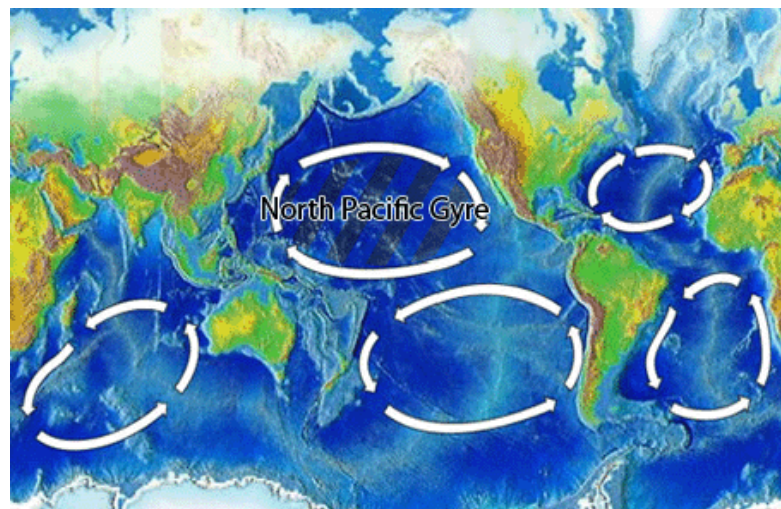


# Great Pacific Garbage Patch

The **Great Pacific Garbage Patch**, also described as the **Pacific Trash Vortex**, is a gyre of marine debris in the central North Pacific Ocean located roughly between 135°W to 155°W and 35°N and 42°N.<sup>[1]</sup> The patch extends over an indeterminate area, with estimates ranging very widely depending on the degree of plastic concentration used to define the affected area.

The Patch is characterized by exceptionally high concentrations of pelagic plastics, chemical sludge and other debris that have been trapped by the currents of the North Pacific

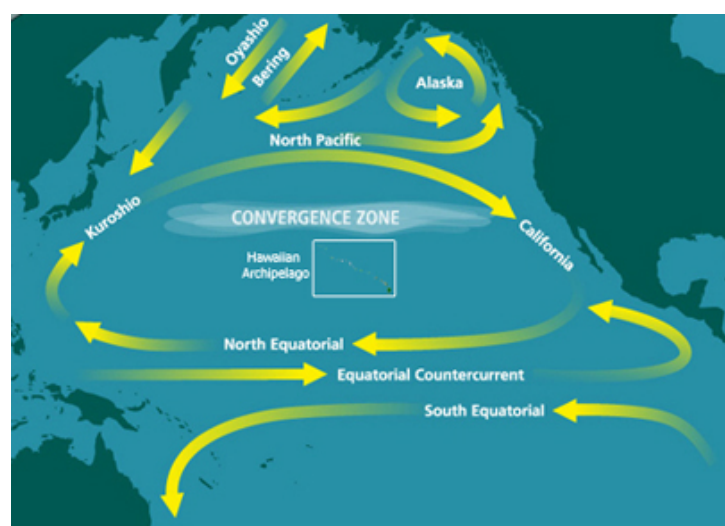
Gyre.<sup>[2]</sup> Despite its size and density, the patch is not visible from satellite photography, since it consists primarily of suspended particulates in the upper water column. Since plastics break down to even smaller polymers, concentrations of submerged particles are not visible from space, nor do they appear as a continuous debris field. Instead, the patch is defined as an area in which the mass of plastic debris in the upper water column is significantly higher than average.



The Garbage Patch is located within the North Pacific Gyre, one of the five major oceanic gyres.

## Discovery

The Great Pacific Garbage Patch was predicted in a 1988 paper published by the National Oceanic and Atmospheric Administration (NOAA) of the United States. The prediction was based on results obtained by several Alaska-based researchers between 1985 and 1988 that measured neustonic plastic in the North Pacific Ocean.<sup>[3]</sup> This research found high concentrations of marine debris accumulating in regions governed by ocean currents. Extrapolating from findings in the Sea of Japan, the researchers hypothesized that similar conditions would occur in other parts of the Pacific where prevailing currents were favorable to the creation of relatively stable waters. They specifically indicated the North Pacific Gyre.<sup>[4]</sup>



The Patch is created in the gyre of the North Pacific Subtropical Convergence Zone

Charles J. Moore, returning home through the North Pacific Gyre after competing in the Transpac sailing race in 1997, came upon an enormous stretch of floating debris. Moore alerted the oceanographer Curtis Ebbesmeyer, who subsequently dubbed the region the "Eastern Garbage Patch" (EGP).<sup>[1]</sup> The area is frequently featured in media reports as an exceptional example of marine pollution.<sup>[5]</sup>

The patch is not easily visible because it consists of very small pieces, almost invisible to the naked eye,<sup>[6]</sup> most of its contents are suspended beneath the surface of the ocean,<sup>[7]</sup> and the relatively low density of the plastic debris at, in one scientific study, 5.1 kilograms of plastic per square kilometer of ocean area.<sup>[1]</sup>

A similar patch of floating plastic debris is found in the Atlantic Ocean. See: North Atlantic Garbage Patch.<sup>[8][9]</sup>

## Formation

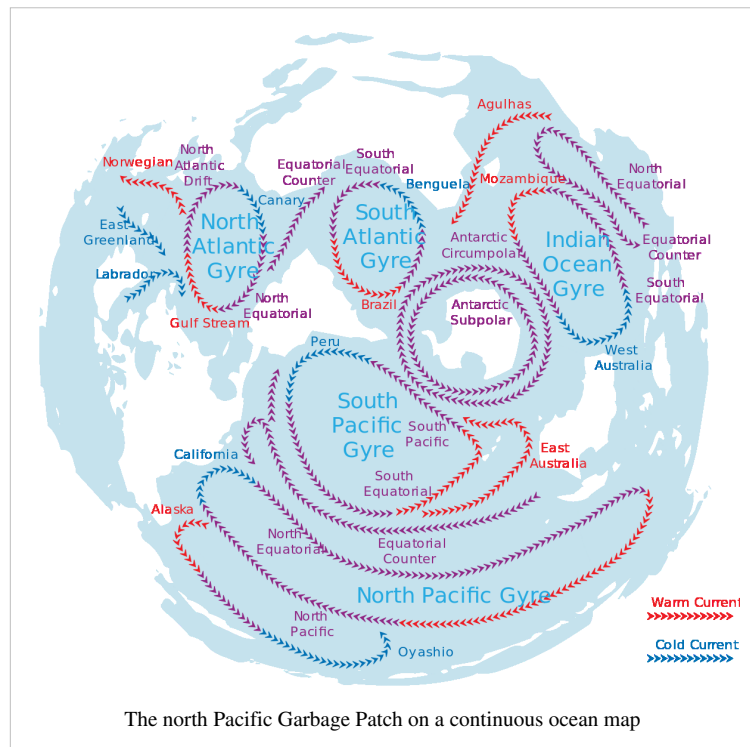
It is thought that, like other areas of concentrated marine debris in the world's oceans, the Great Pacific Garbage Patch formed gradually as a result of marine pollution gathered by oceanic currents.<sup>[10]</sup>

The garbage patch occupies a large and relatively stationary region of the North Pacific Ocean bound by the North Pacific Gyre (a remote area commonly referred to as the horse latitudes). The gyre's rotational pattern draws in waste material from across the North Pacific Ocean, including coastal waters off North America and Japan. As material is captured in the currents, wind-driven surface currents gradually move floating debris toward the center, trapping it in the region.

There are no strong scientific data concerning the origins of pelagic plastics.

The figure that an estimated 80% of the garbage comes from land-based sources and 20% from ships is derived from an unsubstantiated estimate.<sup>[11]</sup> Ship-generated pollution is a source of concern, since a typical 3,000-passenger cruise ship produces over eight tons of solid waste weekly, a major amount of which ends up in the patch, as most of the waste is organic.<sup>[12]</sup> Pollutants range in size from abandoned fishing nets to micro-pellets used in abrasive cleaners.<sup>[1]</sup> Currents carry debris from the west coast of North America to the gyre in about six years,<sup>[13]</sup> and debris from the east coast of Asia in a year or less.<sup>[14]</sup> An international research project led by Dr. Hideshige Takada of Tokyo University of Agriculture and Technology studying plastic pellets, or nurdles, from beaches around the world may provide further clues about the origins of pelagic plastic.<sup>[15]</sup>

Logically, the land-based sources of pollutants and plastics come from the great rivers from around the world. The Ganges, in India, is an example of a source of major sea pollution (see Pollution of the Ganges). The major rivers of Bangladesh, Nigeria, and other developing nations collectively provide another example of marine-pollution sources. It has been noted that the levels of pollution in and around these rivers constitute a major health hazard to people living and doing business around the water.



## Estimates of size

The size of the patch is unknown, as large items readily visible from a boat deck are uncommon. Most debris consists of small plastic particles suspended at or just below the surface, making it impossible to detect by aircraft or satellite. Instead, the size of the patch is determined by sampling. Estimates of size range from 700,000 square kilometres (270,000 sq mi) to more than 15,000,000 square kilometres (5,800,000 sq mi) (0.41% to 8.1% of the size of the Pacific Ocean), or, in some media reports, up to "twice the size of the continental United States".<sup>[1]</sup> Such estimates, however, are conjectural based on the complexities of sampling and the need to assess findings against other areas.

Net-based surveys are less subjective than direct observations but are limited regarding the area that can be sampled (net apertures 1–2 m and ships typically have to slow down to deploy nets, requiring dedicated ship's time). The plastic debris sampled is determined by net mesh size, with similar mesh sizes required to make meaningful comparisons among studies. Floating debris typically is sampled with a neuston or manta trawl net lined with 0.33 mm mesh. Given the very high level of spatial clumping in marine litter, large numbers of net tows are required to adequately characterize the average abundance of litter at sea. Long-term changes in plastic meso-litter have been reported using surface net tows: in the North Pacific Subtropical Gyre in 1999, plastic abundance was 335 000 items/km<sup>2</sup> and 5.1 kg/km<sup>2</sup>, roughly an order of magnitude greater than samples collected in the 1980s. Similar dramatic increases in plastic debris have been reported off Japan. However, caution is needed in interpreting such findings, because of the problems of extreme spatial heterogeneity, and the need to compare samples from equivalent water masses, which is to say that, if an examination of the same parcel of water a week apart is conducted, an order of magnitude change in plastic concentration could be observed.<sup>[16]</sup>

Further, although the size of the patch is determined by a higher-than-normal degree of concentration of pelagic debris, there is no specific standard for determining the boundary between the "normal" and "elevated" levels of pollutants to provide a firm estimate of the affected area.

In August 2009, the Scripps Institution of Oceanography/Project Kaisei SEAPLEX survey mission of the Gyre found that plastic debris was present in 100 consecutive samples taken at varying depths and net sizes along a 1,700 miles (2,700 km) path through the patch. The survey also confirmed that, while the debris field does contain large pieces, it is on the whole made up of smaller items that increase in concentration toward the Gyre's centre, and these 'confetti-like' pieces are clearly visible just beneath the surface.

Charles Moore has estimated the mass of the Great Pacific Garbage Patch at 100 million tons,<sup>[17]</sup> which would be several tons per km<sup>2</sup>.

Although many media and advocacy reports have suggested that the patch extends over an area larger than the continental U.S., recent research sponsored by the National Science Foundation suggests the affected area may be twice the size of Hawaii,<sup>[18][19]</sup> while a recent study concluded that the patch might be smaller.<sup>[20]</sup> This can be attributed to the fact that there is no specific standard for determining the boundary between the "normal" and "elevated" levels of pollutants and what constitutes being part of the patch. The size is determined by a higher-than-normal degree of concentration of pelagic debris in the water. Recent data collected from Pacific albatross populations suggest there may be two distinct zones of concentrated debris in the Pacific.<sup>[21]</sup>

## Photodegradation of plastics

The Great Pacific Garbage Patch has one of the highest levels known of plastic particulate suspended in the upper water column. As a result, it is one of several oceanic regions where researchers have studied the effects and impact of plastic photodegradation in the neustonic layer of water.<sup>[22]</sup> Unlike organic debris, which biodegrades, the photodegraded plastic disintegrates into ever smaller pieces while remaining a polymer. This process continues down to the molecular level.<sup>[23]</sup>

As the plastic flotsam photodegrades into smaller and smaller pieces, it concentrates in the upper water column. As it disintegrates, the plastic ultimately becomes small enough to be ingested by aquatic organisms that reside near the ocean's surface. In this way, plastic may become concentrated in neuston, thereby entering the food chain.

Some plastics decompose within a year of entering the water, leaching potentially toxic chemicals such as bisphenol A, PCBs, and derivatives of polystyrene.<sup>[24]</sup>

The process of disintegration means that the plastic particulate in much of the affected region is too small to be seen. In a 2001 study, researchers (including Charles Moore) found concentrations of plastic particles at 334,721 pieces per km<sup>2</sup> with a mean mass of 5,114 grams (11.27 lbs) per km<sup>2</sup>, in the neuston. Assuming each particle of plastic averaged 5 mm x 5 mm x 1 mm, this would amount to only 8 m<sup>2</sup> per km<sup>2</sup> due to small particulates. Nonetheless, this represents a very high amount with respect to the overall ecology of the neuston. In many of the sampled areas, the overall concentration of plastics was seven times greater than the concentration of zooplankton. Samples collected at deeper points in the water column found much lower concentrations of plastic particles (primarily monofilament fishing line pieces).<sup>]</sup> Nevertheless, according to the mentioned estimates, only a very small part of the plastic would be near the surface.

## Effect on wildlife



Remains of an albatross containing ingested flotsam

Some of these long-lasting plastics end up in the stomachs of marine birds and animals, and their young,<sup>]</sup> including sea turtles and the Black-footed Albatross. Midway Atoll receives substantial amounts of marine debris from the Great Pacific Garbage Patch. Of the 1.5 million Laysan Albatrosses that inhabit Midway, nearly all are found to have plastic in their digestive system.<sup>[25]</sup> Of the approximately one-third of the chicks that die, many of them are due to being fed plastic from their parents.<sup>[26]</sup><sup>]</sup>

Besides the particles' danger to wildlife, on the microscopic level the floating debris can adsorb organic pollutants from seawater, including PCBs, DDT, and PAHs.<sup>[27]</sup> Aside from toxic effects,<sup>[28]</sup> when ingested, some of these are mistaken by the endocrine system as estradiol, causing hormone disruption in the affected animal.<sup>]</sup> These toxin-containing plastic pieces are also eaten by jellyfish, which are then eaten by larger fish.

Many of these fish are then consumed by humans, resulting in their ingestion of toxic chemicals.<sup>[29]</sup> Marine plastics also facilitate the spread of invasive species that attach to floating plastic in one region and drift long distances to colonize other ecosystems.<sup>]</sup> [Wikipedia:Link rot](#)

On the macroscopic level, the physical size of the plastic kills birds and turtles as the animals' digestion can not break down the plastic inside their stomachs. A second effect of the macroscopic plastic is to make it much more difficult for animals to see and detect their normal sources of food.<sup>[citation needed]</sup>

Research has shown that this plastic marine debris affects at least 267 species worldwide and a few of the 267 species reside in the North Pacific Gyre.<sup>[30]</sup>

## Research of cleanup

In April 2008, Richard Sundance Owen, a building contractor and scuba dive instructor, formed the Environmental Cleanup Coalition (ECC) to address the issue of North Pacific pollution. ECC collaborates with other groups to identify methods to safely remove plastic and persistent organic pollutants from the oceans.<sup>[31]</sup>

The JUNK raft project was a trans-Pacific sailing voyage from June to August 2008 made to highlight the plastic in the patch, organized by the Algalita Marine Research Foundation.<sup>[32]</sup>

Project Kaisei is a project to study and clean up the garbage patch launched in March 2009. In August 2009, two project vessels, the *New Horizon* and the *Kaisei*, embarked on a voyage to research the patch and determine the feasibility of commercial scale collection and recycling.<sup>[32]</sup>

The SEAPLEX expedition, a group of researchers from Scripps Institution of Oceanography, spent 19 days on the ocean in August, 2009 researching the patch. Their primary goal was to describe the abundance and distribution of plastic in the gyre in the most rigorous study to date. Researchers were also looking at the impact of plastic on mesopelagic fish, such as lanternfish.<sup>[33][34][35]</sup> This group utilized a fully capable dedicated oceanographic research vessel, the 170 ft (52 m) long *New Horizon*.<sup>[36]</sup>

In 2012 Miriam C. Goldstein, Marci Rosenberg, and Lanna Cheng wrote:

Plastic pollution in the form of small particles (diameter less than 5 mm) — termed ‘microplastic’ — has been observed in many parts of the world ocean. They are known to interact with biota on the individual level, e.g. through ingestion, but their population-level impacts are largely unknown. One potential mechanism for microplastic-induced alteration of pelagic ecosystems is through the introduction of hard-substrate habitat to ecosystems where it is naturally rare. Here, we show that microplastic concentrations in the North Pacific Subtropical Gyre (NPSG) have increased by two orders of magnitude in the past four decades, and that this increase has released the pelagic insect *Halobates sericeus* from substrate limitation for oviposition. High concentrations of microplastic in the NPSG resulted in a positive correlation between *H. sericeus* and microplastic, and an overall increase in *H. sericeus* egg densities. Predation on *H. sericeus* eggs and recent hatchlings may facilitate the transfer of energy between pelagic- and substrate-associated assemblages. The dynamics of hard-substrate-associated organisms may be important to understanding the ecological impacts of oceanic microplastic pollution.<sup>[37]</sup>

The Goldstein et al. study compared changes in small plastic abundance between 1972-1987 and 1999-2010 by using historical samples from the Scripps Pelagic Invertebrate Collection and data from SEAPLEX, a NOAA Ship Okeanos Explorer cruise in 2010, information from the Algalita Marine Research Foundation as well as various published papers.<sup>[38]</sup>

At TEDxDelft2012,<sup>[39][40]</sup> Dutch Aerospace Engineering student Boyan Slat unveiled a concept for removing large amounts of marine debris from the five oceanic gyres. With his concept called *The Ocean Cleanup*, he proposes a radical clean-up that would use the surface currents to let the debris drift to specially designed arms and collection platforms. This way the running costs would be virtually zero, and would the operation be so efficient that it may even be profitable. The concept makes use of floating booms, that won't catch the debris, but divert it. This way by-catch would be avoided, and even the smallest particles would be extracted. According to Boyan Slat's calculations, a gyre could realistically be cleaned up in five years' time, collecting at least 7.25 million tons of plastic combining all gyres.<sup>[41]</sup> He however does note that an ocean-based cleanup is only half the story, and will therefore have to be paired with 'radical plastic pollution prevention methods in order to succeed'.<sup>[41]</sup>

Method, a producer of household products, took the garbage patch as an opportunity and began marketing a dish soap whose container is made partly of recycled ocean plastic. The company sent crews to Hawaiian beaches to recover some of the debris that had washed up.<sup>[42]</sup>

## 2012 Expedition

The 2012 Algalita/5 Gyres Asia Pacific Expedition, though plagued by severe weather on Leg 2, met the goals and objectives it set out to achieve.

Beginning in the Marshall Islands on May 1, Leg 1 investigated the little studied Western Pacific Garbage Patch, arriving in Tokyo three weeks later. During their scheduled layover and crew change, an International Scientific Symposium was held with Captain Charles Moore as one of the speakers.

Marcus Eriksen led the expedition, collecting samples for the 5 Gyres Institute, Algalita Marine Research Foundation and several other colleagues, including NOAA, SCRIPPS, IPRC and Woods Hole Oceanographic Institute. Hank Carson was aboard to study colonial communities fouling marine debris, as well as collect samples of plastic pollution for his students and colleagues at University of Hawaii at Hilo. Filmmakers Alex and Tyler Mifflin were aboard to document the journey for a series titled "The Water Brothers", in which they explore water issues around the world. Belinda Braithwaite, Carolyn Box, Bob Atwater, Valerie Lecour, Michael Brown, Cynthia Matzke, Shanley Mcentee and Kristal Ambrose rounded out the expedition. <sup>[1]</sup>

From October 4 to November 9, 2012, the Sea Education Association (SEA) conducted a research expedition to study plastic pollution in the North Pacific gyre. 38 sailors, scientists, ship's crew, and journalists sailed from San Diego, California to Honolulu, Hawaii aboard the SSV Robert C. Seamans, led by Chief Scientist Emelia DeForce and Captain Jason Quilter. A similar research expedition was conducted by SEA in the North Atlantic Ocean in 2010. During the Plastics at SEA 2012 North Pacific Expedition, a total of 118 net tows were conducted and nearly 70,000 pieces of plastic were counted to estimate the density of plastics, map the distribution of plastics in the gyre, and examine the effects of plastic debris on marine life. <sup>[43]</sup>

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## External links

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- "Plastic Marine Debris: An in-depth look" (<http://marinedebris.noaa.gov/info/plasticdet.html>). Retrieved 7 October 2012.
- "Plastic Surf" The Unhealthful Afterlife of Toys and Packaging: Small remnants of toys, bottles and packaging persist in the ocean, harming marine life and possibly even us (<http://www.scientificamerican.com/article.cfm?id=plastic-surf>) by Jennifer Ackerman Scientific American August 2010
- Plastic Paradise Movie – independent documentary by Angela Sun uncovering the mystery of the Great Pacific Garbage Patch known as the Plastic Paradise (<http://plasticparadisemovie.com/>)

Coordinates: 38°N 145°W



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