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Investigation of Miami's Artificial Reefs by Manned Submersible

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In January 2012, Seattle-based OceanGate Inc. began a year-long expedition to Miami, Florida, the primary focus of which was to conduct research in conjunction with the Miami-Dade Artificial Reefs Program. The three objectives of the expedition were to 1) dive on the artificial reefs aboard OceanGate's manned submersible Antipodes; 2) gather electronic and observational data for local government environmental agencies; and 3) test and evaluate emerging technologies. Using a manned submersible to dive the reefs offered both performance and operational advantages. Not only are submersibles like Antipodes an essential alternative to human divers, especially at depth, but improvements in submersible technology have led to tools that gather a wide range of data as well as the ability to transport multiple investigators to a site where they can work collaboratively.

Antipodes, the flagship of OceanGate Inc., is a manned, American Bureau of Shipping (ABS)-certified submersible utilized for deep-water expeditions, enabling commercial and scientific applications for researchers, scientists, and filmmakers on target sites at depths of 305 m. Antipodes accommodates a crew of four, plus a pilot and boasts twin 147-cm hemispherical acrylic domes, which provide exceptional views for direct observation and filming.

Part of the appeal of exploring the artificial reefs off Miami was rooted in their history. Their construction began in the 1920s and, over the next half century, dozens of vessels and artificial reef materials were sunk off the coast, leading Miami-Dade County to organize reef restoration and enhancement over a 35-nmi coastline in the late 1980s. Since that time, the County has overseen the development of 11 inshore and 17 offshore

reefs, incorporating the deployment of almost 50 additional large vessels, two retired oil platforms, cast concrete materials and limestone, an airplane, and several surplus Army tanks. Today, the artificial reef program, which is administered by the County's Department of Regulatory and Economic Resources (RER), is the largest in the nation (Figure 1). Local scientists admit they still know very little about these deep-water habitats, primarily

due to the inability of investigators to reach them at depth.

Antipodes proved to be an ideal operational platform from which to explore these artificial reefs. She cruises at 1 kt and has a maximum speed of 3 kts. She is highly maneuverable, powered by six 5-hp thrusters vectored for 3-axis propulsion, which allows her to operate around complex structures. She is capable of enhanced dive times that make extended, direct observation possible, allowing a full crew to work for 8 hrs with no decompression time required. Her superstructure allows for mounting a customizable array of sonars developed by technology partner Teledyne BlueView Technologies. During the artificial reef dives, Antipodes was equipped with BlueView's 2D sonar head, the P900-130, as well as its 3D microbathymetry sonar system, the BV5000-1350, on a scanning pan and tilt, which provided a highly effective means of mapping large areas of the seafloor



Figure 1. Miami-Dade County artificial reef sites administered by the County's Department of Regulatory and Economic Resources (RER).

Figure 2. WWII-era fighter plane, the Grumman F6F Hellcat.



and creating bathymetric models. Combining the 2D sonar system for navigation and the 3D head for meteorological data allowed for the investigation of wreck sites in a wide range of conditions, primarily in regions of low water clarity. These high-resolution systems also aided in detecting marine life. Antipodes was also equipped during the dives with both LED and halogen lighting systems along with video and still imaging systems, which were likewise critical components for enabling on-site investigation.

In late March 2012, OceanGate's team dove on the first of numerous sites that RER identified as warranting exploration and evaluation. Since then, Antipodes has conducted 19 dives on nine artificial reefs, with the average dive lasting 2 hrs 21 min and reaching an average depth of 85 m. The deepest dive, done in conjunction with an Explorers Club Flag Expedition in September, was to 244 m. OceanGate crew members logged a total of almost 3,400 man-hours on these dives, which carried 21 non-OceanGate personnel to the reefs, including guest scientists and researchers.

Because the RER program has focused on habitat restoration and enhancement, as well as managing the development of benthic organisms and fish, OceanGate's primary objective in diving the reefs was to provide a visual assessment of the health of the habitats. OceanGate documented visual evidence of habitat quality through the extensive production of still and video images taken in more than 44 hrs of diving on the reefs. During this time, sonar images were also recorded. Initially, 2D scans were performed while flying over new wreck sites to determine their scale and identify any potential obstacles. Once the 2D scans and videos were reviewed topside, a plan for 3D scan locations was developed and bathymetric models were created. On an ongoing basis, OceanGate provided to RER a full range of still and video images as well as extensive sonar imaging records.

The nine sites visited by Antipodes and her crew included several known wrecks, including the Spirit of Hemingway and Mary Star of the Sea, though some of the dives yielded surprises. One site, explored because it had shown up as an unknown anomaly on the National Oceanic and Atmospheric Administration (NOAA) side-scan sonar survey of the seafloor

off Key Biscayne, yielded the wreck of a WWII-era fighter plane, which the U.S. Navy subsequently identified as a Grumman F6F Hellcat (Figure 2). Initial sonar scans of the plane site had displayed a 30-m long target, which led the OceanGate team to assume it was a sunken vessel. However, during the initial dive to the site on 29 June, the sonar technology on Antipodes produced the first-ever, close-range, underwater scans of the distinctive Hellcat at depth of more than 70 m. The OceanGate team has returned for additional observation and data collection on nine more missions, including a long-duration dive of eight hrs. OceanGate has since donated its collection of photographs, videos, and technical scans of the Hellcat to the Naval History & Heritage Command in Washington, D.C. The files will be used in the preservation of this federally protected site and in possible future research on the plane.

Locating the Hellcat was only one of several discoveries that have perfectly illustrated the value of manned submersible exploration. For example, while marine researchers were aware that the lionfish, *Pterois volitans*, was an increasingly invasive species in South Florida waters, the extensive prevalence of the fish as noted during OceanGate dives, even at depths as great as 70 m, has pointed to the need for an ongoing investigation of the species and its effects on the local marine habitat (Figure 3 - background photo).

Considered together, the Hellcat and lionfish discoveries offer evidence of the value of a submersible like Antipodes, which is well suited for investigating at depths of 45 to 150 m, the so-called "forgotten zone," which is beyond the reach of recreational and even most commercial divers. Antipodes offers crew members from multiple disciplines to collaborate in real time, so that those with differing expertise and perspectives can determine how to best integrate photographic and video data, take scientific measurements, and collect samples. This method, which allows the integration of technology with collaborative human observation and control, adds a critically valuable element to exploration—the ability to adapt and improvise.

Figure 3. Large congregation of invasive lionfish, *Pterois volitans*, around the Hellcat artificial reef site.