EXPEDITION DETAILS

- **Distance travelled:** **14,416 nautical miles**
- **Time taken:** **100 days**
- **Start and end points:** **Seattle, Washington, to Okinawa, Kyushu and Hawaii, then back to Seattle, Washington (additional submarines were searched for during the journey; the *USS S-35* and the *USS Stickleback* were both located)**
- **Team size:** **30 people, made up of vessel officers and crew, AUV/ROV technicians, expedition lead and home base operations support staff in New York City**

- **Essential item:** Autonomous-vehicle technology that efficiently covers more ground with higher quality imagery
- **Surprising moment:** Being reminded of how much of the oceans need to be explored, documented and protected as new technology gives humans unfettered access to this largely unregulated frontier

Men and machine

Tim Taylor recalls the trials and tribulations of his team's attempt to find the sunken remains of the Second World War US submarine *Grayback*

Sonar image of the wreck of the *USS Grayback*

It was June 2019 and I was aboard the research vessel *Ocean Titan* with my Lost 52 expedition team, our regular home for what was our fourth season in the Pacific Ocean. *Ocean Titan* is a 68-metre ex-US Navy/ National Oceanic and Atmospheric Administration vessel now turned exploration support vessel. Our quest had us plying the waters of the East China Sea south of Okinawa, Japan, deploying a deep-water autonomous robot in search of the US submarine *Grayback* (*SS-208*), lost on 26 February 1944.

Before she was lost, the *Grayback* completed ten patrols, sinking 19 enemy vessels for a total of more than 66,000 tons. It was ranked 20th of Second World War US submarines by tonnage sank and was the 24th top-scoring. The *Grayback* crew of 80 men received four Navy Citation Commendations and eight battle stars for Second World War service. Commanding officer John Anderson Moore received three Navy Crosses.

Post-war Japanese records indicate that on 26 February 1944, *Grayback* suffered damage when land-based Japanese naval aircraft attacked the ship in the Ryukyu Islands chain. That same day, it was recorded that an Imperial Japanese Navy carrier-based bomber spotted a submarine on the surface in the East China Sea and attacked. There was speculation that the submarine survived and was responsible for the sinking of the naval transport *Ceylon Maru* the next day.

Detailed Japanese records show that the submarine was attacked twice, and, in each case, it was reported that it was submerging. The first attack dropped two bombs at 07:23 local time and missed, one by 50 metres and the other by 20 metres. The second presumed-fatal attack was 1 hour and 21 minutes later, when the pilot reported a direct hit aft of the sail or conning tower. According to Japanese reports, the submarine 'exploded and sank immediately',

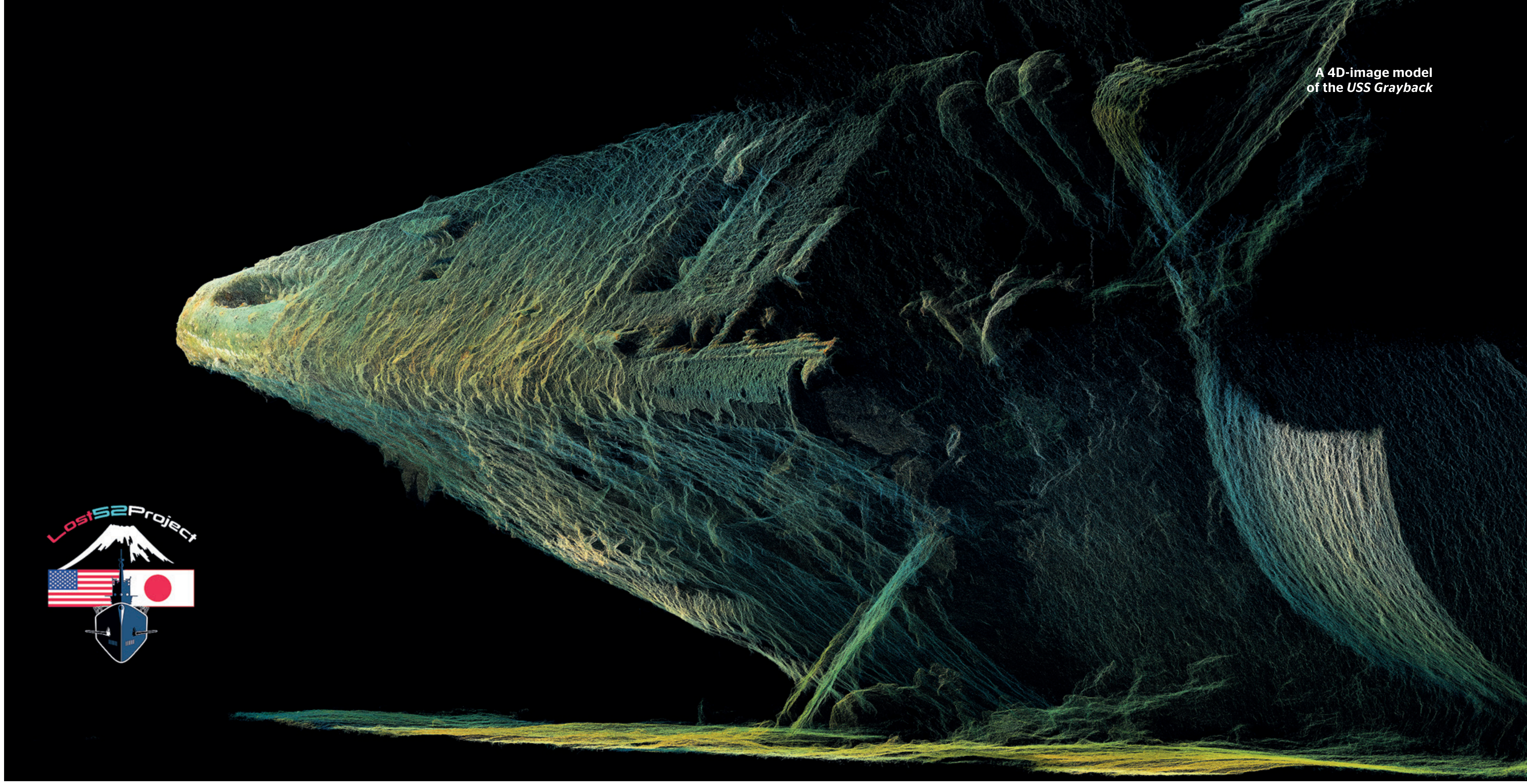
USS Grayback plaque

but anti-submarine craft were called in to depth-charge the area, marked by a trail of bubbles, until a heavy oil slick welled up to the surface.

THE RESEARCH

My journey began ten years ago with my first US submarine discovery, *USS R12* and its 42-man crew lost in WWII. I experienced first-hand the fact that these discoveries are about people, not machines. They're links to generations of families who still feel a huge sense of loss. For the most part, these men disappeared into the unknown. This became the genesis of my founding of the Lost 52 Project and its goal to help provide the fullest possible documentation of the lost US WWII submarines and sailors. We've now discovered six lost submarines and a total of 288 men.

Preparation for our expedition began more than a year in advance. All facts and first-hand accounts were



A 4D-image model of the *USS Grayback*

gathered, checked and rechecked. Many of our more substantial leads are found in the Imperial Japanese Navy war records, which we revisit and retranslate. Often this hasn't been done since the US Navy initially went through them just after the war.

Digging into the historical records, we discovered that the Japanese pilot's log and narrative didn't match the latitude and longitude that were published in the official US post-war translated records. Our retranslating procedures proved that uncovering a long-overlooked error can change everything. In the case of the *Grayback,* we found post-war records that had been transcribed with one number wrong. This one-digit error was repeated in every publication since 1946 and resulted in moving the location of the attack more than 160 kilometres away from what was always considered its last known position. This new clue brought all of our additional research into focus. Using multiple witness accounts, we could now plot new locations along with the possible heading and speed the *Grayback* was making when attacked. In this case, 170° over a distance of 17.5 kilometres between two key events. We had a new 'X' to mark the centre of our search, which matched up to the other historical data.

Search areas are created based on all the data collected, including historical weather patterns and ocean currents, US and Japanese records, and any eyewitness accounts. The intentions of sailors, pilots and commanders are analysed in an effort to fill in the gaps. This is an exercise that attempts to get into the minds of men 75 years ago, in situations that can only be described and not truly understood.

It's the nature of shipwreck searches that one never has a complete picture of where to search or enough time to complete the task. The expectation is that the curtain will be drawn on the effort at any time for any number of reasons, which might be partially or totally out of your control. The weather, the team's health, international permits, funding and of course reliable technology can all become obstacles.

THE SEARCH

Applying the latest technology to my work has always been a priority. Today, that means deploying autonomous underwater vehicles (AUVs) to scan the ocean floor and applying new imagery-collection and -processing technology that generates highly accurate 3D point cloud data. This offers vast improvements over traditional deep-water archaeological methods.

On the ship, the primary robot deployed in our search was an AUV capable of scanning about 22 square kilometres in 24 hours, at depths of up to 4,500 metres. In the case of the *Grayback*, we had an area of more than 300 square kilometres to search. It became apparent at the end of day two on-site that we would only get the chance to search a fraction of that area. Due to equipment issues with our support ship and technical difficulties with the AUV system, we were going to have to make some very difficult choices about where to carry out surveys.

The first survey box went off without an issue. Data collected and reviewed; no discovery made. Our second survey box didn't go so well. When the AUV was close to halfway through its 24-hour task of scanning the designated area, we called it back due to poor data reports. It wasn't collecting sonar images on one side, essentially leaving half of the search area unexplored. We needed to break the system down and search for the issue causing the problem.

This is a painstaking fix, test and repeat cycle that can last for days. The troubleshooting of a complex robotic system out at sea isn't uncommon, but there are no guarantees it will be successful. Thankfully, we were equipped with an abundance of spare parts, highly qualified technicians and a plan for this scenario. Even so, after 20 hours, multiple repairs and numerous in-water tests, the system still wasn't working. The decision was made to replace the entire cabling to the troubled sonar system – we would simply have to wait for that work to be finished.

We didn't waste our downtime being idle, but began developing Plan-B. This involved using low-frequency multi-beam bathymetric data to narrow down potential targets. The plan was to target hybrid search grids and prioritise possible anomalies once the AUV was repaired. This low-frequency system is designed to scan mountains; small ships might only show as noise and can easily be confused with geological structures. It could work – or it could cost us even more time.

While the AUV issue was being resolved and Plan-B was being implemented, another problem arose – the

The Lost 52 team aboard the *Ocean Titan*

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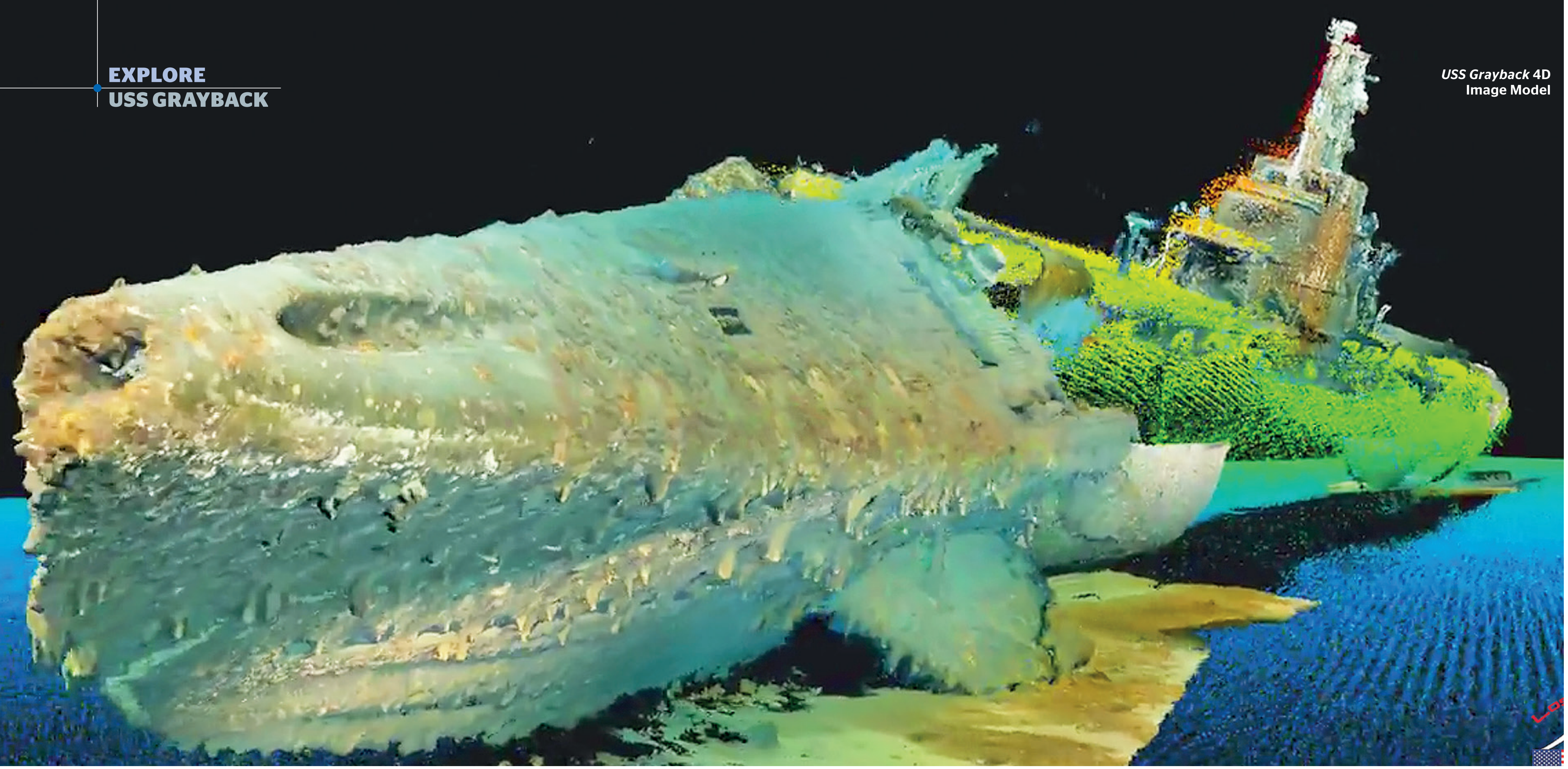

USS Grayback 4D Image Model

vessel's refrigeration system had failed. We would have to make a 48-hour trip to the port of Kitakyushu on the island of Kyushu to repair the freezers and it looked like it would affect our time on site. We now only had a few days left to make something happen. Before we could return to port, hard decisions needed to be made, and one of these had nothing to do with submarines.

During WWII, submarines were granted the luxury of ice-cream makers for the sake of morale. The *Ocean Titan's* cook had chosen to honour that tradition. While in Hawaii on the trans-Pacific trip to Japan, she had purchased a six-month supply of homemade ice-cream from an exclusive creamery. With an all-hands call to the galley, spoons were issued and the crew made a gallant but ultimately futile effort to save what remained from being jettisoned overboard.

THE SURPRISE

Thirty-six hours after repairs began, the AUV was ready for a full test dive. We were confident the repairs were successful, so we opted to take a risk and carry out the test dive at two probable targets identified by Plan-B. These were nothing more than minor anomalies in the patterns of low-frequency-sound-generated recordings and four hours later, we reviewed the data to find we hadn't been lucky. We had, however, been close. Two days later, we discovered that we had missed our target by just 50 metres – the AUV had turned just before discovering the *USS Grayback*.

Our last dive-day also brought complications. Obstacle avoidance is part of the AUV's programmed behavior, but it isn't a perfect solution to rough terrain. The AUV's avoidance system failed to function as programmed and it touched the ocean bottom. Typically, when the vehicle returns to the surface, the nose cone jettisons a line that's retrieved using a grapnel and used to haul the AUV aboard. This time, it jettisoned on impact with the bottom and the recovery line fouled the propeller, resulting in a vehicle shutdown. In the event that this happens, the system is programmed to drop a ballast weight and float to the surface.

It was a low moment. We had spent months on the ocean, the refrigeration system on the boat was in need of repair, the food supply in jeopardy, ice cream sacrificed to the sea and the AUV was in need of service. Resigned to the fact that we would have to return to port and leave this location for the season, there was only one thing left to do – look at the data we had collected before the dive was cut short.

> We were a team ready to move on, lick its wounds, repair equipment and get to the next location

Tim Taylor snaps a selfie as the ROV is deployed

The process of reviewing the data once it's downloaded from the vehicle is done for all to see on the large data screen in the AUV operations lab to the aft on the ship. Lined with a couch and half a dozen chairs, it's an occasion for the crew to gather and see the fruits of their labour as it unfolds. The captain announces the event over the ship's PA system as: 'Movie time!'

Research vessel *Ocean Titan* with the AUV deployed in the water

On the footage, the ocean floor is painted in a pattern similar to the way you might cut your lawn at home. The sonar scans play out in accelerated time on the screen in what's known as a 'waterfall view'. The scan on each side of the AUV is about 177 metres, making for a 354-metre-wide view. A 100-metre submarine would cover about a third of the screen.

We were a team ready to move on and lick its wounds, repair equipment and get on to the next location – a solemn room of tired, determined people watching line after line reveal the bottom of the ocean floor. We became conditioned to seeing those empty lines of data; an endless bottom of sand and rock.

Then, as we watched the final quarter of the final line of the aborted dive, a haunting shape scrolled into view, revealing, in perfect silhouette, the *USS Grayback*, upright with periscopes and conning tower as if still underway. Just like that, our day, our expedition and our year turned around. The rest of the day was spent deploying and filming with the ROV. For the first time in 76 years, the *USS Grayback* became visible, in 430 metres of water in the East China Sea.

Before departing the site, we held a memorial service. The *Ocean Titan* stood watch above the gravesite of 80 brave sailors who had made the ultimate sacrifice. Saying a prayer and reading the names of each sailor, and ringing the ship's bell once for each man, reminded us all that our search had always been about people, not machines. ●

Tim Taylor FRGS is an ocean explorer, founder of the Lost 52 Project and president/CEO of Tiburon Subsea Services, which specialises in underwater technology services. He is currently developing and advancing 4D modelling and autonomous underwater robotic applications. He's the recipient of an Explorers Club Citation of Merit and a Navy League of Brazil Medal of Honor and was made an Honorary Submariner by the Brazilian Navy for his discovery and ongoing work on the USS R-12. *He currently resides in New York with his wife Christine Dennison FRGS and adopted husky Ginger.*
www.lost52project.org | www.tiburonsubsea.com