Oscar-winning filmmaker James Cameron successfully completed a solo dive to the South Pacific's Challenger Deep, the deepest point on the planet. The preparation and dive are documented in the National Geographic film *James Cameron's Deepsea Challenge 3D*.

James Cameron's Deepsea Challenge 3D photos by Mark Thiessen, courtesy of National Geographic and Deepsea Challenge 3D. Additional images provided by Jules O'Loughlin, ACS and John Bruno.

Deepest-Sea Explorers
By Iain Stasukevich

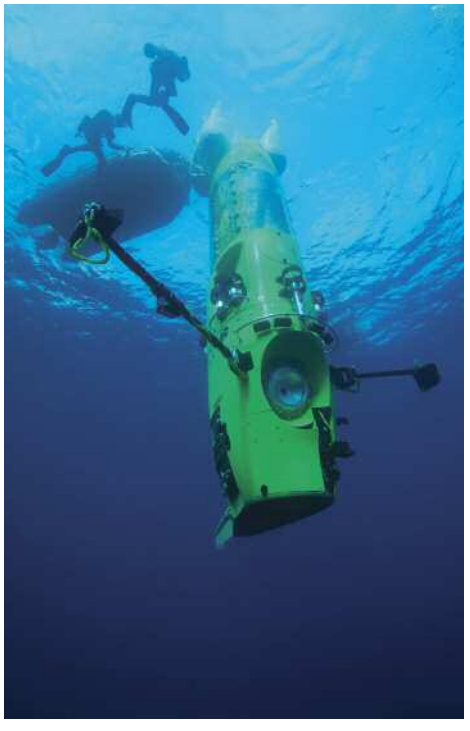
There are two narratives at play in the National Geographic documentary *James Cameron's Deepsea Challenge 3D*. One tells the story of the young Cameron, child of the '60s and avid viewer of *The Undersea World of Jacques Cousteau*, developing a keen interest in ocean exploration. The other is a document of Cameron, the Oscar-winning filmmaker and explorer, preparing to make an historic descent to the deepest point on the planet, the South Pacific's Challenger Deep. Reaching the bottom would make Cameron one of only three human beings to do so, after explorers Don Walsh and Jacques Piccard made their descent in the *Trieste* some 50 years earlier.

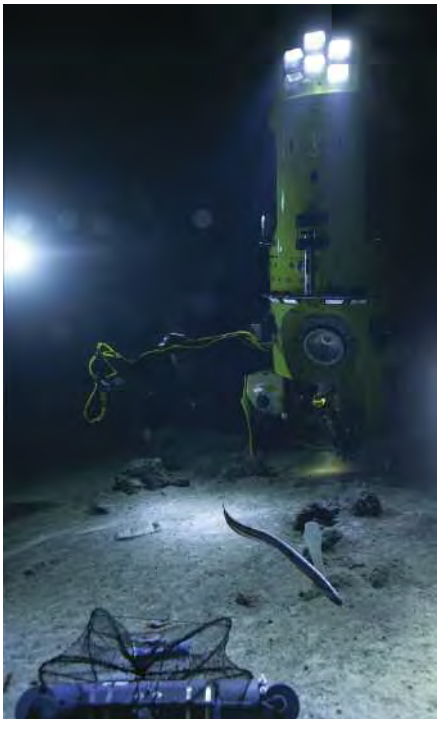
The film's main focus is the expedition, from its early development to the construction and launching of the manned *Deepsea Challenger* submersible. Cinematographer John Stokes, ACS spent a year filming the construction of the submersible, but departed the project in the wake of co-director Andrew Wight and U.S. underwater cinematographer Mike deGruy's deaths in a helicopter accident during the testing stage of the expedition. With a tight window of opportunity for the dive, a new cinematographer and co-director were needed. Producer John Bruno (*Ghosts of the Abyss*; *AC* July '03) took Wight's place at the helm, and Jules O'Loughlin, ACS's camerawork on another Cameron-produced 3-D project, *Sanctum* (*AC* Feb. '11), made him the ideal candidate to take the cinematography reins.

"John knows how to cover sub launches and recoveries, and the various activities on the ship deck, and Jules knows how to shoot good 3-D," says Cameron. "Between the two of them, we were covered."

Much of Stokes' crew, including gaffer/key grip Aaron Walker, stayed on for the expedition, sailing aboard the multipurpose vessel *Mermaid Sapphire*. O'Loughlin and camera operators Chris McHattie and Justin Hanrahan employed multiple platforms across an integrated 3-D system designed by Cameron-Pace Group's Vince Pace, ASC. Stereographer Manning Tillman pulled focus and set interocular and convergence for a handheld Red Epic MX Fusion rig from CPG, while 3-D camera systems engineer John Turner set convergence and interocular for two Sony HDC-P1 Fusion rigs (one on the upper deck and one on the

Top: The one-man deep-submergence vehicle *Deepsea Challenger* rests aboard the *Mermaid Sapphire* before carrying Cameron underwater. Bottom left: The crew conducts the first 2.5-mile test dive off the coast of Papua New Guinea. Bottom right: During a test dive off the Ulithi atoll, the *Deepsea Challenger* is photographed 1,100 meters below the surface by an unmanned lander built by Scripps Institution of Oceanography/ University of California, San Diego.





(one on the upper deck and one on the main) with the assistance of focus puller Sam Winzar, who also took on the duties of a 2nd AC and data manager.

It was a small roster for a 3-D production — 10 out of an overall expedition crew of 40 — but shooting *Deepsea Challenger* in 3-D was always a given. "It's more of an immersive experience for the audience," O'Loughlin remarks. "Let's put the audience right there in the drama, experiencing it on the boat, in the water and in the sub with Jim."

Once assembled in Papua New Guinea, the expedition plan was to perform a series of test dives near the township of Rabaul in the relatively shallow New Britain Trench (26,791') before descending 35,787' into the Challenger Deep. What would happen along the way was anyone's guess, so it was up to O'Loughlin to prepare the ship and equip his crew to capture any unexpected critical moments.

"One of the big challenges of the expedition was taking a feature-film mindset and adapting it to the documentary mindset," says O'Loughlin. "We can make a rough plan based on the day's schedule, but running and gunning with heavy 3-D rigs is still challenging and takes longer to set up, and — on a documentary shoot — time can make the difference between getting a great shot or just an okay shot."

The Fusion rig's beam-splitter configuration allowed for variable interocular settings, enabling the camera to get in close to the action. The Epic Fusion was equipped with synchronized Angenieux Optimo 15-40mm T2.6 or Optimo 28-76mm T2.6 zoom lenses and recorded 5K Full Frame (with a 1.9:1 aspect ratio) at 5:1 compression (6:1 when extended recording times were needed) to onboard magazines, making it the most versatile option aboard

Cinematographer Jules O'Loughlin, ACS (bottom and top right, wearing plaid shirt) operates a Red Epic Fusion rig. He is flanked by gaffer/key grip Aaron Walker (in beige jacket) and 1st AC/stereographer Manning Tillman.

the *Mermaid Sapphire*. The HDC-P1 rigs used Fujinon 6.3-101mm f1.8 zooms and recorded 4:2:2 at 23.98p to a single SR tape for both eyes via tethered HDCam-SR VTRs, which limited movement to their respective decks, although independent cables running to different parts of the vessel allowed the crew to reposition the cameras with minimal wrangling. A self-contained ENG-style Sony PMW-TD300 was O'Loughlin's most maneuverable 3-D option, but its fixed interocular meant keeping a distance of at least 8' from the subject.

"Dry equipment" included an SI-2K in a side-by-side configuration on a Steadicam for specialty shots, and a single-eye Arri Alexa Classic. (The SI-2K recorded to a 1 Beyond Wrangler Mini 3D using the CineForm Raw codec, while the Alexa footage was recorded in ProRes 4:4:4:4 to SxS cards.) Several GoPro Dual Hero kits were positioned about the vessel, including atop the crane hook that lowered the *Deepsea Challenger* into the water. "The GoPros were great because we could put them in places where our full-sized 3-D rigs didn't fit, but they were also limited by their size, fixed interocular and image quality," O'Loughlin explains, noting that no GoPro footage made it into the Imax version of the film. "There's some in the TV release. On television it's easier to get away with mixing different cameras."

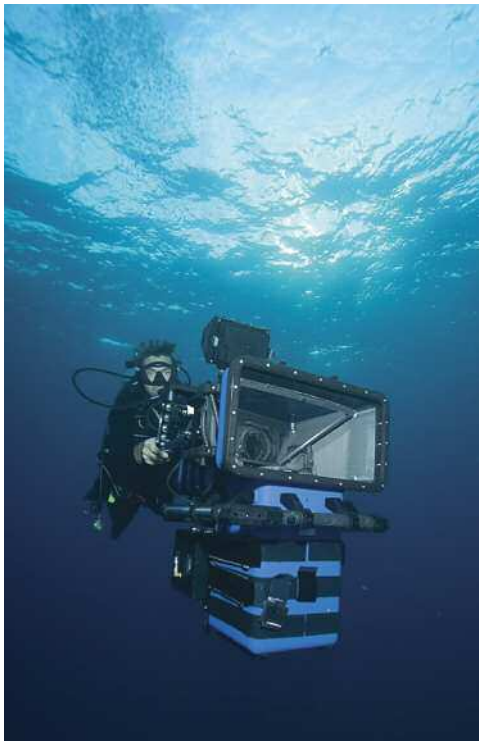
Submersible dives and recoveries were also covered by aerial-unit director of photography Ian Thorburn, ACS and underwater camera operators Simon Christidis, ACS and Charlie Arneson. CPG manufactured a custom underwater housing for the Epic Fusion, and a single-eye Canon EOS 5D Mark II was used in an underwater rig for additional coverage.

Operating with limited resources in an unpredictable environment meant the filmmakers couldn't afford to be precious about technical perfection. Consequently, the film contains more stereo post-conversion than initially planned. "We didn't plan for any," says Cameron. "But then we ended up converting about 20 percent of the film, which I think is perfectly valid for a documentary. The most important thing is to get the shot."

After waiting out days of inclement weather, on March 26, 2012 the *Deepsea Challenger* was finally ready to make its 7-mile descent to the bottom of the Mariana Trench. For this journey, the filmmakers needed a specialized 3-D camera system that could operate at full ocean depth, where the pressure reaches 16,500 pounds per square inch. No system yet existed, so Cameron, Pace, submersible co-designer Ron Allum, electrical engineer Blake Henry and imaging technical lead Adam Gobi created one, turning the *Deepsea Challenger* into an integrated stereoscopic imaging platform.

"Our goal was to create a small, lightweight camera no bigger than the size of your fist," says Cameron. Henry designed the camera electronics out of his lab in California, while Gobi led a development team in Sydney, handling the imaging workflow, optics and housing design. The product of this research and development is the "mini-cam," a solid-state HD imager built around a 1/2.3" 10-megapixel Aptina CMOS sensor inside a 2-pound titanium housing.

During the dive, four external and two internal imagers output a 24-frame 10-bit 1080p signal over 1.5G HD-SDI single-mode fiber multiplexed with camera control from the pilot sphere. Stereo pairs were fixed at a 55mm interocular with convergence at 6'. Outside the submersible, clear acrylic domes protected the mini-cam's S-mount optics, a combination of Evetar and Lensation lenses, the 35mm-equivalent of which were approximately 28mm at f2.0. Inside the cramped 43" pilot sphere, the



Underwater camera operator Simon Christidis, ACS wields the camera rig, which is safely encased in Cameron-Pace Group's underwater housing.

focal length was approximately 24mm at f1.6. Focus was remotely controlled via a piezoelectric motor.

"With these types of lenses, which are mainly used for CCTV applications, the only focus control you have is back focus," says Gobi. "You move the entire lens with relation to the image sensor, requiring less than a millimeter in overall travel."

One of the external stereo pairs was mounted to a remote pan-and-tilt head on the end of a 2-meter carbon-fiber boom, "so the sub could do a selfie," Cameron quips, "which also proved to be a great diagnostic tool for the ballast system, manipulator arm and dive lights."

Two other mini-cams were mounted to the submersible's hydraulic manipulator arm. One was equipped with a 28mm lens for wide shots, and the other with a 90mm f1.6 for macro shots of any jellyfish, sea anemone or amphipods that might be encountered. A stills mode enabled Cameron to take full advantage of the imagers' 10-megapixel sensors.

Gobi admits that the mini-cam's designers never got around to measuring its native ISO. Signal gain was adjusted from the pilot-sphere based on a built-in histogram. "It's a compromised image compared to what you can get with the dynamic range of a Red Epic," says Cameron, "but we couldn't put two Epics on the end of a boom, so it was the right compromise to make."

The first half hour of the *Deepsea Challenger*'s descent was filmed by a GoPro mounted to an Israeli arm at Cameron's eye level through the pilot sphere's 1'-thick acrylic viewport, after which it was swapped out for a single-eye Red Epic rated at ISO 800 with a Nikkor 10-24mm f3.5-4.5 zoom. "The full 5K image covered the viewport's 80-degree field of view, while allowing us to crop a 2K image from the center," says Gobi.

The mini-cams filmed continuously during Cameron's nine-hour dive into the Challenger Deep, recording 1080p ProRes 4:2:2 HQ to an onboard array of nine 750GB Atomos Samurai recorders. The Epic was able to record up to five hours of 5K

raw to four onboard 512GB SSDs specially developed for the expedition by Red.

A perennial challenge of filming in near-freezing deep-sea temperatures is the condensation that comes from the pilots' breath and collects on the inside of the viewport. To address this, mechanical-design engineer David Bleads attached a sealed, heated optical flat to the inside of the dome port with a purge valve for dry nitrogen. "Nothing could condense on the outside of the optical flat because it was heated, and the dry nitrogen had no water vapor, so nothing could condense on the inside of the port," Cameron explains.

With the submersible floating vertically in the water, the long beam section offered an ideal baseline for mounting a lighting array. "I wanted to light the place up like a football field," says Cameron, which prompted Allum to install 30 75-watt LED bricks into a 7'-long pressure-balanced bank on the submersible's front face.

Later in the submersible design process, hydraulic-systems engineer Ty Boyce introduced Cameron to a custom 735-watt LED spotlight, which provided an output comparable to a 1,000-watt halogen. Four "Ty lights" were used: three "high beams" to augment the LED array, and one on a second 2-meter carbon-fiber boom, extending the submersible's visibility to almost 100' in clear water.

Though destined for National Geographic's theatrical Imax and television documentaries, the high-resolution 3-D images captured at the bottom of the Challenger Deep also held great scientific value. "At hadal depth, which is anything below 6,000 meters, the sea life is sometimes hard to catch, so the only record of a new species might be an image," Cameron explains. "Certainly it will be the only record of one alive and functioning, because none of these creatures can survive the pressure drop or the transition into warmer water."

Photogrammetry of the stereo pairs allows scientists, such as the ones at Scripps Institute of Oceanography in San Diego, Calif., to calculate the size of an organism based on its range from the camera, angle of view, and the number of pixels it occupies. In this fashion, 68 new species were identified in footage returned to the surface by the *Deepsea Challenger*.

"The objective of exploration isn't going by yourself," Cameron muses. "That's a closed-loop, solipsistic thing to do. Exploration is going and bringing back the story, and bringing back the story means bringing back the images."

TECHNICAL SPECS

1.78:1

3-D Digital Capture

Red Epic MX; Sony HDC-P1, PMW-TD300; Silicon Imaging SI-2K; Arri Alexa Classic; GoPro HD Hero, HD Hero 2; Canon EOS 5D Mark II; custom mini-cam

Angenieux Optimo, Fujinon, Evetar, Lensation, Nikkor ●