

An engineer uses high-frequency sonar to image the fuselage of a Corsair near Palau. Dozens of World War II aircraft lie in the waters surrounding the island chain.

DOWNED

WORLD WAR II COMBAT PILOTS HAVE BEEN LOST AT THE BOTTOM OF THE PACIFIC OCEAN FOR NEARLY 70 YEARS. NOW AUTONOMOUS ROBOTS HAVE BEEN DEPLOYED TO FIND THEM.

STORY BY ANDY ISAACSON



O N A BRIGHT morning in mid-March, Pat Scannon stands on the deck of a 40-foot catamaran looking for an airplane hidden in the waters of Palau's western lagoon. A limestone ridge thick with vegetation juts into the cloudless blue sky behind him. His quick-dry clothing, coupled with a red bandanna knotted around his neck, befits Scannon's role as an amateur archaeologist. He has spent the past 20 years making annual wreck-hunting trips to Palau, about 500 miles from the Philippines, to find aircraft that had been shot down during one of World War II's fiercest battles—planes that may still be holding their pilots. His organization, BentProp Project, works to repatriate their remains to the U.S. To guide the search, Scannon ordinarily relies on interviews

Delaware, which received a grant from the U.S. Office of Naval Research. The funding enables oceanographers to test new technologies while helping BentProp locate World War II airmen—an effort they named Project Recover.

The lead scientist is Eric Terrill, director of the Scripps Coastal Observing Research and Development Center. Board shorts and sandals make the athletic oceanographer look more surfer than scientist—he even brought a board on the research vessel for what he calls “wave sampling.” For the past few years, Terrill's team has used a Remus to study the ocean circulation around Palau.

“Historically, on unmanned underwater platforms, you might spend the better part of your experimental time just ensuring the sensors were functioning, tracking the vehicle navigation, and charging batteries,” he says. “The systems now have matured to where we can run them hard, like outboard motors. The oceanographic community is engineering new sensors for them and having them do smarter

With the oceanographers' help, he hopes, BentProp could find it. “On land our major technology was a machete, and underwater it was scuba tanks,” he says. “The ability to extend our mission is, like, I don't know how to describe it. It's like starting out walking, and suddenly you're in a supersonic jet.”

BY THE 1920s, Palau had grown into a thriving Japanese port for goods and services en route across the Pacific. Recognizing the strategic location, Japan established an airfield there, and after World War II broke out, it began to shore up its defenses—building hundreds of bunkers and caves to defend the islands from an American attack. General MacArthur, who wanted to secure islands to the east as he prepared to invade the Philippines, ordered that attack in 1944. The U.S. began with a furious air campaign that was designed to knock out Japanese vessels clustered in Palau's western lagoon and adjacent harbors, and clear the way for an amphibious assault.

“THESE PEOPLE DIED DEFENDING US.”

with Palauan elders, military records, and maps hand-drawn after the war. But on this trip, he has a new tool at his disposal.

Two technicians in a nearby Boston Whaler cradle a small, torpedo-shaped craft, then lower it into the water. Scannon watches as its nose tilts down and its rear propeller pushes it beneath the surface. Out of sight, the autonomous underwater vehicle (AUV), an oceanographic workhorse called a Remus, begins gliding through the lagoon in a pattern that resembles the long, linear passes of a mowed lawn. From roughly 10 feet above the seafloor, its side-scan sonar sends out acoustic waves that build a two-dimensional map. The strength of the reflected waves also helps distinguish metal from mud or coral.

For a group like BentProp, the use of advanced oceanographic instruments is a huge technological leap forward and one it couldn't afford on its own. The vehicles come from the University of California, San Diego's Scripps Institution of Oceanography and the University of

things during their searches.”

When Terrill and Scannon met through a mutual friend on the island, a collaboration seemed natural. BentProp could find planes in a tricky marine environment—with steep terrain, fast currents, and coral heads—while Scripps tested circulation models and advanced imaging systems. “If we're able to use those techniques on natural environments, there's nothing to say we can't apply it to the man-made objects on the seafloor,” Terrill says.

Scripps and the University of Delaware shipped 60 packages of equipment to Palau, including underwater vehicles, cameras, various types of sonar, and, for aerial surveys, an autonomous hexacopter drone that had been rebuilt to survive sea spray and aquatic landings. The mangroves growing along the shore around Palau are so dense that aluminum wreckage from aircraft has been found sitting on top of the tree canopy about 30 feet up.

This year, Scannon has his eye on a major prize: a B-24 that he believes had been shot down in Palau's western reef.

That September, the U.S. Marines landed on the island of Peleliu. Although they ultimately won that battle, it came at a terrible cost: 10,000 Japanese and 1,700 Americans were killed in action—the highest casualty rate of World War II's Pacific Theater. And between the beginning of the air campaign and the end of the war, BentProp estimates, 200 U.S. aircraft were shot down inside Palau's barrier reef. Some 40 to 50 planes and 70 to 80 airmen have never been recovered.

Scannon, a medical doctor and founder of a biotechnology company, first visited Palau in 1993 as a recreational scuba diver. He came with a group looking for a Japanese naval vessel that had been sunk by George H.W. Bush, who flew torpedo bombers during the war. After the group found it, Scannon hired a local guide to take him to other wreck sites, where he eventually discovered the wing of a B-24. When he researched Palau's history at home, he realized there must be many more planes in ruins around the islands. “Palauans knew of them but didn't know



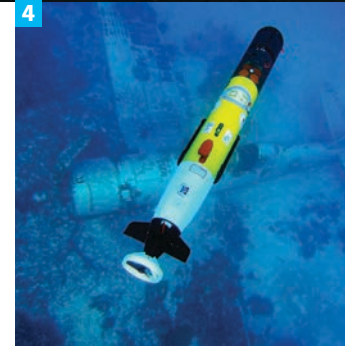
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OPENING PAGE: COURTESY SCRIPPS INSTITUTION OF OCEANOGRAPHY

CLOCKWISE: ANDY ISAACSON; COURTESY SCRIPPS INSTITUTION OF OCEANOGRAPHY (2); ANDY ISAACSON (2)

anything about them,” he says. He was particularly gripped by the thought that many airmen couldn't have survived the impact. “These people died defending us,” he says. “And they deserve to be honored and, if possible, brought home.” So began Scannon's quest. He returned to Palau for the next few years by himself, chasing leads. Then in 1996, he formed BentProp and recruited volunteers, roughly half of whom are retired and active-duty military members, to help him search. Combing the jungle and surrounding waters, they located debris from more than five dozen aircraft.

Last year, local spear fishermen diving on Palau's western barrier reef stumbled

across one of the most impressive finds: an intact plane. They alerted the owner of a dive shop, who passed photos of the wreck along to BentProp. Scannon's team eventually identified the plane as an American Corsair. It had sustained some damage to its left forward wing root, but the wing flaps were down, and the canopy had been locked open, suggesting that the pilot had ditched. “It had been sitting there unknown for 65 years,” Scannon says. “It gave us great hope that there were other intact airplanes out here that no one has seen.”

BentProp calculates that eight American planes, including a B-24 bomber, remain hidden in Palau's western lagoon.

HIGH-TECH IMAGERS

- [1] Eric Terrill [left] and Billy Middleton of the Scripps Institution of Oceanography prepare to launch a Remus autonomous underwater vehicle in Palau's western lagoon.
- [2] The team also deploys an Echoscope, a 375kHz multibeam sonar, to image the seafloor under the research vessel.
- [3] The sonar produces a real-time display showing the fuselage of a Japanese floatplane.
- [4] Equipped with GoPro HD cameras, the Remus surveys the wreck of an American Corsair.
- [5] Algorithms developed by Autodesk fuse those images into a 3-D model of the plane's nose.

FIELD TRIP



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The B-24, in particular, would be a tremendous discovery. It carried 10 to 11 men, including a pilot and co-pilot, gunners, bombers, a radioman, and a navigator. Of the four B-24s BentProp suspects were shot down near Palau, two were found after the war. BentProp located a third in 2004; the organization notified the Department of Defense's Joint POW/MIA Accounting Command, and the remains of the eight men onboard (three had parachuted out, only to be apprehended and executed) were repatriated to Arlington National Cemetery.

Mission photographs from World War II show the fourth, a Consolidated B-24 Liberator, on a path toward the western lagoon. Two of its crew had bailed out midair, landing in Malakal Harbor to the east, where the Japanese took them into custody; the rest presumably went down with the plane. "We have very, very good information about what heading

EXPEDITION PREP

- [1] Mark Moline [left] of the University of Delaware pilots a remotely operated vehicle while Eric Terrill of Scripps adjusts sonar and video displays of a sunken Japanese warship.
- [2] The team consults historical documents at its command center at the Coral Reef Research Foundation.
- [3] The archival information helps the team plan transects for autonomous underwater vehicles (AUVs).
- [4] Scripps engineer Billy Middleton offloads data from the Remus AUV after each mission.
- [5] Flip Colmer volunteers in BentProp's search for downed aircraft and airmen.
- [6] Joe Maldangesang [left] and Pat Scannon [right] of BentProp with Scripps's Shannon Scott [center] study various warplanes flown into battle over Palau.
- [7] Scott prepares the handheld Shark Marine Navigator system, which contains sonar, lights, and cameras.
- [8] The machine's Blueview sonar allows divers to find targets in very-low-visibility water.

they were on during the bombing mission, and we have very good information about what heading they took leaving," Scannon says, on the deck of the research vessel during this year's expedition. "So bringing the two of those together essentially brings you right here."

THE OCEANOGRAPHIC team's official command center in Palau is on the second floor of the Coral Reef Research Founda-

tion, but their unofficial headquarters is an open-air bar called the Drop Off, originally built for the production crew of CBS's *Survivor: Palau*. Several days into the expedition, they head there for dinner and order a round of local Red Rooster beers. As they wait for their food, Mark Moline, an oceanographer from the University of Delaware, opens a Toughbook laptop and scrolls through sonar images produced by the Remus.

Grainy and reddish, the sonar images look like transmissions from Mars. Some show deep scours; others, shadowy trenches. The team have given the features names like Homer Simpson, Crying Baby, and SpongeBob's Grave. After identifying promising targets in scans, they will have to investigate in person, diving to the various sites to determine if the features are purely biological, like coral heads, or actual wrecks.

Moline pauses on an image with an oblong shape. On closer inspection, it seems to have intact wings and a tail. "We got a plane!" Moline announces. Everyone springs up and huddles around the screen, snapping photos with their phones. Their excitement attracts the attention of a Japanese man dining at the other end of the long communal table, who cranes his neck for a peek at the computer. Moline abruptly shuts the laptop; World War II wrecks attract dive tourists and salvagers.

The next morning, at the coral-reef lab, Terrill debriefs Scannon and the BentProp group. Paul Reuter, a Scripps programmer, projects Google Earth onto a wall. Reuter had used an archival map of observed plane crashes to mark Google Earth layers with known wreck sites; he then added a layer with intriguing objects that had turned up in the sonar images.

Terrill uses a laser pointer to indicate the newest find. "The hard edges provide bright scatter," he says. "There's a long shadow here and here." He then shifts his pointer to a spherical object about 45 meters away and wonders if it could be the pontoon of a floatplane.

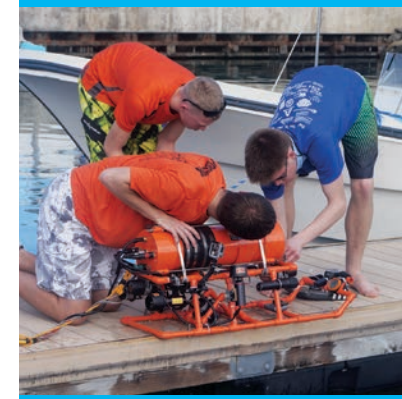
"If that's intact, it tells me it was a low-speed impact, perhaps ditching," says Daniel O'Brien, a former skydiver and Hollywood stuntman who now volunteers for BentProp. "My first impression is that's a Zero"—a long-range fighter aircraft. "There are rounded edges at the tail. But if it is a floatplane, the only U.S. airplane it could be would be amphibious. The shape looks like a Kingfisher." Flip Colmer, a former Navy pilot who now flies for Delta, also with BentProp, reaches for the book *Floatplanes in Action* and begins flipping through color pictures.

The Kingfisher, O'Brien explains, was typically flown for observation and to rescue downed pilots. "If they were in this deep, it would have been on a risky endeavor. There weren't anti-aircraft along

THE VESSELS that typically explore the oceans are professionally engineered. But in Palau, eight students from the Advanced Underwater Robotics team at Michigan's Stockbridge High School also deployed a remotely operated vehicle (ROV). The 40-pound craft successfully dived to 140 feet towing a video-camera system and sonar that it used to image several unknown shipwrecks and a Corsair plane.

A local BentProp volunteer had read about the team in 2011 and reached out to the students for assistance. They set to work on building a ROV, using 3-D computer-aided-design software and soldering and electronics skills learned in class. Because Stockbridge, located in a rural community, doesn't have a swimming pool, they tested the craft in a cattle trough. The team also raised \$45,000 to pay for the ROV parts and the trip 7,000 miles across the world. "The class is run more like a small business or research team than a traditional classroom," says teacher Robert Richards, a retired Army sergeant. "We're focused on building a robot and doing a mission."

The team represents the last level of a robotics program that starts in elementary school. Stockbridge also integrates the Palau project into the curriculum for grades 3 through 12, so 300 kids learn about subjects like island biology and World War II Pacific Theater history. Next year, the students hope to return to Palau for a third field trip—this time, with an autonomous vehicle and hexacopters.



the ridge. But existing ships that were still moored had anti-aircraft. So for him to come in and land here, it would have been to pick somebody up."

During World War II, floatplanes in Palau often flew rescue operations. As they scooped airmen from the water, another plane provided cover overhead. BentProp knew that two Kingfishers on reconnaissance missions had disappeared during the war, and the western lagoon seemed the most likely location for them to have ended up. The identification number painted on the plane's exterior would have degraded by now; to confirm the exact craft, divers would try to recover a stamped metal plate riveted to the inside of the cockpit. "It's our holy grail," O'Brien tells me.

Colmer cautions the group about jumping to conclusions. The Japanese also flew seaplanes. "If there's any primer left on the interior of the cockpit—which will last longer than straight paint—that's one way to take a peek at it," he says. U.S. airplanes used lime-green zinc chromate; the Japanese had a red primer. The team will have to get a close look.

GUIDED BY GPS coordinates from the AUV, Pat Colin, director of the Coral Reef Research Foundation, pilots the vessel across the lagoon to the approximate location of the mystery plane. Then Terrill lowers a device called an Echoscope over the side. As we creep along the surface, an onboard computer displays 3-D images of the seafloor in real time.

While side-scan sonar provides a general impression of contours along the bottom, it doesn't directly measure the elevations of features. The Echoscope, or multibeam volume imaging sonar, does, enabling oceanographers to map topography accurately and in high enough resolution to distinguish man-made objects. Terrill describes it as "the oceanographic seafloor-mapping equivalent of ultrasound sonar used to look inside the human body." Using the two technologies in tandem helps to narrow wide-area searches and then pick out targets from clutter on the seafloor, so that human divers maximize their time at the correct site.

With the boat now directly over the plane, the dive teams begin to suit up.

CONTINUED ON PAGE 77

ANDY ISAACSON (8)

COURTESY ROBERT RICHARDS

DOWNED

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A B-24 bomber flying over Japanese installations in Koror, Palau, in 1944. The trail of smoke is from another B-24, crashing.

Terrill fills his scuba tank with nitrox to allow himself more time to explore the aircraft 100 feet below. Shannon Scott, an engineer from Scripps, descends with Terrill, Colmer, and O'Brien. He carries a handheld sonar that displays acoustic images on an LCD screen, allowing the divers to zero in on the floatplane even in five-foot visibility. About 20 minutes later, O'Brien surfaces. "Well, it's not a Kingfisher," he says.

After descending to the plane, O'Brien noticed that the windscreen on the cockpit was located behind the wing. In Kingfishers, it was situated in front. He'd also detected a subtle distinction in the shape of the fuselage near the tail.

I strap on a scuba tank and jump into the water with Scannon, who wants to see for himself. We follow a rope line, pinching our noses on the way down to equalize pressure, until we arrive at the fuselage. It lays on a bed of thick sediment that our fins kick up into dusty clouds. Long, gangly strands of black coral grow up and through the corroded metal. The front motor and propellers have broken away from the body of the plane, so that it now resembles a chewed-off cigar or the burnt end of a firecracker. Scannon waves me over to the cockpit and places my hand on the gun mount. It held a 7.7mm machine gun, Scannon later explains to me, developed by the Japanese navy.

The next day, BentProp compares the aircraft in the western lagoon with a hundred different vintage planes. Eventually,

the team determines that the wreck has all the characteristics of a Kawanishi E15K1 Shiun, code-named Norm by the Allies. The high-speed reconnaissance floatplane had a single engine, contra-rotating propellers, and a center pontoon that could be jettisoned during an attack. It also had a flattened beaver tail around the vertical stabilizer, an aft cockpit machine gun, and no wing armaments. According to BentProp, the Japanese manufactured nine prototypes; six were brought to Palau for combat testing, and all were shot down by U.S. forces.

Though it isn't an American plane, Scannon is pleased with the discovery. "It's a very unusual aircraft, one of the rarest archaeological planes you will find," he says. "And there's a very high likelihood that the remains are still on it." BentProp alerts the Palauan government, which will notify the Japanese embassy.

OF MORE THAN 60 aircraft BentProp has identified in Palau—half of which are Japanese—the team has recovered just one metal plate stamped with a serial number: that of the American Corsair discovered by the spear fishermen. That plate revealed the Corsair's story.

On November 21, 1944, a young Marine captain named Carroll McCullah set off from the American airfield to finish off a Japanese vessel that had been bombed earlier. On the way back, he and his wingman strafed four Japanese ammunition dumps; an explosion at the last one sent shrapnel into the oil cooler of his plane. McCullah placed a distress call and made for the island's western reef. Then he tightened his seat belt, locked the canopy back, and turned off the plane's engine switch. Placing his left hand on the cockpit coaming, he braced for impact.

"There was no shock," McCullah later wrote in a mission report. He launched his life raft and swam across the reef, where a rescue aircraft swept down to pick him up. For the rest of his life, McCullah—who, after his rescue, went back to the base, had a brandy, and then flew another mission the next day—retold the story of that landing. "And many other ones," his son, Patrick, told me by phone from Florida, where McCullah lives (with dementia) at age 92. "His tales were tall, but they were true."

Today, McCullah's plane rests intact

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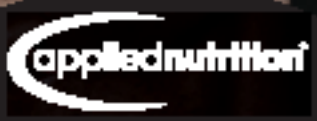
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on the seabed, with its nose up against the edge of the reef, like a car driven up onto a curb and abandoned. But time has turned the craft into a relic: corrosion has gnawed at the metal, and the reef has crept into the propellers and the engine; a large, bulbous coral head has taken up occupancy in the cockpit. Originally painted blue, with a white star-and-bar symbol, the aircraft has been scoured to bare aluminum.

Scripps wants to use its technology to document this chapter of the Corsair's story too, before it ends altogether. "We're not only here to find and detect underwater objects, but to get a snapshot of the state of those objects that may be corroding or eroding away in time," Terrill says. "There's a whole new field in trying to baseline-capture all the detail we can about these historic artifacts. I'm calling it digital preservation."

Suzanne Finney, an American archaeologist working with Palau's Bureau of Arts and Culture, joins us for the 45-minute boat ride to the site of the Corsair. Marine archeology rarely gets to benefit from such advances, she says. "Most of the work I've done, you've got a tape measure and some string and a dive slate and a pencil, and you're taking photographs and measurements by hand. And that's what you do." With data from the robotic vehicles, Palau can add downed aircraft to an inventory of the country's rich underwater sites, something previously unattainable for an office that can barely afford to buy gas for a boat. "There are a lot of wrecks in water that's inaccessible to diving," she says, "so you need remote-sensing equipment." By the time the expedition

ends, the AUV has scanned 18.9 square kilometers of the sea-floor at slightly better than 10cm resolution, an area that would have taken scuba divers a decade to explore. The sonar also revealed what Terrill says could be a new species of coral.

When we reach the Corsair, engineers lower the Remus, now equipped with GoPro HERO3 HD cameras, into the water, and it once again begins a methodical sweep. Back in California, Terrill and his team will use the thousands of captured images, plus hundreds of photos taken by human divers, to build a 3-D reconstruction of the plane. Terrill is beta-testing algorithms developed by Autodesk for the company's new cloud-based, reality-capture software, called ReCap; the software has been designed to model aboveground areas like historic sites and factory floors, and Terrill is evaluating how well it works in an aquatic environment, where light is distorted. "Man-made structures underwater are an ideal testbed for that," he says. "If it pans out, it'll be a great archaeological tool to baseline a lot of these wrecks."

Scientists and naval historians could use such technology to document how wreck sites decay. Oceanographers and biologists studying living structures such as coral reefs could also benefit from it; 3-D models would enable them to detect how ocean acidification and events like typhoons alter reefs over time. And, of course, Scannon hopes that one day AUVs will lead him to his biggest find, the final B-24, so that a perfect replica of it, too, can be recorded for posterity. For now, it still lies somewhere in the lagoons surrounding Palau, concealed by water and time. ◀

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