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APPLICATION NOTE

Coastal Management

# Protecting our oceans with Optech CZMIL

## The Great Pacific Garbage Patch

» Increasingly dense garbage endangers many marine creatures.

There is a sort of monster lurking in the Pacific Ocean, one of our own making. While the water can look clear from a ship, decades of plastic waste have been caught in ocean currents to form a massive concentration of trash covering millions of square kilometers: The Great Pacific Garbage Patch.

The waste isn't just ugly. As the larger pieces of garbage gradually degrade into smaller particles, marine creatures swallow them and absorb the plastic into their bodies, with predictably unhealthy results. As the plastic goes up the food chain, even humans can be exposed to the plastic through eating seafood.

Many groups are working to reduce the Patch, including The Ocean Cleanup. Led by Dutch inventor Boyan Slat, The Ocean Cleanup is designing giant floating barriers to capture the largest pieces of plastic, but first of all they need to know where to deploy them and how much garbage to expect.

THE OCEAN CLEANUP

## Working with The Ocean Cleanup

The Ocean Cleanup has already surveyed areas in the Patch with nets from a fleet of ships crossing the area at the same time. This provided excellent information about the quantity of small and medium objects (<50 cm) in the water, but the small area covered by the ships made it difficult to count larger objects, which are spread out sparsely throughout the Patch.

To locate the larger items, The Ocean Cleanup's lead oceanographer, Dr. Julia Reisser, developed a plan to start an Aerial Expedition. To complement the visual observations from an airplane flying at low altitude, she contacted Teledyne Optech to discuss using the Optech CZMIL airborne sensor. Armed with water-penetrating bathymetric lidar, an RGB camera and a shortwave infrared hyperspectral sensor (SWIR), the CZMIL could survey large swaths of the Patch from the air and count the number of large debris items.

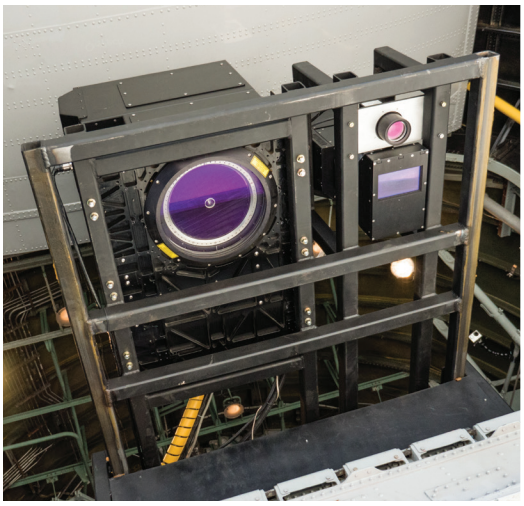

The CZMIL Project Program lets scientific and commercial entities rent the CZMIL for special projects, including the necessary technical training and logistical support from Teledyne Optech to get the job done. In consideration of the important nature of the work, Optech significantly reduced the rental cost for The Ocean Cleanup.


» Ocean Force One needed an early start to get to the Patch.

## Preparing for a 4,000-km round trip

The Ocean Cleanup's Aerial Expedition was certainly a new experience for Optech. The CZMIL is normally installed on small aircraft to save fuel, but the proposed survey area was several thousand kilometers from the California coast, so a larger aircraft was needed. Moreover, The Ocean Cleanup wanted to use CZMIL's results as a supplement to the visual observations from a dozen of their own staff, who could see garbage over a wider area, so they rented a large C-130 for the project, dubbed Ocean Force One.

To install the CZMIL Optech staff travelled to the aircraft's home base in Mesa, Arizona, then flew a calibration and training flight from NASA's Moffett Airfield in California. The up-side of this large aircraft was that an Optech hardware technician could travel along to address any system adjustments in the middle of the long flight out to the Patch.



» CZMIL brought its lidar, camera, and SWIR hyperspectral sensors to bear for this project.

**Over 5 trillion pieces of plastic currently litter the ocean**


## CZMIL gets the bird's-eye view

As it turned out, the CZMIL had an excellent flight. The system executed two surveys on October 2 and 6, 2016, with each flight consisting of a single, extremely long flightline or transect stretching 600 km (375 miles). The ambition was to survey double that distance, but fuel considerations forced the pilot to shorten the trip to "just" a few hundred kilometers. In any case, the team did not intend to cover a specific area but to get a good sample, which could then be used to data-calibrate the model that calculates the amount of plastic over the entire Patch.

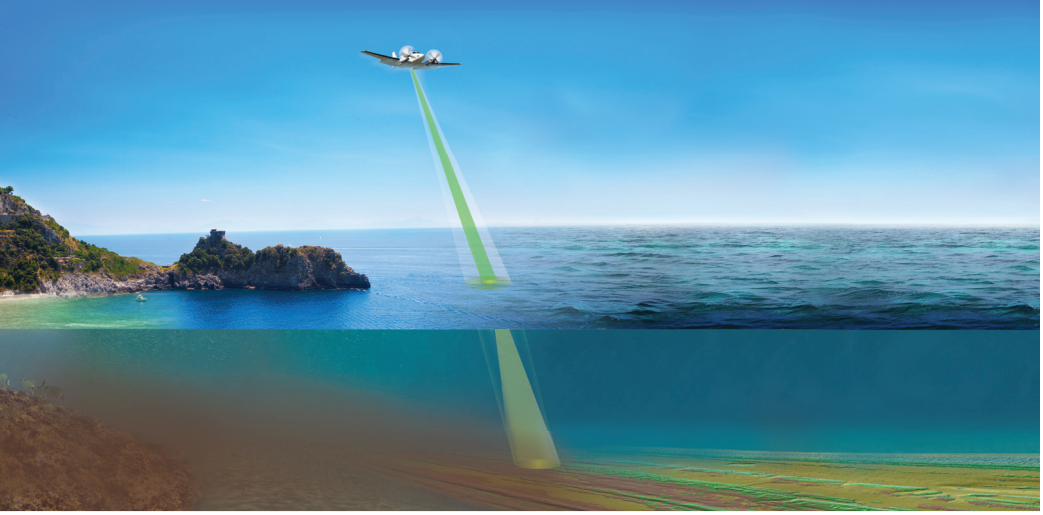
There was clear weather on the first flight, and low cloud and fog in portions of the second flight. After dropping down from cruising altitude to only 400 m over the water surface, the CZMIL started surveying and the spotters began recording sightings of trash.

» A selection of large objects observed in the Great Pacific Garbage Patch during the Aerial Expedition.

Each of the CZMIL's three instruments had a different role to play in detecting objects. The RGB camera images could identify objects floating in the water as small as 200 $cm^2$, but the sunny weather caused the sunlight to glint from waves, which often appeared like objects in the images. However, the hyperspectral sensor, an ITRES SASI-600 SWIR, could differentiate these glints from actual objects.

Most important, the CZMIL's bathymetric lidar provided 3D information about the large objects, including size and volume. This is important for estimating the total mass of each object and extrapolating the total mass of large objects that The Ocean Cleanup's barriers will encounter. Being an active system, the lidar could also penetrate much more deeply than the camera or hyperspectral sensors, giving operators a full view of objects that could barely be seen in the imagery. Furthermore, the information collected by the three types of sensors allows The Ocean Cleanup to better assess the feasibility of different airborne technologies, such as satellites, to monitor ocean plastic pollution remotely.

Each flight took 10-11 hours, with 2.5 hours spent surveying, so despite leaving at dawn the team only got back to California late in the day. After each flight, Optech's data processor was waiting to convert the data into a viewable format and give it a quick check to make sure that the quality was good.

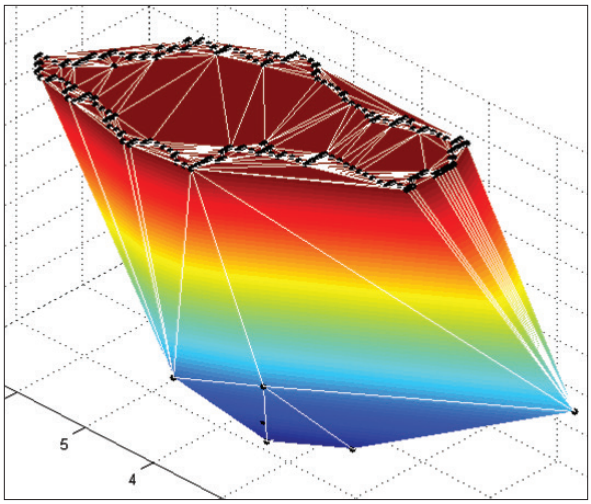


» CZMIL's active bathymetric lidar penetrates up to 80 m below the surface.

## Picking out garbage from the CZMIL data

The Ocean Cleanup now had the data, but our work did not end there: the raw size of the survey area made it impractical for them to ensure that their observers had located all debris individually. Therefore, our software team created the Optech Feature Detection Program, a tool that partly automates the debris location process. This software locates potential objects in the RGB camera images and lidar point cloud and displays them on the screen. The operator can then verify whether they are real or just artefacts, either visually or by referring to the hyperspectral data.

Once a large object is located, it can be measured in the CZMIL's lidar data to determine its shape and volume. As the spot size of CZMIL's laser beam is about 2.5 meters (deep channel) or 0.8 meters (shallow channels) on the water surface, it managed to detect objects as small as 2-3 meters across. Interestingly, most of the objects CZMIL found were only 5 meters deep at most. CZMIL can theoretically find objects up to 80 meters deep in such clear water, so this indicates that the vast majority of the large objects are close to the surface.




» Cameras capture debris from above, while the CZMIL lidar gets a 3D view of their volume and depth.

## Next steps with The Ocean Cleanup

The success of the mission has suggested several future steps for cooperation between The Ocean Cleanup and Optech. For now, Optech's team is continuing to refine the Feature Detection Program, and is looking at directly incorporating the hyperspectral data to improve the object detection process. Future flights are also under consideration so that the CZMIL can collect more data in areas of accumulation and production of ocean plastics.

Regardless of any future flights, the CZMIL has given The Ocean Cleanup a trove of data over a wide area of the Pacific to pore over. This information about the number, distribution and size of large debris objects will inform their choices when they design their cleanup technologies to rid the oceans of plastic.

CZMIL nova

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