Cleaning up the Great Pacific Garbage Patch

How LiDAR is helping the Ocean Cleanup project

IN the middle of the Pacific Ocean, hundreds of miles from the closest land, you might imagine that you've escaped civilisation's influence on the world. That is, until an abandoned fishing net or the remains of a plastic container floats by to remind you that modern civilization is affecting even the most remote places on the planet. In fact, the Pacific Ocean is a hot spot for the waste that we dump from our coastal cities or lose overboard from ships. Its currents push the trash into the middle of the ocean where it remains for years, concentrated into a region called the Great Pacific Garbage Patch.

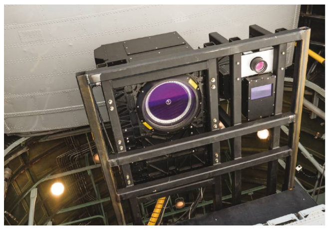
While large items like nets can occasionally harm sea life directly, the real danger comes when their plastic starts breaking down into tiny particles. Smaller animals like fish or sea birds accidentally consume these particles and store the plastic in their own bodies. The plastic then goes up the food chain as larger animals eat the smaller ones, harming the entire ecosystem and even winding up on our plates as seafood.

Being more careful with our trash is the long-term solution to the patch, but even if we stopped adding waste today, the patch would persist for many years. Scientists and environmentalists are considering ways to reduce the plastic waste, including up with the idea of using static floating barriers that could capture large pieces of trash before they could break down.

The wider perspective

First, however, Ocean Cleanup needed to know where to deploy its barriers and how much garbage to expect. It had already used a fleet of boats to sail through part of the patch with tiered nets to sample the plastic at various depths. The nets caught many small and medium objects (< 50cm), but the slow-moving boats couldn't cover a wide area and didn't get a representative sample of the largest objects, which are relatively infrequent.

This is where airborne sensors came in. The Optech CZMIL's bathymetric LiDAR can detect large objects in the water tens of metres deep, and is accompanied by an RGB camera and shortwave infrared hyperspectral sensor for additional information. Mounted on an aircraft, it could efficiently search for objects over a wide area far faster than any boat.



Dr Julia Reisser, Ocean Cleanup's lead oceanographer, borrowed the system under a programme which is specifically designed to make the CZMIL available for scientific and commercial entities in short-term projects, along with the required training and logistical help. For this project we also significantly reduced the rental cost due to the important nature of the work.

Bringing in the Hercules

Most operators install the CZMIL on a light aircraft to save on fuel costs, but that clearly wouldn't have enough range to get to the middle of the Pacific Ocean and back. Moreover, Dr Reisser wanted to have several observers in the aircraft to count objects manually, so we needed more space than a little Navajo or Cessna.

In the end, Ocean Cleanup decided to rent a massive C-130 Hercules aircraft to get CZMIL and the observers to and from the patch in a single flight. The aircraft itself was dubbed 'Ocean Force One', and the project as a whole was called Aerial Expedition. A side benefit of using such a big aircraft was that our hardware technician could fly along to keep an eye on the system and make any adjustments required (though this turned out to be unnecessary because CZMIL had an excellent flight).

Over the patch

made two survey flights in 2016, one on 2 October and one on 6 October. The weather was generally quite co-operative for both flights, being mostly clear on the first flight and only some low cloud and fog on the second flight. To give the CZMIL and the human observers a good view, the Hercules dropped down to just 400m over the water. The original plan for each flight was to survey a single line well over 1,000km long. However, fuel considerations meant that the pilot had to cut the distance to 'just' 600km (375 miles) per flight. This was not too much of an issue, however, because Ocean Cleanup simply needed to get a good sample of the patch, which could then be used to data-calibrate its model and calculate the amount of plastic over the entire patch.

Each transect took 2.5 hours to survey, plus several hours to get to the survey area and then back to California, which made for a very long working day for everyone on board. After each flight, Optech's data processor quickly processed the data and looked over it to confirm that it looked okay.

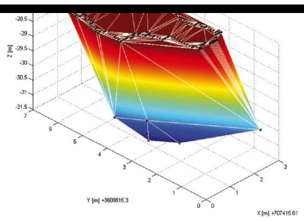
Getting garbage data

CZMIL's three sensors each provided different information for the survey. The images from the RGB camera let us identify smaller objects, down to just $200cm^2$. Meanwhile, the hyperspectral sensor, an ITRES SASI-600 SWIR, differentiated actual objects from glints on the waves caused by the sunlight, which could otherwise be mistaken for trash.

Of course, the main star was the bathymetric LiDAR, which collected data that was unavailable to the cameras and observers. For one thing, while the cameras could only capture the objects in 2D, the LiDAR saw them in 3D, which showed us each one's volume and let us guess its mass as well. This was quite important because Ocean Cleanup could extrapolate from that to determine the total mass of trash that would end up in its barriers.

In addition, the LiDAR could penetrate deep into the water, giving operators a full view of objects that were barely visible in the images. Interestingly, CZMIL found that most of the large objects in the area were within 5m of the water surface. Given that CZMIL can

Pacific Garbage Patch remain quite close to the surface.



Finally, the combination of the data collected by these sensors helped Ocean Cleanup to better assess the feasibility of using various airborne sensing technologies like satellites to remotely monitor the plastic in the ocean.

Putting the data to work

There was still plenty of work to do even after handing over the initial data. It was impractical to ask Ocean Cleanup's data processors to manually pore through 600km of data and confirm that it had caught every single object. Instead, Teledyne Optech's software team developed a feature detection program, which located possible objects in the RGB images and LiDAR point cloud and puts them up on the screen for the processor to check. The processor just needed to identify whether it was a real object or a data artefact, cross-checking with the hyperspectral data as needed, and either rejects it or enters it as an object. By partially automating the identification procedure, the feature detection program greatly accelerated data processing.

After the processors identified the objects, they measured their volume and shape in the LiDAR data. CZMIL's laser beam is about 80cm wide in the shallow channel (2.5m in the deep channel), which gave it enough resolution to detect objects just 2-3 m across.

Following up

With this mission a success, Teledyne Optech is looking forward to assisting Ocean Cleanup in the future as well. Additional flights are under consideration so that the CZMIL can collect more data in areas of accumulation and production of ocean plastics, and the Teledyne Optech software team is improving the feature detection program in various ways, such as improving the object detection process by directly incorporating the hyperspectral data.

The CZMIL gave Ocean Cleanup a massive amount of data about the number, distribution and size of large debris objects, which it can use to model the rest of the Great Pacific Garbage Patch. Such information will help decide how to design the technologies that will start extracting plastic and making the oceans a better place.

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