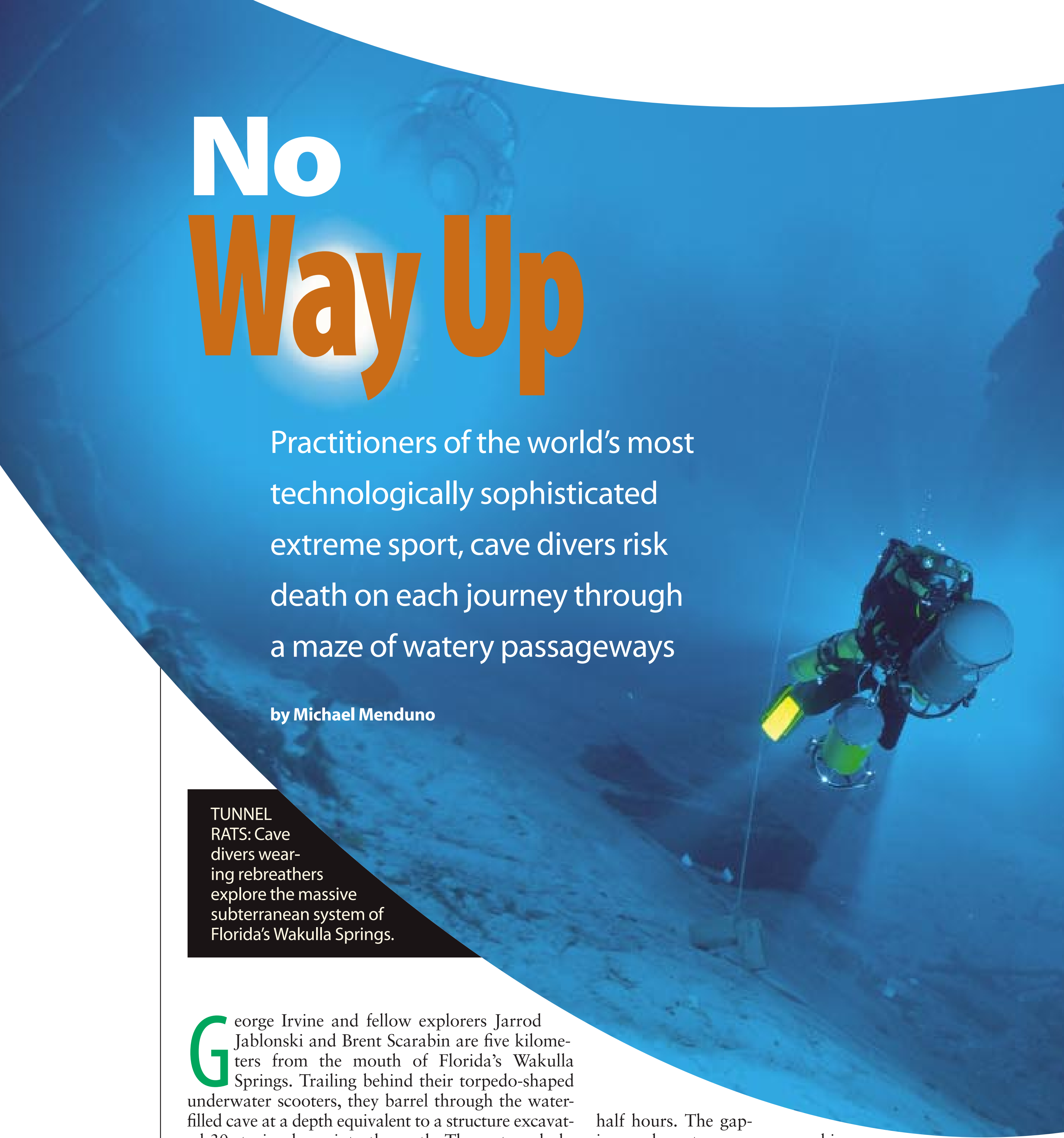
No Way Up



Practitioners of the world's most technologically sophisticated extreme sport, cave divers risk death on each journey through a maze of watery passageways

by Michael Menduno

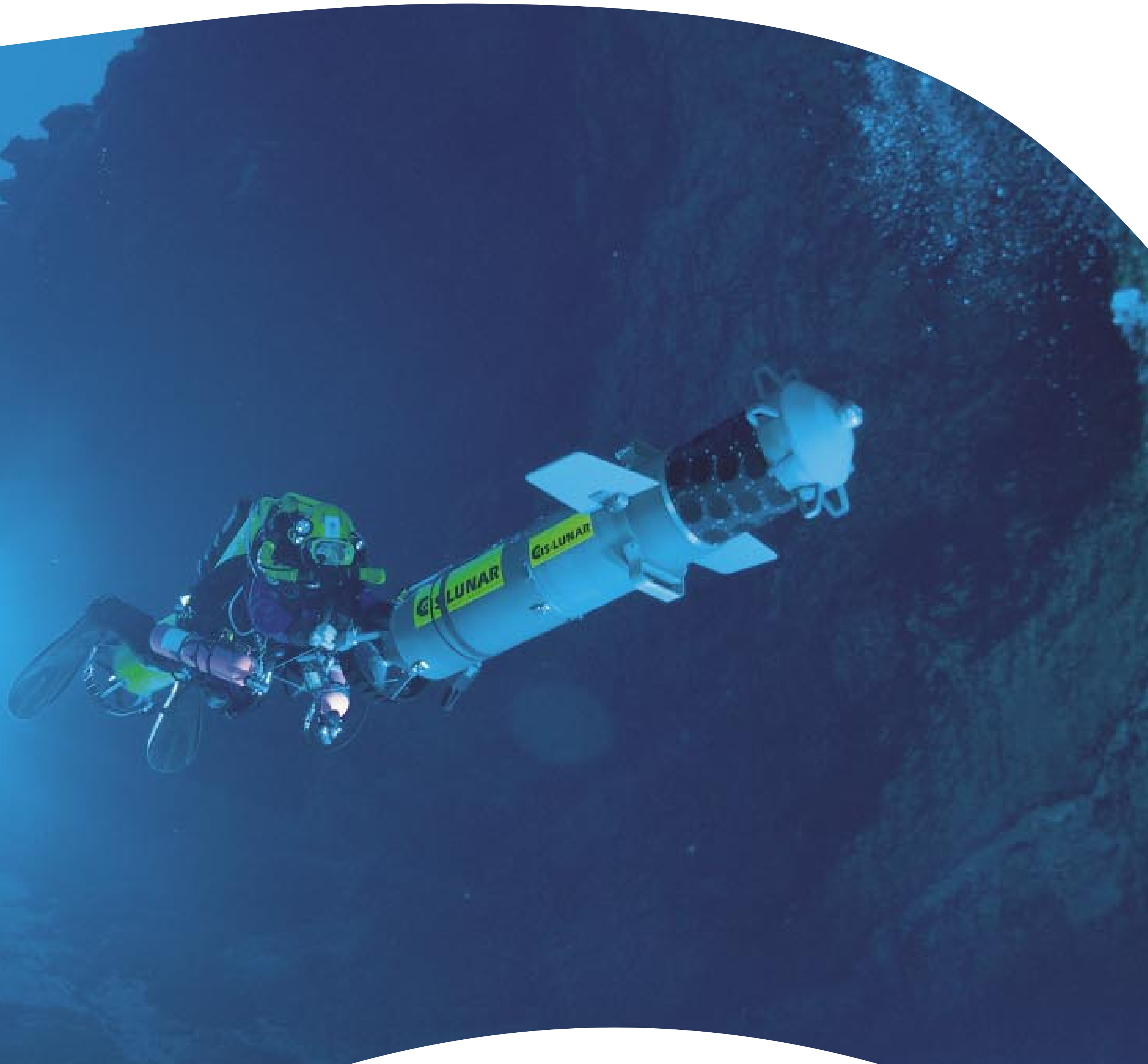
TUNNEL RATS: Cave divers wearing rebreathers explore the massive subterranean system of Florida's Wakulla Springs.

WES SKILES *Karst Productions*

George Irvine and fellow explorers Jarrod Jablonski and Brent Scarabin are five kilometers from the mouth of Florida's Wakulla Springs. Trailing behind their torpedo-shaped underwater scooters, they barrel through the water-filled cave at a depth equivalent to a structure excavated 30 stories down into the earth. The watery darkness presses in around them, swallowing the beams of their 100-watt arc lamps. The recesses of the submerged limestone tunnel have not been illuminated in the millions of years since the sedimentary rock accreted from the remains of dead sea creatures.

After descending for 30 meters through the clear waters of a lake to the cave entrance, the daredevil crew has motored in formation for more than two and a half hours. The gaping underwater passageway—big enough to accommodate a taxiing 747—shows no signs of narrowing as the men press on with their mission of finding the elusive source of the waters that well up to the surface, where bald cypress trees line the shore and alligators make their home.

Each of the divers wears a back-mounted life-support system called a rebreather, similar to those used by astronauts. Rebreathers recycle their air supply by re-



moving the exhaled carbon dioxide and adding supplemental oxygen, extending the time divers can stay underwater by a factor of eight to 10, compared with ordinary scuba gear. They are taking in a mixture of oxygen, helium and nitrogen designed to prevent the epilepticlike seizures and narcosis caused by inhaling compressed air beyond a depth of 65 meters. Even so, the men remain hyperalert; if any equipment fails at this point in the dive, they could lose their lives.

Their biggest fear: a rebreather problem that would force them to switch to their backup scuba systems. At their current 90-meter depth, a scuba cylinder might last 10 to 12 minutes, as opposed to 120 minutes near the surface, a consequence of the pressure, which is 10 times that above. As a precaution prior to the dive, the team's support divers set a supply line partway along the route, placing 30 scuba tanks along a length of four kilometers. These backup cylinders are cached at 400-meter intervals. Theoretically, this should give them enough gas to return to the surface in the event that their rebreathers fail. A scooter failure is less threatening. Each explorer began the dive towing four backup scooters, which each have a burn time of two and a half hours. When the batteries on their operating scooter reach the halfway point, they switch to a fresh machine, depositing

DEEP LOGISTICS: Support divers assist recently returned exploration divers who are decompressing inside the nearby chamber.

STEVEN AUER

the spent one along the way and then picking it up on their return journey.

Jablonski is in the lead, paying out line from a handheld reel while carefully motoring a meter off the cave floor to avoid stirring up the silt. The thin nylon cord is tied off to one of the guidelines that the Woodville Karst Plain Project (WKPP) team installed on a previous dive—one of dozens they've made to reach this point in the cave. The network of lines snakes through the maze of chambers and massive tunnels, forming a continuous trail that leads back to the entrance. Without it, the team would very likely be unable to find its way out.

Irvine's third scooter is running low on power. He signals to his partners that it's time to turn the dive. Jablonski finds a small outcropping near the floor of the cave and ties off the line. They've been scooting for 170 minutes and have covered five and a half kilometers, surpassing their previous world-record distance by more than a kilometer. Although others have gone deeper, no one has penetrated an underwater cave this far from its entrance.

Getting there is just half the challenge; the most important part of the dive lies ahead: the three-hour return transit to the cave entrance, followed by an eight-hour staged ascent, or decompression, needed to adjust to the reduction in pressure. A direct ascent to the surface would almost certainly cause paralysis or death. During the decompression, the team will ascend in timed, three-meter increments up to the entrance, beginning at a depth of 75 meters—almost twice the maximum 40-meter depth limit recommended for recreational divers. As they climb, they will alter their gas mixtures five times to accommodate the different stages of decompression. They emerge from the water around 8 P.M., almost 14 hours after they began their dive.

Expedition-level cave diving is arguably one of the most high-tech sports on the planet. It's also one of the most dangerous. Pioneering cave explorer Sheck Exley, who died in 1994 during a 300-meter-deep cave expedition, called it an exercise in "controlled paranoia." Asked once what motivated him to explore underwater caves, Exley replied, "You can't see what's in the back of a cave unless you go there."

Few people have the skill, time and financial resources to tackle a dive as complex as the WKPP's 1998 world-record penetration—it required over $300,000 worth of equipment and a support team of more than a dozen divers. Even basic cave diving requires a commitment to training and equipment that far exceeds that of the typical recreational diver. The endeavor is part of the fastest-growing segment of sport diving: technical diving, which encompasses forays into shipwrecks and dives to great depths. Think of it as sport diving's version of extreme skiing. Whereas recreational diving is restricted to no-decompression journeys at depths not exceeding 40 meters in open waters, technical divers are limited only by their training, equipment and experience.

Unlike their open-water counterparts, cave divers do not have direct access to the surface in an emergency. Any problems they encounter must be solved underwater. The big risk is running out of air and drowning, which can occur as a result of panic, poor planning, a catastrophic equipment failure or getting lost in a cave, a major cause of cave-diving fatalities. Cave divers depend on their line for navigation and carry three lights, because there is no ambient illumination. "Silt-outs" are another hazard that can make navigation difficult. Although the water in most spring-fed caves is crystal-clear, disturbing the settled powdery layer of silt and clay can cause visibility to drop instantly from tens of meters to zero, rendering the diver virtually blind.

WATERY GRAVES

According to statistics kept by the National Speleological Society's Cave Diving Section, an estimated 480 people have died in underwater caves since 1965. Actual incident rates are hard to calculate because no one knows exactly how many people participate in the sport or the number of dives made. Although more than 5,000 divers have completed some level of cave training over the past five years, underground veterans estimate that there are only about 1,000 active cave divers in the world. In comparison, there are approximately three million recreational divers in the U.S., among whom about 100 deaths a year occur, according to Diver Alert Network statistics. In 1994 Jeff Bozanic, who coordinates accident files and statistics for the Cave Diving Section, estimated that one out of every 100 trained cave divers would die in an accident. This figure is probably lower today, he says, because of the increasing number of divers being trained, as well as better techniques and equipment.

One of the primary causes of mishaps is the lack of proper training. Today cave-diving courses are available through both the National Speleological Society and the National Association for Cave Diving. A number of technical-diving training agencies also offer cave certification. A cave-diving course runs 50 to 60 hours and requires that the diver be certified as an advanced open-water diver and have completed a minimum of 50 dives. The course includes 15 supervised cave dives and can cost from $1,200 to $2,000. In addition, there are specialty courses to train divers on the proper use of scooters, alternative gas mixes and rebreathers. But even trained cave divers are not immune to accidents, which are almost always fatal. In 1999, for example, there were six fatalities; five of those who died were cave certified. In virtually all these accidents, the divers violated one or more of the major safety principles of the sport, such as poor gas planning: cave divers should use no more than a third of their gas for the penetration leg of their journey and reserve two thirds for their return trip—enough for two divers to make it out of the cave should one suffer a catastrophic air failure.

Although overall safety has improved, in recent years there has been an increase in technology-related fatalities. Lured by easy access to advanced technologies such as scooters and complex gas mixtures, some divers push harder than their experience warrants. "Today the big dives are easy to do; that's part of the problem. There's a wealth of information on the Internet, and the technology is readily accessible," explains Lamar Hires, a former training director for the Cave Diving Section.

Hires is concerned that divers are trying to move too fast. As an example, he cites the double drowning that occurred last November when two inexperienced cave divers scootered a kilometer into Madison Blue Springs in Madison, Fla., became disoriented, panicked and drowned. One of them still had gas in his tanks when his body was recovered. "In the past, divers had to work up to these dives," Hires says. "Now they don't seem like such an ominous mountain to climb. Unfortunately, divers confuse knowledge with experience."

$10,000 ON YOUR BACK

To survive in a hostile environment, cave divers require far more equipment than do their open-water counterparts—it's not uncommon for someone to enter the water with $10,000 worth of gear. The key is having a backup for all critical life-support equipment. Experience has shown that if a piece of gear can fail, then it will, at the worst possible time.

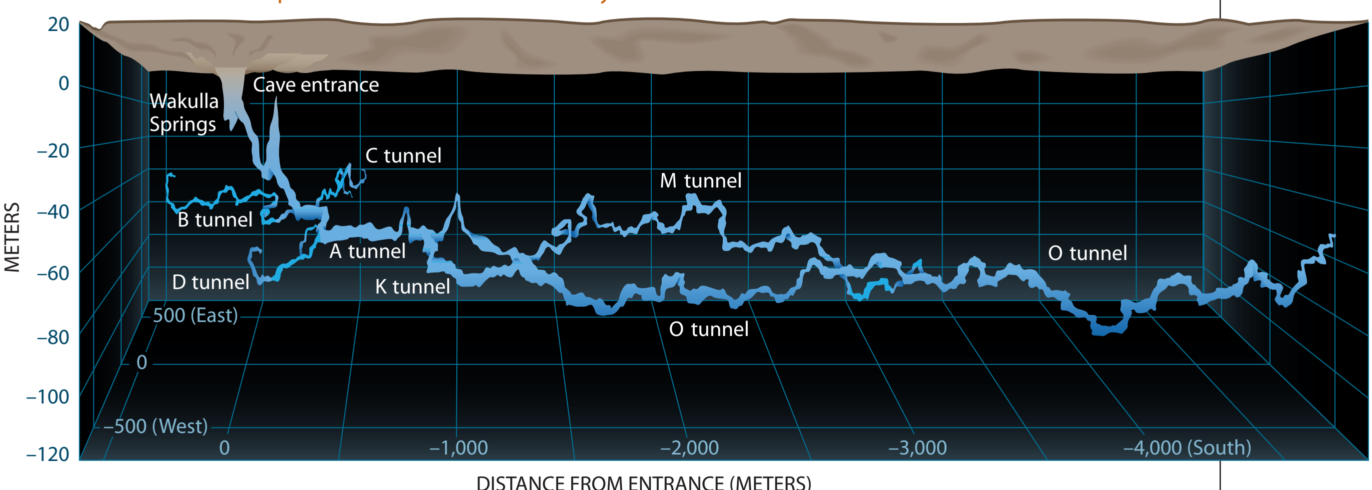
The most important thing on a diver's back is, of course, the breathing system. Compared with recreational divers, who typically carry a single 2,200-liter aluminum tank, cave divers usually descend with a minimum of 6,800 liters of breathing gas carried in dual back-mounted tanks called doubles. The doubles are connected by a manifold and have a primary and a backup demand regulator—a mechanical device that enables breathing underwater.

In addition to their doubles, cave divers often carry one or more 2,200-liter side-mounted tanks, called stage bottles, that are filled with their decompression gas mixture. They can also be used to extend a diver's main gas supply. Divers maintain neutral buoyancy (floating in water at the desired level) by inflating a buoyancy-compensating device called wings, a sealed, U-shaped bag that is mounted on the diver's backpack and can be inflated by means of a valve to achieve the appropriate amount of lift. Yet swimming through the water with up to 100 kilograms of equipment can slow one's pace. For that reason, many cave divers prefer to ride on battery-powered underwater scooters that allow them to travel farther and conserve energy and so exhaust their tanks less.

SAMUEL VELASCO; SOURCES: WKPP AND TODD R. KINCAID *Hazlett-Kincaid, Inc., and Global Underwater Explorers*

Mapping Netherworlds

Wakulla Springs extends for kilometers, as the WKPP group has charted in this map. The full extent of the cave system is still not known.



To avoid getting hypothermia during their lengthy dives, Florida cave divers rely on watertight dry suits with fleece or Thinsulate underwear. The garb is typically inflated with argon gas carried in a thermos-size cylinder to provide an extra layer of thermal protection against the chill 20 degrees Celsius water. Neoprene wet suits are usually adequate in the warmer cave systems found in Mexico, Brazil and the Bahamas. The well-dressed cave diver also carries a variety of specialized equipment, including a primary 50- to 100-watt light and two backups. In the event of primary-light failure, the diver has a secondary light and a backup, at least one reel of line used for navigation, and a dive computer to monitor depth, time and decompression status, along with a backup set of decompression tables, a watch or timer, and a backup mask. Most cavers, however, rely on a low-tech solution for handling the call of nature: adult diapers.

A SPELUNKER'S APOLLO MISSION

Beyond its niche in television and film lore (it was the location of the movie *Creature from the Black Lagoon* and the TV series *Sea Hunt*), Florida's Wakulla Springs holds nearly iconic status among cave divers. Off-limits to anyone who does not hold special (and hard-to-get) permission from the state, the gigantic spring system is considered the birthplace of technical diving, and its poster child is Bill Stone. In 1987 the structural engineer pulled off technical diving's equivalent of the Apollo moon shot when he pioneered the use of mixed-gas technology for deep cave exploration at Wakulla. Using helium-based breathing gases in place of air, as well as scooters and an experimental rebreather, Stone and his team mapped nearly 3.3 kilometers of underwater passages at depths exceeding 80 meters, far beyond the realm of ordinary scuba. Although the technologies were not new—they had been used by commercial and military divers for more than 20 years—they had never been applied to sports diving. Today, thanks to Stone, mix technology has become commonplace among cave divers, and rebreathers are starting to be used for cave exploration.

Despite its availability and low cost, compressed air—a mixture of about 21 percent oxygen and 79 percent nitrogen—has several disadvantages as a diving gas. Because nitrogen is absorbed by the lungs at increased pressure, its presence in air limits the time a diver can stay underwater without having to decompress. In addition, the nitrogen becomes increasingly narcotic beyond about 30 meters, impairing a diver's ability to perform underwater. Some early diving textbooks compared the effect to that of drinking a martini for every 15 meters of depth. Beyond about 60 meters, the oxygen in air also becomes toxic as a result of the pressure, which is more than seven times that at the surface. This can lead to epilepticlike seizures, resulting in unconsciousness and, subsequently, drowning.

To avoid these physiological problems, cave divers rely on one or more special gas mixes. For dives of less than 40 meters, divers typically use "enriched air nitrox," an oxygen-nitrogen mixture whose oxygen fraction varies from 23 to 50 percent, depending on the depth of the dive. By increasing oxygen levels, divers inhale less nitrogen and therefore reduce their decompression requirements, because less nitrogen is absorbed by the body. When diving beyond 60 meters, they often breathe a mixture of oxygen, helium and nitrogen, called "trimix," whose oxygen fraction is lower than that of air, to avoid the problems of oxygen toxicity. Nonnarcotic helium is substituted for some or all of the nitrogen, enabling the divers to effectively set the amount of narcosis they're willing to tolerate. In the midrange between about 40 to 60 meters, air is close to optimal, and the narcosis is manageable for an experienced diver.

In addition, divers usually take in a nitrox mix and pure oxygen during their decompression to help eliminate the excess helium and nitrogen absorbed by their body during the dive. Although mix technology offers divers numerous advantages, it comes at the price of increased planning, logistics and cost.

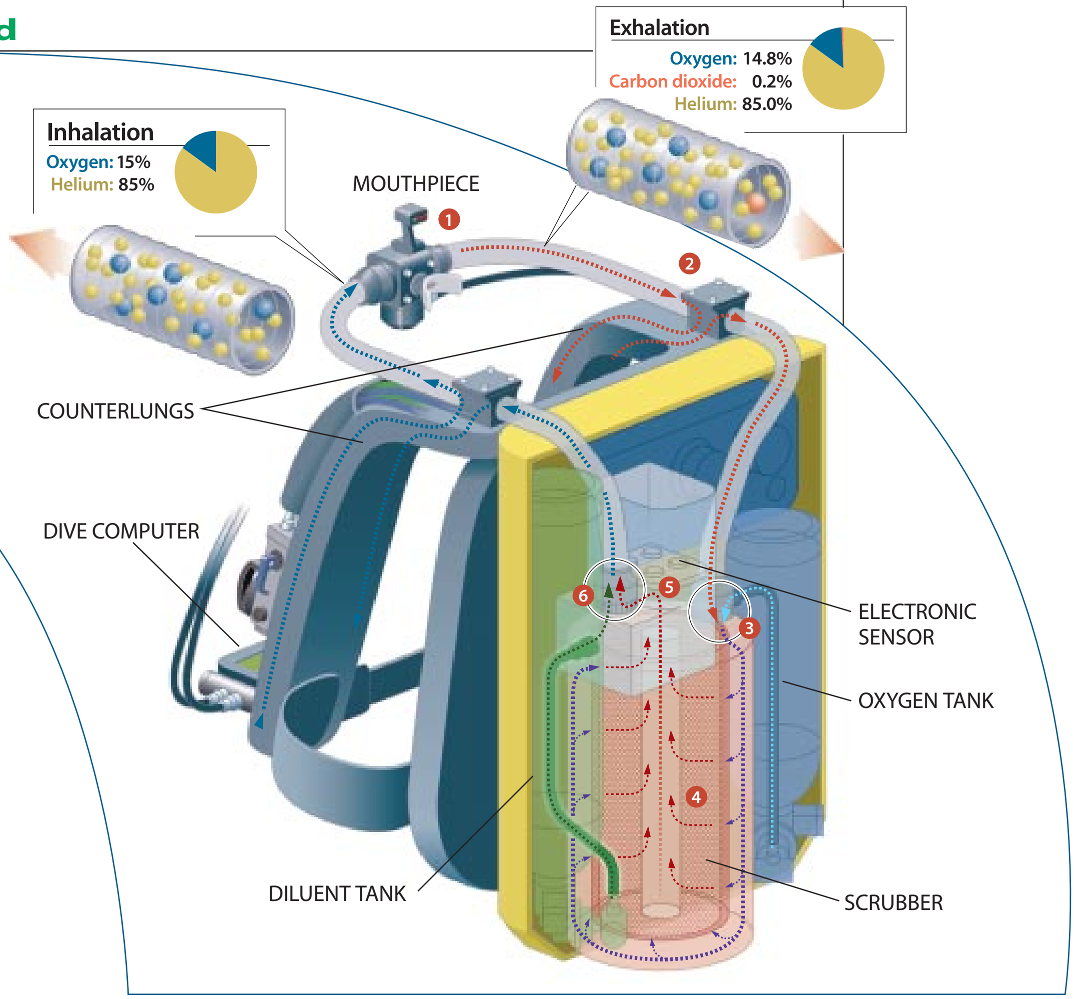
Rebreathers are the latest item in a cave diver's equipment locker. By greatly extending the time a diver can stay underwater, rebreathers make it possible for cave divers to travel farther and deeper. But because of their complexity and expense—a mixed-gas rebreather can run from $7,500 to $20,000, depending on the model—they have not been employed by many divers. First conceived of by 17th-century technologist Giovanni Borelli, rebreathers have long fascinated the diving community. Although the first

MORE THAN YOUR WEIGHT: Cave divers carry up to 100 kilograms of equipment, including extra breathing tanks and scooters.

WES SKILES *Karst Productions*

What Goes Around

An electronic closed-circuit rebreather recycles a diver's exhalations, extending a gas supply up to 40 times longer than conventional scuba's. Exhalations through the mouthpiece (*1*) pass through a counterlung in the strap that ensures a sufficient volume of gases (*2*). Oxygen is added (*3*) before the gas passes through a scrubber (*4*) that removes carbon dioxide. An electronic sensor (*5*) monitors the oxygen before the addition of a helium-and-oxygen diluent (*6*) provides a breathable blend of gases tailored for dives at great depths.



working unit was invented in 1876, the technology wasn't deployed in appreciable numbers until World War II, when its utility in war proved its value. The absence of bubbles and extended range of closed-circuit rebreathers enabled combat swimmers to penetrate behind enemy lines. Twenty years later doctoral-candidate-turned-inventor Walter Starck introduced to consumers the Electrolung, the first electronically controlled rebreather. Within a year, however, a series of tragic deaths forced the manufacturer to pull the system from the market. Rebreathers remained almost the exclusive province of military divers until 1987, when Stone and his team brought them to cave diving.

Today two different types of rebreathers are being used by the cave-diving community. One is electronic and recycles all the gas; the other is mechanical and vents gas from the system every four out of five breaths. By recycling the gas, rebreathers offer enormous efficiencies over open-circuit scuba. An electronic rebreather can extend a gas supply by a factor of 40 to one, whereas a semiclosed system provides an eight- to 10-fold advantage. Their complexity, however, makes them less reliable than scuba and introduces additional physiological risks. In the event that the system malfunctions, the diver may suffer hypoxia (too little oxygen), hyperoxia (too much oxygen) or hypercapnia (CO_2 buildup, in this case caused by a malfunctioning scrubber), all of which can result in unconsciousness and drowning.

In addition, rebreathers require extensive training and significant predive and postdive maintenance to ensure that they function properly, making the equipment too complex for most divers. But that won't stop well-heeled explorers from plunking down their cash nor hinder the continued development of rebreathers. Because most of the easily accessible sites have been visited, cave exploration is becoming increasingly technology-driven. Future exploration will most likely require further refinements in gas and rebreather technologies. So a sport that is already one of the world's most dangerous exploits will demand even more expertise and daring of its practitioners.

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FURTHER INFORMATION

Various cave-diving organizations maintain sites on the Web, including the National Speleological Society's Cave Diving Section (www.caves.org/section/cds/) and the National Association for Cave Diving (www.safecavediving. com/).

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