes the animal feel full without having had anything nourishing to eat.

Researchers are starting to document another problem. Many plastics release toxic chemicals, both the chemicals that were part of the plastic from manufacture, and the chemicals that the plastic has absorbed from its environment. One experiment showed that after two weeks in the ocean, the level of POPs in nurdles rose to up to one million times the level in the ambient seawater (Mato et al, 2001). We are conducting studies now at Algalita to gain a better understanding of how plastic might be transporting and concentrating POPs up the food chain.

What effects does plastic have on human health?

Many substances associated with plastic are, without question, poisonous to people. The manufacture of conventional plastic involves toxicants (poisonous substances; note that 'toxins' refers only to poisons produced by a living organism while 'toxicants' includes all poisonous substances) such as benzene and toluene that are transformed through industrial processes into useful chemicals. However, some of the main building blocks of plastics are themselves toxic (such as vinyl chloride and styrene). “The Petrochemical Tree” at the website of the Gulf Petrochemicals & Chemicals Association (www.gpca.org.ae/overview.asp) provides an excellent overview of how oil and gas become plastics, and the most important intermediaries in that process.

Then there is an expansive, growing, but contested literature regarding the potential for adverse health effects in humans from another set of chemicals, called endocrine disruptors (chemicals that interfere with hormone signaling). A few of the chemicals under investigation are phthalates, nonylphenols, perfluorooctanoic acid and bisphenol-A. The health problems these chemicals are suspected of playing a role in vary from cancer to brain damage to reproductive and cardiovascular effects. There is not scientific consensus at this point, and the debate in regulatory and legal arenas is often heated.

Industry argues that the amounts of poisons that consumers absorb from using plastic products are so tiny that they are insignificant. Many experts disagree, citing studies that show serious and irreparable harm at doses so low (parts per trillion) that we would have been unable to measure them a few decades ago. One interesting aspect of the debate is that the so-called "low-dose" health effects are often the opposite effects that the same chemical is known to produce at a higher dose. For example, Tamoxifen at high doses is used to treat breast cancer. At extremely low concentrations, however, it appears to activate the aromatase enzyme pathway that it turns off at high doses. If the dose indeed makes the poison, different doses may turn the same substance into very different poisons. Dr Tyrone Hayes, a biologist at University of California, Berkeley, has been studying this phenomenon for many years and has written extensively about it.

To make things even more complicated, some new types of substances used in polymers have not been studied enough yet to draw any conclusions. An example of this is nanoparticles (particles so tiny that they can slip through the human cell membrane).

What are the solutions?

Algalita believes that the solution is prevention. We can not clean up the garbage already in the gyre, but we can stop the flow of waste. We can reconsider our use of disposable plastic products, prevent the spillage of nurdles, and work towards closed-loop manufacturing processes. Green chemists are working on non-toxic plastics that will degrade at sea and on land. We support these efforts. Meanwhile, we promote education to help us all make more informed and responsible choices.

Why can't we just clean up the plastic in the gyre?

Think of how difficult it would be to gather confetti from along a stretch of beach. Now imagine that the area you are trying to clean is not only miles long but also miles deep. Remember that plastic debris occurs throughout the water column. Some of it floats, some of it has sunk to the sea floor, and some swirls below the surface. More trash is constantly being added.

While some of the plastic debris is large enough to be scooped out, much of it consists of tiny plastic fragments. If we were to sieve out pieces that small, we would inevitably capture tiny fish and plankton as well. The by-catch would be impossible to sort without harming the marine life.

Captain Moore likens the task to trying to collect the ozone-depleting chemicals from the stratosphere, molecule by molecule.

What are the next steps in Algalita's research agenda?

A ten-year retrospective voyage to the gyre is being planned for Fall 2009. Top priorities for our land-based researchers include an ongoing project examining plastics' role in transporting POPs (persistent organic pollutants). Biologists with AMRF have dissected lantern fish and albatross (by-catch of the fishing industry) from the Pacific. The tissues will be analyzed for POPs, and the POP levels compared to the quantity and types of plastic each ingested. Additional work is yet to be done on the characterization of trawl samples from previous gyre voyages. Another project this year will examine coastal sediment for contaminants from plastic, such as bisphenol-A.