

In Every Nook and Cranny

The fact that our oceans are becoming increasingly polluted with plastic litter is common knowledge. To date, however, researchers have primarily focused on the visible litter floating on the sea surface or on beaches; how much litter there is in the deep seas remains largely unknown. Addressing that gap, AWI researcher Melanie Bergmann has now analysed in detail the level of pollution on the ocean floor of the Arctic. The results are disquieting.

When AWI marine biologist Melanie Bergmann is out at sea, her main task is to observe on a computer monitor what is going on deep below the ship that she is on. Every 30 seconds, her monitor displays a new photo, a snapshot from the depths, a new glimpse of the Arctic seafloor. The photos are produced by the [OFOS \(Ocean Floor Observation System\)](#) > - a heavy steel frame that the ship slowly tows on a long steel cable. Drifting a metre and a half above the ocean floor, it is equipped with a downward-facing still and video camera, allowing it to take pictures at regular intervals or record videos. "When the seas are rough, things can get a bit dicey: when the ship rises and falls with the waves, the OFOS follows suit. That's when we have to be extremely careful that it doesn't hit the seafloor," explains Bergmann.

While she watches for interesting objects on the monitor and takes additional shots with the camera, an engineer keeps an eye on the technology. The third person in the equation is the winch operator, who has to stay equally alert: when the ship dips into a trough, he acts fast to retract a length of cable, so that the OFOS does not plunge into the sediment below.

Contact

 [Dr Melanie Bergmann](#)



Melanie Bergmann (Photo: Kerstin Rolfes)

Once it was sea cucumbers, now the focus is on glass and plastic

The OFOS captures several hundred images in a single transect. Meticulously, these are analysed by Bergmann and her team when back at the AWI. Normally, the marine biologist scans the images for signs of larger bottom-dwelling organisms such as sponges, sea cucumbers or fish inhabiting the bottom of the Fram Strait - the waters between east Greenland and Svalbard. This part of the world is home to the [HAUSGARTEN](#) > observatory, which is part of the [FRAM](#) > infrastructure.

It is monitored year-round by measuring devices such as sediment traps and flow sensors which are moored or fitted to benthic landers. In addition, the HAUSGARTEN stations are visited and sampled every year with the research icebreaker Polarstern.

For some time now, however, Bergmann's attention has been diverted from the animals of HAUSGARTEN to something quite different: the litter lying on the ocean seafloor. "At some point I got the feeling that the images revealed more and more rubbish every year. I then began to scan several thousand images from our archive, and investigated marine litter during my expeditions."

The findings are clear: between 2002 and 2011 the amount of litter and debris lying on the ocean floor in one square kilometre of the HAUSGARTEN 2,500 metres beneath the sea surface more than doubled, rising from ca. 3,600 to 7,700 pieces. Plastic bags, glass bottles, and tangled bits of old fishing nets - there is a variety of trash to choose from.

"We can still only guess where it all comes from," says Bergmann. It may be transported to the Arctic from the more populated North Atlantic; or it could be from the ships that are now venturing farther and farther northwards as the Arctic's sea-ice cover recedes. "Unlike in the past, we can sometimes hear fishers on the radio. And we now find fishing nets here - which tells us the trawlers are now following the Atlantic cod farther north."



OFOS photo of marine debris found at the bottom of the ocean in proximity of the AWI deep-sea observatory HAUSGARTEN in the Fram Strait (Sea passage between Greenland and Spitsbergen). (Photo: Melanie Bergmann/OFOS)



Plastic bag at the HAUSGARTEN (Photo: Melanie Bergmann/OFOS)

The litter is collecting in deep-sea canyons

For many years, it has been a complete mystery how much litter there was on the ocean floor. On board, researchers can easily count litter drifting on the surface. But measuring the amount of deep-sea litter with the help of the OFOS or remotely-controlled underwater robots (Remotely Operated Vehicles) is not only a major technological challenge; it is also extremely expensive.

Accordingly, in the EU project HERMIONE, 23 researchers joined forces in 2013 to investigate their archived deep-sea images for litter and publish their findings in a joint study. Melanie Bergmann contributed the results from the AWI's HAUSGARTEN.

The study made many sit up and take notice, as it showed that marine litter is ubiquitous: it can be found in the comparatively shallow Gulf of Lion off the Mediterranean coast of France, and far out in the Atlantic.

Surprisingly, the highest concentrations can be found in deep-sea trenches such as the Lisbon Canyon off the coast of Portugal or the Guilvinec Canyon, 120 kilometres off the coast of Brittany. In these areas, the plastic litter is accumulating like at a dump site. This has led the researchers to believe that the deep seafloor may be a sink for marine litter.

"We know that half of the plastic from municipal waste has a higher density than seawater. So, it quickly sinks, and the majority of that amount probably finds its way to the deep sea. The highest amounts have been reported from deep-sea canyons," says Bergmann. She and other researchers believe the litter breaks down far more slowly on the deep ocean floor, thanks to the darkness, lower temperatures and lower wave energy.

New data from the Fram Strait

To determine to what extent the results from the HAUSGARTEN are representative for the overall situation in the Arctic, in the course of 2015 Melanie Bergmann's colleague Mine Tekman investigated new images of the same station and additional images from a station further north. The new data indicate that litter is still increasing, also further north. That being said, the regions vary somewhat in terms of the makeup of the litter.

While small pieces made up the majority of the litter (73 per cent) further north, medium to large litter accounted for 61 per cent at the station in the centre of the HAUSGARTEN. "We can't yet explain these differences, but we're seeing more and more small fragments. In addition, the percentage of plastic has definitely grown over the years," reports Bergmann.

The Arctic: Higher litter concentration than in the garbage patches

Though many images in the media would suggest otherwise, this litter density does not look like a rubbish dump. If we applied it to an area the size of a football pitch, we would see between five and 46 pieces of litter: after a football match with plenty of spectators on the sidelines, it usually looks much worse.

Nevertheless, the findings are sobering in comparison to the concentrations in the major ocean gyres, which have gained attention as "garbage patches" in recent years. Here the surface litter concentration is ca. 60 pieces of plastic per square kilometre. In comparison, even the lowest values from the Arctic seafloor are ten times higher!

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[Tracking down microplastic >](#)

[Interview with Lars Gutow >](#)

[Using Expertise to Combat Marine Litter >](#)

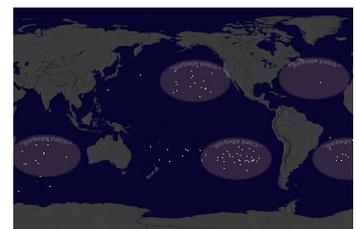
[Deep-sea observatory HAUSGARTEN >](#)

[Camera system OFOS >](#)

[Online portal LITTERBASE >](#)



The result of a waste collect in the deep sea (Photo: Antje Boetius)



Garbage Patch (Graphic: NASA's Scientific Visualization Studio)

Visualization of garbage patches

The NASA collected data about garbage patches for over 35 years. This Video shows a Visualization of the garbage patches.

Video: [NASA's Scientific Visualization Studio >](#)

What are the impacts on marine life?

Since the release of the first litter study from the HAUSGARTEN, Melanie Bergmann has often been asked how the litter is affecting organisms in the Arctic depths. But little is known in that regard. In her office, the researcher directs our attention to her computer monitor, where we can see a deep-sea sponge, a fragile structure with delicate branches, in which a scrap of plastic has become tangled. Other pictures show sea anemones colonising a piece of rope or a plastic bag. According to Bergmann, "More than half of the plastic litter we see is in some form of contact with deep-sea inhabitants."

This is especially true for the white sponge species *Cladorhiza gelida* and *Caulophacus arcticus*. Bergmann cannot yet say for certain whether the litter offers these animals "solid ground" among the soft sediment, or whether it poses a threat to them. As such, the researcher conducted a number of experiments using a remotely operated vehicle during an expedition to the HAUSGARTEN in the summer of 2015, covering certain areas of the seafloor with plastic foil and slipping plastic bags over deep-sea sponges. On one of the next expeditions, she will check back to see how the sponges and other marine life are reacting to the plastic.

We already know that marine litter is found in larger denizens of the Arctic such as Greenland sharks. Yet, as Bergmann stresses, "Despite that knowledge and a few initial studies, we're still only beginning to understand deep-sea litter. We still can't gauge the total amount of litter on the seafloor worldwide." One problem: the lack of international standards for measuring litter.

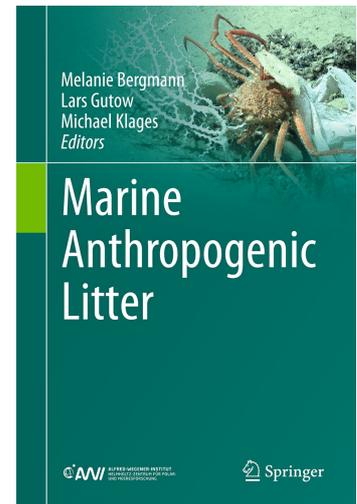
Some researchers collect litter with trawling nets and calculate the weight, while others such as Melanie Bergmann rely on underwater cameras. Some extrapolate on the basis of the amount in a given area (one square kilometre); others use the distance covered (in kilometres) instead. As the AWL expert explains, "Unfortunately, this makes it difficult to compare and combine results - which is why we need to agree on standards. Nevertheless, we now believe that, globally speaking, the deep seas could represent a major sink for our garbage."

A textbook for all those researching marine litter

Melanie Bergmann's goal is to help professionalise litter research - even though it is not her research speciality. She laughs: "Actually, I should be focusing on biology instead." But who can say; perhaps marine litter is currently the more pressing problem.

In any case, Melanie Bergmann and her colleagues Lars Gutow and Michael Klages have definitely made a solid start: in the spring of 2015 they published the freely available book *Marine Anthropogenic Litter*, which summarises the current state of knowledge on marine litter research.

Free download



Litter on an Arctic ice floe. (Photo: Melanie Bergmann)