The Journal of Global Underwater Explorers

Quest

Vol. 25, No. 1 – February 2024

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EDUCATION · CONSERVATION · EXPLORATION · COMMUNITY

EDITOR'S LETTER

Never stop exploring

This edition of *Quest* is dedicated to the spirit of exploration and delves into the tools, training, and mindset essential for the successful execution of exploration activities in challenging environments.

In his article on page 42, Kees Beemster Leverenz celebrates a significant milestone: the first GUE Technical Diver Level 3 course in many years. The Tech 3 course has long been an aspiration, with only a few conducted in the early years of the organization. It's fitting that the inaugural revamped Tech 3 course took place on the *Britannic* in Greece, a wreck intertwined with GUE's history, as some of the GUE founders made a pioneering exploration on this historic vessel in the early days of the organization. Kees concludes that one of the best parts was the opportunity to pick the brains of the seasoned instructors and getting a chance to share the knowledge and experience gained on numerous projects in the 100 m/300 ft and deeper range.

Leo Fielding's article on the exploration of the wreck of the SS *Belgique* in the English Channel, known for its iconic electrical trams, vividly illustrates the skills and techniques employed by deep wreck diving teams. See page 12.

This issue strives to maintain a harmonious balance between wreck and cave exploration, with the BEL team's article summarizing their insights and discoveries after numerous dives in Ox Bel Ha—yet another historically significant location seen from a diving perspective. Needless to say, uncovering over 10 km/6 mi of new cave tunnels imparts invaluable lessons in cave surveying, and the team generously shares tips and tricks. See page 24.

Without a doubt, the BEL team has been applying the gas management techniques and strategies explained in our cave diving series on page 64. The robust gas planning principles taught in GUE's cave curriculum are an important factor in the safe approach to cave diving and exploration.

A common denominator in all articles, whether the subject is wrecks or caves, is the training involved. Professor Marcus Doshi teaches university-level stage lighting techniques—a subject very far from diving. But, as a seasoned educator and avid diver, he draws parallels between his teaching and dive training. He discusses the importance of addressing contradictions in teaching, being an ally to students, understanding threshold concepts, and utilizing effective assessments, emphasizing formative assessments and feedback. His goal is to stimulate student-centered teaching concepts to enhance training effectiveness and create a positive learning environment for students. See page 54.

As we immerse ourselves in the stories of exploration within these pages, let us not forget that the essence of exploration extends far beyond oceans or caves. It permeates every facet of our lives, urging us to push boundaries, challenge conventions, and continuously seek knowledge and understanding. Never stop exploring!

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Quest
The Journal of Global Underwater Explorers
Vol. 25, No. 1 · February 2024

Quest is published quarterly by
Global Underwater Explorers
18487 High Springs Main Street,
High Springs, Florida 32643
www.GUE.com

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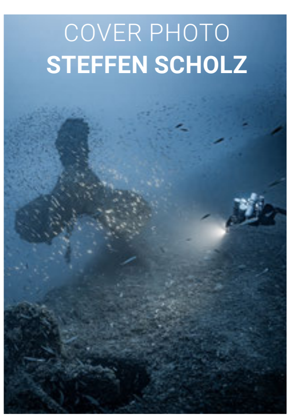
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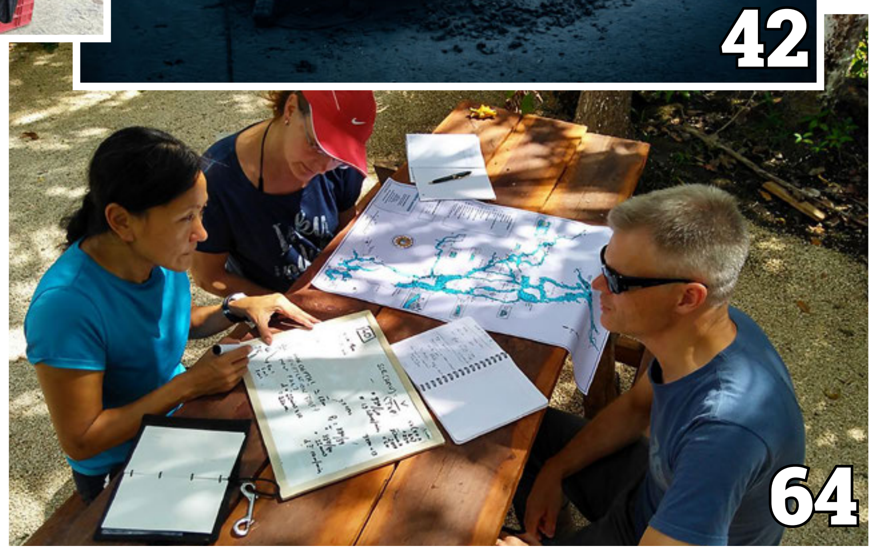


QC CORNER

A BRIGHT FUTURE

TEXT **BRAD BESKIN**// PHOTOS **SJ ALICE BENNETT & DOROTA CZERNY**

Since his early days at Scuba Camp Brad has been attracted to thrilling underwater adventures. Discover how the guidance of GUE's pioneers, including Jarrod Jablonski, shaped his path and learn why leadership excellence remains at the heart of the GUE experience.

Greetings, *Quest* readers. I hope your year already is filled with awesome adventures, including great diving. Reports from my side of the globe show incredible conditions in Florida's caves, and I simply cannot wait to get back to High Springs to enjoy them. I hope the same for you in your corner of the globe.

At GUE's 25th Anniversary Conference and celebration, we took several trips down "memory lane." Perhaps my favorite was the slideshow by Jarrod Jablonski and Rich Denmark showing some of the earliest photographs we have of our most tenured instructors. Many of these were worth a few laughs…or perhaps even gasps. Hair color may have changed (or, for some, disappeared and even reappeared in previously unknown places), but the faces remain unchanged. I saw in the eyes of our young leadership that same spark you'll notice when they tell old dive stories around a fire pit, when they teach Fundamentals to an aspiring explorer, or when they introduce you to their family. It is the same spark we see in Jennifer Thomson and Harry Gunning, our outgoing and incoming NextGen Scholars (respectively)—an eagerness to unravel the world and decode its secrets.

I was humbled to be included in their presentation. I have often said that while my teenage peers idolized superstar athletes like Jordan, Griffey, Jr., Sanders, Agassi, and Gretzky, my heroes wore red and black TLS drysuits and drove Gavin scooters into endless water-filled holes in the ground. To find myself in same room as those who defined my passion for diving through twenty-five years of relentless hard work was powerful. To call them friends is, frankly, still somewhat overwhelming.

Brad has made significant progress since his early days of filling tanks at the local dive shops 25 years ago.

PHOTO **DOROTA CZERNY**

Scuba Camp

Admittedly, I'm not an instructor and my involvement with GUE was relatively limited until assuming the helm of the Quality Control mechanism. Nevertheless, at risk of self-indulgence, I'd like to share with you my journey to GUE. To avoid burying the lede (even more so), my point in doing so is what I found to be the most important takeaway from the Conference: the values that served as GUE's foundations in the 90s are the same values we cultivate today. There is a congruence that ties us to GUE's progenitor leadership—a congruence that will carry us forward as we continue to pursue excellence.

I grew up in Virginia Beach, Virginia. Twenty-eight years ago (I was age twelve), my parents enrolled me in "Scuba Camp", a two-week immersive program through my local dive shop. I emerged with an SSI open water certification (contingent on parent/guardian supervision, of course).

My first dives were in the shallow sections of what is now Lake Phoenix. My second were on the islands of the Chesapeake Bay Bridge Tunnel—a true exercise in Braille diving. But the lack of visibility didn't matter; being underwater captivated me.

> **"To find myself in same room as those who defined my passion for diving through twenty-five years of relentless hard work was powerful.**

As if fate had determined it, my first dive trip followed shortly after: a fourteen-hour bus ride to Florida's cave country with my mom. We dove Devil's Den and Blue Grotto, snorkeled with manatees, and let the Manatee headspring blast us down river.

I was hooked. From that point forward, I spent almost every waking free moment at LDC. I vacuumed the pool, dusted the shop, emptied the cat litter (because of course there's a shop cat), organized the fill station, and annoyed the you-know-what out of the staff. No, Kyle, some things don't change. As I grew older, I helped fill tanks, sell gear, and even run the dive boats—anything to garner experience and learn more about diving.

The shop supported a growing group of would-be technical divers. It was what you'd expect from the U.S. east coast in the mid 90s: scary, with way too much brass and bungee and not enough planning or control. We had little standardization, clung to the anchor line for stability, and kept our deco on our wrists. To our credit, our tanks were manifolded, long hoses were properly routed, and the gas had some helium in it. And the experienced divers on the team were diving—for example the Billy Mitchell Fleet wrecks—in the 60-120 m/200 to 400 ft range with remarkable success. We thought we were hot; amusingly, I recently found a video of us all diving together, and it turns out we weren't so hot, after all.

Immortality complex

By age sixteen, I had scraped together enough shop credit from my chores to cobble together a set of doubles with a backplate and wing. The configuration was imperfect. But, only mere rumblings of this thing called GUE had made its way to Virginia by that time. I would spend my allowance and part time shop earnings on what bit of helium I could manage, along with deco gas and boat fees. I would lie to my parents about how deep we were going, and often leave an old computer on the line at 30m/100 ft for some cover when my mom asked to see the readout.

Summers spent as boat crew meant five to six dives a day, four to five days a week. Most of these were solo (even at night, miles offshore), and many were hot drops with the anchor chain wrapped around my forearm. I am truly lucky to be alive—and for no lack of trying to put myself in absurdly dangerous positions—with both eardrums intact. To be certain, this is a condemnation (not a glorification) of the practice, especially in light of the standards I now enforce through my role. It was foolish teenaged naiveté fueled by an immortality complex.

My friend Tom Sawicki was the only GUE-trained diver I knew at the time. He gently coaxed me away from my recklessness, suggested im-

Brad manages to carve out time for cave diving adventures in destinations like Mexico, Florida, and Sardinia.

PHOTO **SJ ALICE BENNETT**

provements in configuration, and impressed upon me the importance of team dynamics. He offered a refreshing dose of control to what always seemed out thereof. "Where'd you learn this?", I'd ask. "Jarrod Jablonski", he said.

Fundamentals first

Then, Jarrod came to visit. Our rag-tag group of anchor line clingers invited him to speak to and dive with us for the weekend. He kindly obliged, and I volunteered to be his chauffer for the weekend. That he still speaks to me only shows how gracious he is; I don't think I gave him a moment's peace in the car with my incessant questions.

His visit was life-changing for me. Frankly, we all expected dogmatic criticism and a heavy-handed condemnation of our practices. This was, in our defense, the reputation of the day. It shows how little we knew about Jarrod or GUE. As is true today, Jarrod didn't need (or try) to tell us where we'd veered astray. Rather, he showed us the difference, which was as plain as his perfect trim and impeccable control juxtaposed to our need to cling to the anchor line. He answered countless questions, made suggestions only upon solicitation, and was consummately kind, supportive, and encouraging. We wanted to be a team, we just didn't know how, and he gave us credit for trying. He embodied the gold standard for how GUE leads the way toward safer, elevated diving today.

I dropped him off at the end of the weekend, said goodbye, and asked “what do I do now?” He answered: “Work on your fundamentals, Brad. The rest will follow.”

Hard work

Indeed, Fundamentals followed in 2001 at Lake Phoenix. The experience was formative, to say the least. At the time, it wasn’t really a graded course, but I’m confident none of us swam out with anything akin to today’s technical pass. It showed us the bar, and we began working toward it. After months of hard work on fundamentals skills, I enrolled in Cave 1 with Tamara Kendel.

To date, I am not sure I have ever seen anyone move in the water like Tamara. It was magical. Tamara set what has always been the gold standard for me in GUE education and training. She was kind but firm, demanding but reassuring, and demonstrably exemplary in every fashion.

These themes remain paramount to me as I work with GUE instructors. Excellence in leadership is not dogmatic or condemning. Rather, it is demonstrative, supportive, and benevolent. It shows the way with “do as I do” and leaves little for only “as I say.” It walks the walk, and mostly leaves the talking to those who are oblivious to how lacking their skills truly are.

“*Leadership excellence is the ability to recognize potential and create an atmosphere of empowerment and support. A key aspect of this is encouraging [the] practice self-management through a strong sense of self-awareness and understanding of the importance of collaboration and teamwork*.” Hofmann, Leadership Excellence, Forbes (Mar. 30, 2023).

Bright future

I have enjoyed the privilege of diving with many of you. I mark as friends, dive buddies, and mentors stellar instructors and stellar divers. To me, each of these friends and mentors embodies the gold standard Jarrod, Tamara, and many other originals set—leadership by doing, relentless personal improvement, and a desire to bring people into the fold. Without this kind of leadership, I would likely still be clinging to the anchor line…or worse. It is a priceless gift GUE has afforded me.

But the best part of GUE is how pervasive this quality is, especially in our instructor cadre. I read each and every bit of substantive student feedback that follows a GUE course. From that data, I am confident in and proud of the way each of our instructors throughout the globe embodies that standard. It is, at risk of cliché, a commitment to leadership excellence.

GUE’s future is bright. We continue to evolve as an organization, and we continue to challenge the status quo. Faces may age, but the light never dims.

It remains an honor and privilege to serve GUE and you. My best to you for spectacular diving in 2024.■

Brad Beskin

Brad Beskin has been diving actively for approximately 29 years. He first became involved with GUE by taking Fundamentals in 2001, and then Cave 1 with Tamara Kendel in 2003. He is now a proud GUE DPV Cave diver and is actively working his way through GUE’s technical curriculum. When he is not diving, he earns his living as a civil litigator in Austin, Texas, and he also finds time to act as Director of Quality Control and the Chair of the Quality Control Board for Global Underwater Explorers.

GUE TECH 1

A GIANT LEAP FORWARD

Read more about the GUE Tech 1 course and see scheduled classes on www.gue.com

THE GUE TECHNICAL DIVER LEVEL 1 COURSE

- Cultivates, integrates, and expands essential skills required for safe technical diving
- Teaches you how to prevent, identify, and resolve problems
- Addresses the potential failures associated with twinsets
- Introduces accelerated decompression strategies, single stage diving, and the use of helium to minimize narcosis

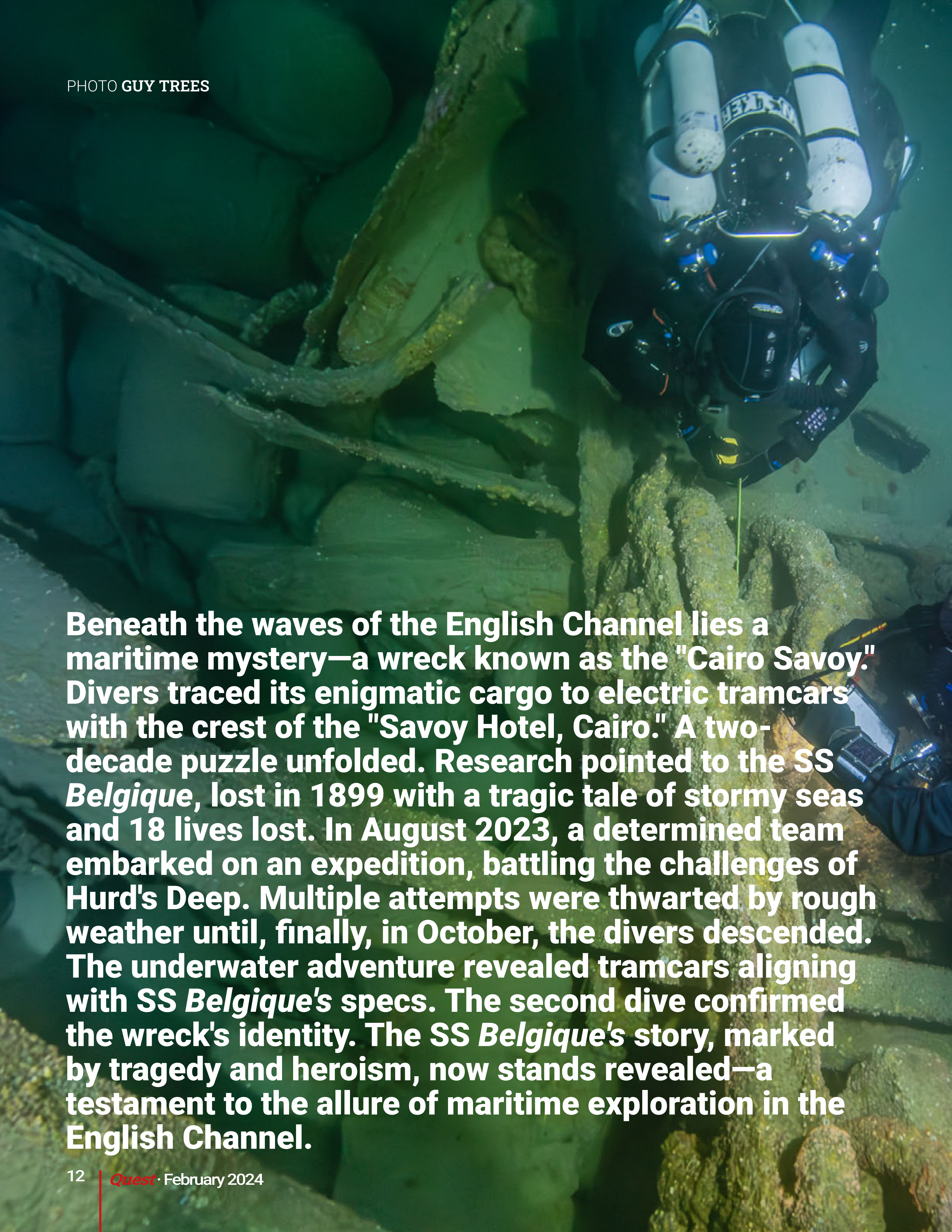


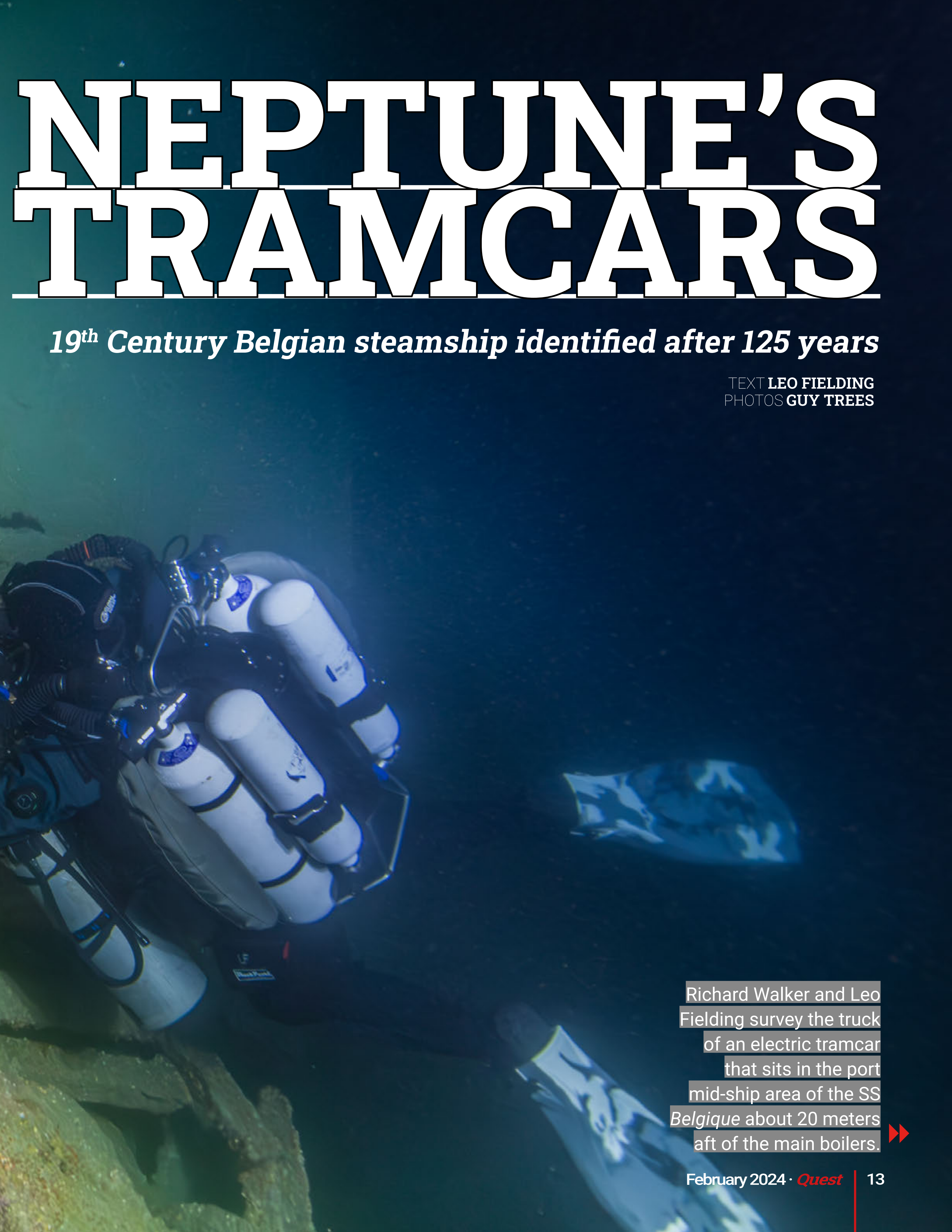
PHOTO **GUY TREES**

Beneath the waves of the English Channel lies a maritime mystery—a wreck known as the "Cairo Savoy." Divers traced its enigmatic cargo to electric tramcars with the crest of the "Savoy Hotel, Cairo." A two-decade puzzle unfolded. Research pointed to the SS *Belgique*, lost in 1899 with a tragic tale of stormy seas and 18 lives lost. In August 2023, a determined team embarked on an expedition, battling the challenges of Hurd's Deep. Multiple attempts were thwarted by rough weather until, finally, in October, the divers descended. The underwater adventure revealed tramcars aligning with SS *Belgique's* specs. The second dive confirmed the wreck's identity. The SS *Belgique's* story, marked by tragedy and heroism, now stands revealed—a testament to the allure of maritime exploration in the English Channel.

NEPTUNE'S TRAMCARS

19th Century Belgian steamship identified after 125 years

TEXT **LEO FIELDING**
PHOTOS **GUY TREES**



Richard Walker and Leo Fielding survey the truck of an electric tramcar that sits in the port mid-ship area of the SS *Belgique* about 20 meters aft of the main boilers.

Where on earth can you dive a wreck with a cargo of electric tramcars? As a result of Britain's exalted maritime heritage plus two world wars, the English Channel is strewn with thousands of wrecks carrying all manner of exotic cargo. Some remain "unknowns" and others take years to finally identify.

The wreck, nicknamed the *Cairo Savoy*, was first located and dived around two decades ago by British skipper and diver Ian Taylor of *SkinDeeper*. The wreck lies to the southwest of the Hurd's Deep canyon in about 80 m/262 ft of water.

Mystery has surrounded the wreck's identity ever since. Her nickname was based on her cargo that included ornate crockery stamped with the crest of the Savoy Hotel, Cairo.

The ongoing puzzle over the circumstances of her loss, and the challenges posed by her remote resting place and relative depth, enticed many an intrepid diver to visit. Indeed, few wrecks had woven themselves as tightly into the local lore of diving in this area of the Channel. Nevertheless, while some suspected that the Cairo Savoy might be the SS *Belgique*, evidence remained elusive.

The ship and her loss

The SS *Belgique* (ex-*Mount Hebron*) was a 2,560 GRT, well-deck, single-screw, schooner-rigged steamer with two masts, two main boilers, a donkey boiler, and a triple expansion engine built in Belfast in 1889.

On the night of November 10, 1899, the SS *Belgique* was on a voyage from Antwerp, Belgium, to Alexandria, Egypt, when she foundered in a strong gale blowing WSW, to the southwest of the Hurd's Deep canyon. It was reported that 18 lives (including that of the captain) were lost out of a total crew of 26. The grim events were reported in the British and Belgian press, including in the Lincolnshire Chronicle of November 17, 1899:

"*She started in weather, which grew worse as she went down the Channel… On board were ten electric tram-cars for Alexandria, and in the storm they broke loose from their lashings and swept the deck, smashing hatches and bulwarks and everything else. Then the steering gear went wrong, and the ship fell towards the sea."*

"She started rolling, and the water was pouring down the broken hatchways," said Edmund J. Backeljauw, the second officer, "…At eleven o'clock at night there was 12 feet of water in the hold, and the captain ordered one boat out, with myself, the third officer, the third engineer, and thirteen hands to man her. We left her at half-past eleven, and the water had then increased to 17 feet. We could see the Casquet light clearly, being about six or seven miles away."

"It was a terrible night. Five of our sixteen men died from exhaustion [Note: this may be a mis-translation of "exposure*"] and we had to drop their bodies overboard. It was between half-past twelve and one on Saturday that we sighted the* St. Kilda*. When she got close and threw a line there was a jerk which threw three of our men out, two being drowned, and the other killed between the boat and the ship's side. When we got on board, the third engineer told us that a quarter of an hour after we left the* Belgique *he saw her disappear to the waves. There is no doubt, I think, that the captain, the chief and second engineers, and the seven other hands went down in the ship. We lost all our belongings, but were glad to escape with our lives."*

Captain John McCarte of the *St. Kilda* testifies to the utterly exhausted condition of the Belgians when he picked them up. "*We threw lifebuoys and lines to the men who were jerked out of the boat*," he said, "*but they were too exhausted to save themselves. Mr. Ward, my chief mate, jumped into the boat, which was half-full of water, and put bowlines round some of the men, and thus we hauled them on board." The survivors are warm in their praise of the* St. Kilda's *captain and crew, and especially of Mr. Ward, who "jumped into their boat in a gale of a wind."*

Research

Fast-forward to the near-present. In August 2023, our team was in the midst of planning an expedition to dive unknown and lesser-visited wrecks when my phone buzzed with a WhatsApp mes-


Pre-breathing the rebreathers before another 80 m/262 ft dive in the English Channel.

PHOTO **GUY TREES**

sage from Andy Colderwood: *"I'm sure I have told you about the Cairo Savoy. That is a great dive and we need to prove what she is!"*

Sure enough, I was hooked. I spent the following weeks poring over old newspaper reports and ships' archives. Wreck research can be like solving a puzzle where you put together seemingly unrelated pieces of information to build a bigger picture of what happened.

Initial clues to the ship's identity were spotted in the SS *Belgique's* port of destination (Alexandria, Egypt), her date of loss (1899), which was consistent with the opening of the Savoy hotel in Cairo in 1898, and the link between footage of what had been previously thought to be the trucks of small railway carriages with the cargo of electric tramcars carried by the SS *Belgique*, which all generated interest in investigating further.

"Wreck research can be like solving a puzzle where you put together seemingly unrelated pieces of information to build a bigger picture of what happened.

Fellow British divers Ian Taylor, Al Wright, Jos Greenhalgh, and Andy Colderwood provided intel and sketches of the wreck from their previous dives that proved invaluable in planning further work. We located blueprints of the SS *Belgique* to cross-check the dimensions of known features on the wreck.

Specialist input on 19th Century Belgian tramcars was provided by Mr. Roland and Philippe Dussart-Desart, editors of Tramania and Tramway Review, and Mr. Yves-Laurent Hansart, author of numerous books on Belgian trams. The team located documentation confirming that the electric tramcars had been two-axle cars equipped with Thomson-Houston electric motors and controllers ordered by Les Tramways du Caire in 1898.

Tasks were assigned. We agreed that our first dive on the wreck would focus on the tramcars, and the second dive would focus on the wreck itself. I lost count of how many hours were spent outlining the picky little details that can make the difference between success and failure. On the first dive, Richard Walker, Guy Trees, and I were to survey and photograph the tramcars; Andy Colderwood, Toni Norton, and Stephen Elves were to search for evidence of any manufacturer plates fitted to the tramcars; and Tom Aucott and Duncan Simpson were to measure the tramcar motors against the dimensions of a nose-suspended G.E. 800 motor, which was the type of motor typically fitted onto electric tramcars operated in Cairo at the relevant time. On the second dive, Richard, Guy, and I were to survey the propeller and rudder; Andy, Toni, and Stephen were to survey the engine cylinders; and Tom and Duncan were to survey the two main boilers.

Hurd's Deep canyon

To visit the SS *Belgique,* divers must prepare to meet the specific challenges posed by conditions around the Hurd's Deep canyon.

The Hurd's Deep canyon cuts a great slice nearly 180 m/590 ft deep and 113 km/70 miles long through the middle of the English Channel, just south of the Eastbound shipping lane, which is one of the busiest shipping lanes in the world.

The unpredictable nature of this stretch of water is in large part due to its tidal range, the change in seabed depth created by the canyon itself, and its exposure to the prevailing weather that rolls in from the south-west.

Movement of water into and out of this canyon can create a treacherous sea state. While many seas around the world experience strong tides, few are as unpredictable as here, where the set and drift of the tidal stream may behave differently at different depths in the water column.

In addition, Alderney itself lacks any support for technical diving operations. Whatever is needed for a multi-day expedition—sofnolime, suit inflation, drop sets, cameras, lighting, scooters, and so on—has to be transported in and out on the boat. While this adds complexity to the planning, it also adds to the allure of the adventure.

Efforts to reach the wreck

Initially, the wreck seemed reluctant to let us visit without paying our dues. On August 26, 2023, a multi-day expedition set off, but rough weather prevented diving. Instead, the team took the opportunity to check out the shipwreck exhibition in the Alderney Society Museum, plus one or two local pubs! On September 23, 2023, a further expedition was canceled due to rough weather, this time without us even leaving port. With the nights drawing in and the end of the season fast approaching, it was far from clear whether we would be able to dive the wreck this year at all.

Finally, on October 9 and 10, the weather cooperated. An area of high pressure swept in over the Channel and opened up a window to allow diving to go ahead. It was on!

As the team grabbed passports, packed cars, and headed for the coast, an advance group gathered in the Ming Wah Chinese restaurant in nearby Weymouth for crispy aromatic duck with pancakes and beef fried noodles.

The first day of diving

So it was that the weather gods smiled brightly as the first day dawned and the sea was calm. We placed those jumping first nearest the gate. A long journey, plus time to scope the site, meant an early start. With decreasing hours of autumn sunlight, we planned to overnight on the island rather than attempt a return day-trip.

After about three and a half hours of travel, we were on site. Placing a shot line in 80 m/262 ft of water is never easy, and the tide in Hurd's Deep was going to make it even trickier, even though we were sure of the wreck's position.

On this day, there was a tidal range of 2.5 m/8 ft, which was a low neap by Hurd's Deep standards, where the mean spring range is 6 m/20 ft! However, it still made for strong tides and we expected to have no more than about half an hour of slack water. This meant that we needed to be ready to jump in as soon as conditions allowed.

With the shot in and everyone ready to go, the first team of Richard Walker, Guy Trees, and myself jumped in. After pausing at about 6 m/20 ft for a quick bubble check, we descended.

As we made our way down the line, the half-knot or so of tide forced us to proceed hand-

The truck of an electric tramcar that sits in the bow area on the port side of the SS *Belgique*.

PHOTO **GUY TREES**

over-hand. At about 60 m/200 ft, the wreck came into view. Leaving a strobe on the shot line, we regrouped. As our eyes became accustomed to the lowered light levels, the visibility opened up to an impressive 15 m/50 ft or so.

The shot had landed amidships, just aft of one of the two main boilers. The wreck sat more or less upright on the seabed. Her main axis lay partly across the tide, with her bow broadly NE and stern SW. After a quick check of the compass, we set off towards the stern following the port rail.

After a couple of minutes' swimming, the eerie outline of a tramcar loomed out of the shadows. Richard and I quickly set to work with measuring tape and wetnotes while Guy took photos, and then we swapped roles with Richard and I taking over offboard lighting duties.

As I worked, I became gradually but distinctly aware that somebody appeared to be rapping in my ear. *"Look at the situation they got me facing/I can't live a normal life, I was raised by the street,"* the voice insisted. I asked myself where this voice might be coming from, and for a split-second started to question my own sanity. How much helium had I added to my diluent? Could this be the rapture of the deep? In fact, the submersible loudspeaker that Guy had brought to make deco pass more agreeably had self-activated with the pressure and begun playing "*Gangsta's Paradise*" by Coolio!

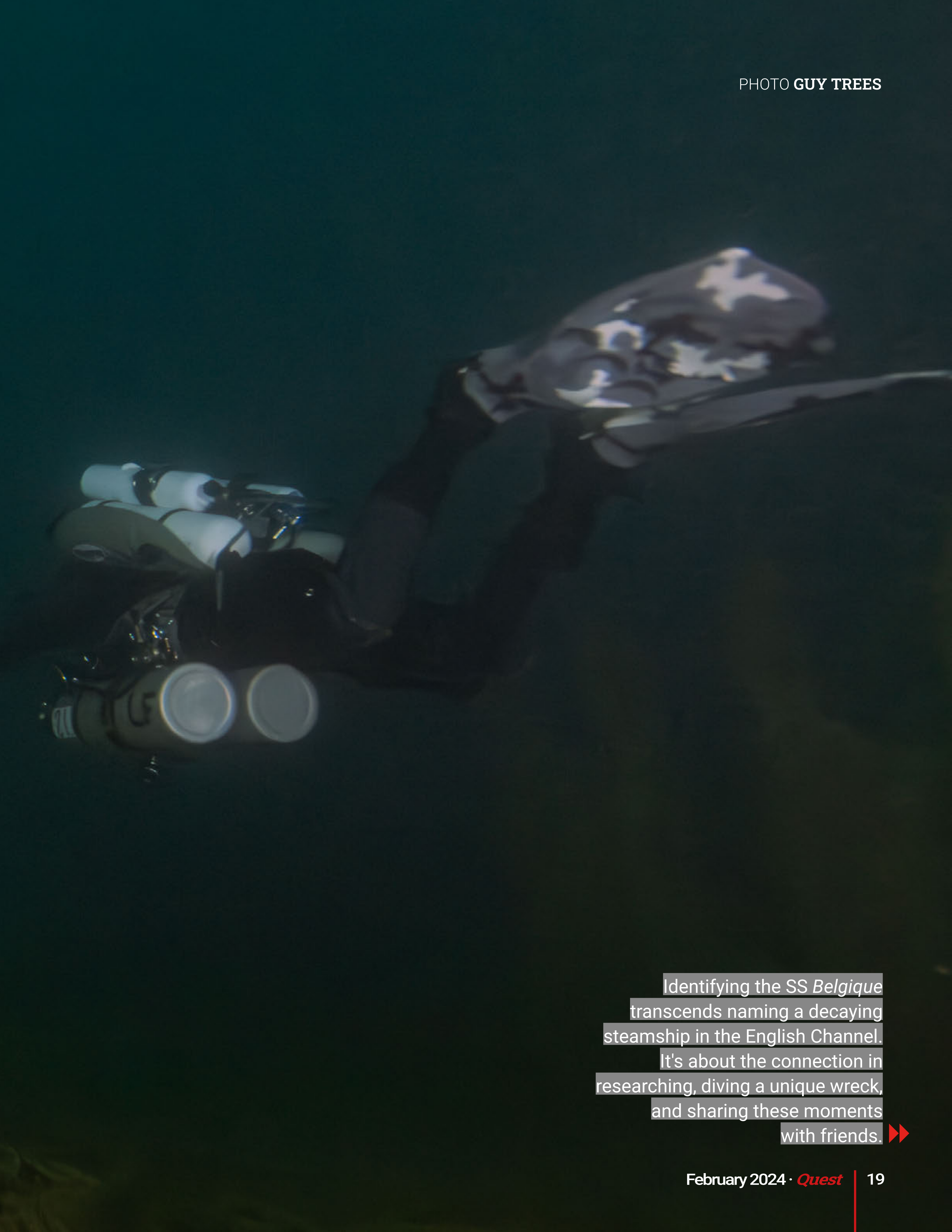
With this new soundtrack to our dive, we swam on towards the stern where we found another better-preserved truck of a tramcar and finally the single-screw four-blade propeller that we had hoped to measure on the second dive. A surge of relief washed over me as we seemed to be not only meeting but now exceeding our goals for the dive. After about 35 minutes on the wreck, we gave the turn-around signal and returned to the shot.

Deco ran to plan with a relatively balmy water temperature of 17° C/63° F and before long we rejoined the boat on the surface, with Guy's rap festival being replaced by Duncan Simpson's drone buzzing overhead shooting video.

Back on the boat, the divers who were visiting the wreck for the first time could scarcely con-

> **In fact, the submersible loudspeaker that Guy had brought to make deco pass more agreeably had self-activated with the pressure and begun playing "*Gangsta's Paradise*" by Coolio!**

PHOTO **GUY TREES**



Identifying the SS *Belgique* transcends naming a decaying steamship in the English Channel. It's about the connection in researching, diving a unique wreck, and sharing these moments with friends.

tain their enthusiasm. Everyone was comparing notes on their findings. While, unsurprisingly, we did not locate any manufacturers' plates on the tramcars, it was nevertheless apparent that they had front and rear-axle electric motors as expected. The atmosphere was, well, electric!

Island life

Once all the gear was secured, we headed in towards Braye Harbour on Alderney. The weather was blissfully calm and the sun washed orange light over the evening sky. By 6:30 pm, we had arrived at our accommodation at the Harbour Lights Tavern, dropped bags, and fired off reports to Roland and Philippe Dussart-Desert in Belgium. The pieces of the puzzle were falling into place.

The ground floor of the tavern hosts the only French restaurant on Alderney, Le Pesked, which is owned and run by Brittany Chef David Ollivrin. At supper, all thought of diving faded as the group launched into a three-course dinner of Burgundy snails in garlic butter, French onion and cider soup, braised lamb with harissa, and bouillabaisse of Provençal seafood, followed by crepe Suzette and baked meringue.

The second day of diving

Overnight, the clouds had gathered and a fresh breeze was waiting for us when we emerged onto the pontoon. A quick review of the weather told some of us that, once we left the shelter of Braye Harbour, it would be as well to be fully suited for the choppy ride out to the wreck. We were about to encounter one of Hurd's Deep's many challenges!

Within minutes of leaving Braye Harbour, the Sea Leopard—our 11 m/36 ft, twin-engined South Boat Catamaran renowned for its sea keeping—was offering a rollercoaster ride rivaling anything Disney could have envisaged. Eyes squinted uneasily at the horizon as if seeking reassurance that conditions might improve. Rigs were lashed tighter. Shelter was sought. Dark oaths were muttered. Happily, reassurance was provided by seasoned skipper Al Wright. "It's the 'Alderney race.' We'll be through in a sec!" Al called as he put the hammers down. Sure enough, just as our intrepid gang began huddling like penguins in a snowstorm in a manner that suggested they might be content to call it a day, the sea flattened off and it was all systems go again.

Buoyed by this sudden reversal in our fortunes, it was the turn of Andy Colderwood, Toni Norton, and Stephen Elves to jump first, while Rich Walker, Guy Trees, and I took care of installing the lazy shot. As we had jumped tides and were now diving the high-water slack, the visibility seemed less spectacular than the previous day, and the overcast sky meant less ambient light at depth. The shot was slightly off the port side of the wreck, and her rusted steel heel cut an imposing sight towering about six or seven meters above the sea bed and surrounded on all sides by inky-black water.

While Richard, Guy, and I set about taking photos of a well-preserved truck, Tom Aucott and Duncan Simpson measured the diameter and length of the two main boilers; and Andy Colderwood, Toni Norton, and Stephen Elves inspected the engine cylinders. We also took time to venture further in the direction that we had not swum on the previous dive revealing more of the bow area.

Time spent at 80 meters in the English Channel is at a premium. As the tide was now on the ebb and starting to run, we made our way back to the safety of the shot after about 25 minutes on the bottom. The only casualty of the dive was Andy Colderwood's reel, which he had charitably donated to line off to the wreck and was never retrieved (sorry, Andy!).

As we headed home to Portland fueled by Freda's homemade cakes and hot drinks, the mood was upbeat. Seasoned divers had renewed their acquaintance with the wreck after many years, and a fresh generation of divers had discovered her appeal for the first time.

Documentation

The dives had proved remarkably productive. We managed to take measurements of the gauge, wheelbase, wheel diameter, motor case, gear case, axle bearings, and chassis of the trucks of the tramcars, which matched what we had expected to find.

We had also measured the diameter and length of the two main boilers, and the diameter

PHOTO **GUY TREES**

> **"The only casualty of the dive was Andy Colderwood's reel, which he had charitably donated to line off to the wreck and was never retrieved (sorry, Andy!).**

A couple of hours' deco gives ample time to reflect on the dive and plan the work ahead.

We believe that the SS *Belgique* may be unique in being the only shipwreck recorded to have sunk with a cargo of electric tramcars.

of the single-screw four-blade propeller, which all matched measurements shown on blueprints of the SS *Belgique*. After 125 years, the mystery of the wreck's identity had been finally solved.

Back ashore, Philippe Dussart-Desert managed to create a 3D model of the truck of a tramcar from Guy's photos. To our knowledge, at 80 meters, this tram was and is the deepest artifact 3D modeled by recreational divers in the English Channel.

The wreck today

We believe that the SS *Belgique* may be unique in being the only shipwreck recorded to have sunk with a cargo of electric tramcars. We are aware of three instances of accidents at sea involving the loss of electric tramcars. However, in the other two instances, the tramcars were merely lost overboard in isolated events with the ships otherwise continuing to their ports of destination.

The SS *Belgique* today remains intriguing, challenging, and under-visited. The grim loss of over two-thirds of her crew, the heroism shown by Mr. Ward, the chief mate of the *St. Kilda* who jumped down into the SS *Belgique*'s waterlogged lifeboat in a gale in the middle of the night to save the survivors, the unusual variety of cargo including state-of-the-art tramcars and ornate crockery, and their role in Belgium's then-growing industrial links with Egypt, all form part of her story.

Identifying the SS *Belgique* has not just been about putting a name to a slowly decaying steel steamship in a far-flung corner of the English Channel. As ever, the best part has been the great sense of connection found in researching and diving a unique shipwreck, and being able to share the experience with a group of friends old and new.

The future

We hope that the successful completion of this project might encourage further interest in expeditions in the English Channel. There is still much to explore, even for those of us who have been doing this for some time. We look forward with excitement to more opportunities for adventure on the high seas!

In the meantime, thanks to everybody who played a part in piecing together the story behind the SS *Belgique*, her crew, and her cargo, particularly to Ian Taylor of SkinDeeper who first located and dived the wreck, as well as to Al and Freda Wright of *Sea Leopard* and to Ed Gollop of *SkinDeep* who took us safely there and back.■

Leo Fielding

Leo is a GUE diver based in London who has been diving actively for over 15 years. From the dark corners of Welsh mines to the expanse of Hurd's Deep, he is an avid wreck, mine, and cave diver. He is passionate about organizing expeditions to locate and identify wrecks in the more remote parts of the English Channel. Ever since watching the classic diving film Le Grand Bleu as a teenager, he has been motivated both by the pursuit of adventure with good friends and the importance of helping to build a safer diving community.

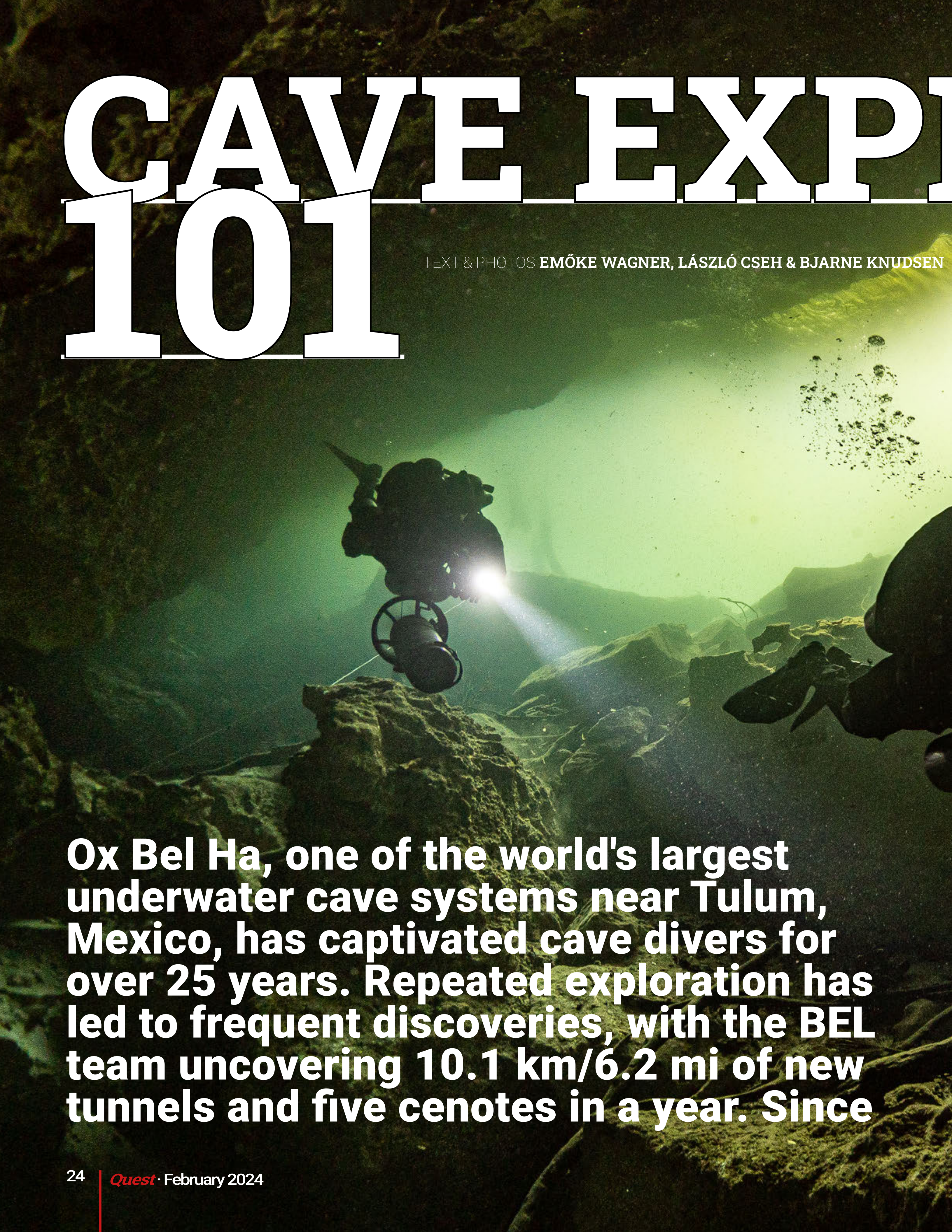
The team hit the water on the first day of diving.

FACT FILE // SS *BELGIQUE*

DIVE TEAM	Leo Fielding, Richard Walker, Guy Trees, Andy Colderwood, Tom Aucott, Duncan Simpson, Toni Norton, Stephen Elves, John Kendall, Rachael Kendall, Joe Colls-Burnett, Joe Tidball, Steffen Scholz, Neil Powell, Liam Colleran, Jos Greenhalgh, Greg Marshall, and Luke Sibley.
SUPPORT DIVERS	Aithne Atkinson and Jacob Broughton-Venner.
HISTORIANS	Mr Roland and Philippe Dussart-Desart, and Mr Yves-Laurent Hansart.
SKIPPERS	Ian Taylor of *SkinDeeper*, Al Wright of *Sea Leopard*, and Ed Gollop of *SkinDeep*.
CREW	Freda Wright, Alexandra Eyles-Owen and Jacqui Colderwood.

CAVE EXP
101

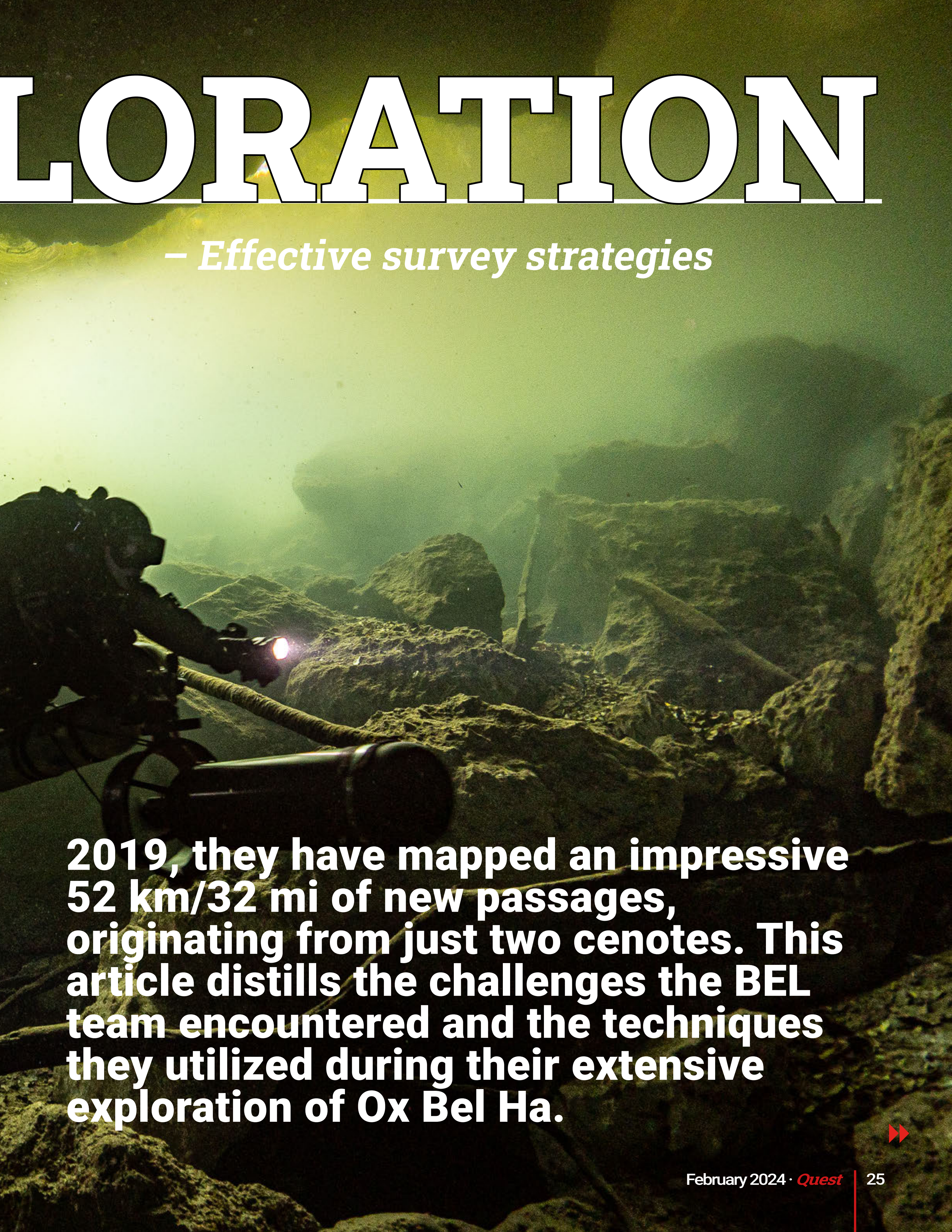
TEXT & PHOTOS **EMŐKE WAGNER, LÁSZLÓ CSEH & BJARNE KNUDSEN**



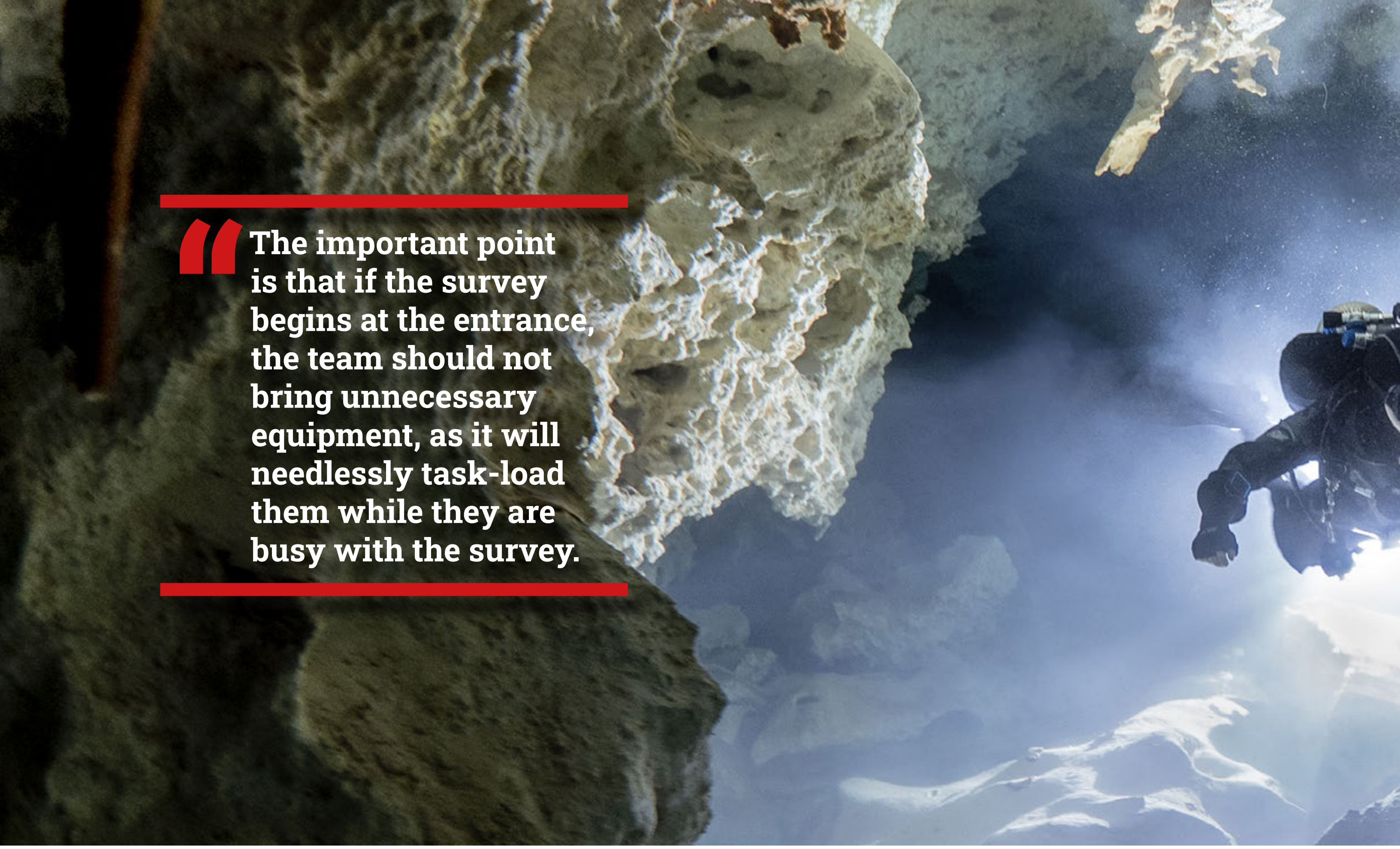
Ox Bel Ha, one of the world's largest underwater cave systems near Tulum, Mexico, has captivated cave divers for over 25 years. Repeated exploration has led to frequent discoveries, with the BEL team uncovering 10.1 km/6.2 mi of new tunnels and five cenotes in a year. Since

LORATION

– *Effective survey strategies*



2019, they have mapped an impressive 52 km/32 mi of new passages, originating from just two cenotes. This article distills the challenges the BEL team encountered and the techniques they utilized during their extensive exploration of Ox Bel Ha.



> The important point is that if the survey begins at the entrance, the team should not bring unnecessary equipment, as it will needlessly task-load them while they are busy with the survey.

The best starting point for any motivated dive team is to pick a cave system they would like to explore and gather as much information about the cave as possible. Previous explorers, divers, and communities are a good source of information about the features and conditions in the cave. Since many of the public caves known today (not just in Mexico, but worldwide as well) are already quite well explored and surveyed, it should be easy to find at least a stick map overview of the area, either online or for purchase. The digital versions are also handy, because even in low resolution, they offer the user at least a general idea of the directions in which the cave is extending. Plus, a satellite image layered over existing lines provides better land surface visibility.

So, even before the first dive starts, the new explorers can establish a solid starting point by talking to other divers and looking at maps. Talking to the landowner of the cenote selected for the project is also critical. Normally, the cenote is already open to the public, which makes the daily access easy, even though the explorers will need to deal with potential short opening hours and regular fees. Alternatively, the cenote may not be open to the public. In this case, it might be difficult to locate the landowner. But once that has been accomplished and an agreement has been made, the divers can probably stay in the water longer than they could at public places, and they will not have the burden of entrance fees.

In either case, talking to the local landowners is necessary because the team will be diving there regularly. Building a good relationship with them facilitates a welcoming experience. Showing them maps is often not so impressive, but pictures or videos from inside the cave give them more incentive to allow you to dive there. Once the nessecary trust—sometimes perhaps even friendship—has been established, as they see you more regularly, the owners will be receptive to your longer stay, might share information with you, and they will often even support the team by providing additional conveniences, such as ladders, platforms, and steps for the divers.

"Quintana Roo's extensive cave systems, both known and unknown, offer great potential for discovering new, unseen sections by focusing on larger, unexplored areas."

The cave

Once the initial preparation and information gathering is over, it is finally time to dive the cave. Since the team is about to work in a cave that has been explored before, they should focus on resurveying all existing lines they find. Resurvey can be conducted by hand with compass and notes. This works well in caves with overall good conditions, but it is slow. Using automated devices works well in small caves with low visibility and is a faster method of surveying, but the team still needs to take notes.

Usually, teams don't find anything new on the first of many dives. The expectation of how quickly new cave sections can be found depends on a lot of things. If the team has no previous data of the system, and the cave is complex, they will need a number of dives just to figure out all the important lines close to the starting point. In order to tell which lines are important, a map, if available, is the best answer. Memorizing it, in combination with using compasses efficiently underwater, works best. If the cave starts to head in a direction not relevant to the project, it is better to switch to another section of the cave. An experienced dive team might find new, undiscovered areas faster than an inexperienced one, since they can predict what will most likely happen on a certain line.

Also, if the team possesses previous survey data from the cave that identifies a new point of interest for exploration further in the overhead, this can complicate the project. In order to reach the point of survey work, the team might have to swim a great distance, which requires more gear and breathing gas. These challenges will be discussed later.

The important point is that if the survey begins at the entrance, the team should not bring unnecessary equipment, as it will needlessly task-load them while they are busy with the survey. Also, smaller areas can be reached early without divers being overloaded with equipment that could damage the cave.

Teams of two

It is generally best to dive in two-person teams: There is less redundancy, but often exploration conditions are challenging, so two divers can more easily work and stay together. Thinking about the process of the survey, a third team member would not have anything to do anyway. In a team of two, the last diver should take measurements of the line, and the first diver should scout the surroundings while having the best visibility. The lead diver has the important role of identifying leads, locating navigational points, fixing the line, and often taking notes for better task distribution within the team. A common mistake during survey dives, even with experienced divers, is that both members are too focused on their own individual tasks. At this high level of cave diving, a bit of independence is to be expected from the divers, but all procedures used in GUE are team-oriented; nothing functions without both team members. For this reason, the same team rules apply: slow down at challenging parts of the cave and get even closer to each other. Even if the cave has good conditions and is big, try to be in contact with each other at every station.

The moment enough survey data of old existing lines is gathered, it is time to figure out where potentially untouched areas of the cave could be. Unfortunately, many divers don't reach this point since they are overwhelmed by the amount of resurvey they need to do first. Still, it is worth investing a significant amount of time into surveying. Even if teams don't find anything new, they'll still see parts of the cave that have been seen by only a few people; and, our experience shows that for every kilometer of old line resurveyed, another kilometer of new tunnel was found. A 1:1 ratio between old and new lines is not bad at all!

Quintana Roo has amazing amounts of cave, both discovered and undiscovered, which is part of the reason this has been possible, but most places will still have at least some undiscovered caves to find. The potential for finding the most amount of new cave lies in focusing efforts on these massive systems, as they are more likely to hide corners which haven't been seen before, and they are longer.

Good judgment

Let's assume a very pessimistic statistic: all known caves hide only 1% of undiscovered tunnels compared to their original size. When working in a cave system that is only 3 km/1.8 mi long, there are hidden corners as well, but they might only produce 30 m/100 ft of new cave. If a team surveys in a huge cave system with 400 km/250 mi of tunnels, finding something new might immediately mean a new 4 km/2.5 mi section. Looking for potential leads can be challenging for the first diver in the team, especially in caves where the mainline already exists. However, the team should focus on empty areas of the map and try to read the way of the water. Caves are technically underground rivers, so there will probably be new cave parallel with the flow. And divers must be very thorough when checking the walls of the tunnel. Here, it is important that the lead diver is thorough and attentive.

> **"Looking for potential leads can be challenging for the first diver in the team, especially in caves where the mainline already exists.**

Instead of just waiting for the surveyor to swim up to them, the lead diver needs to check both sides of the wall between two stations. Often one side is enough—the one that looks toward an empty area in the survey. Here, the explorers need to look under and over ledges, for holes in the wall, and between collapsed rocks. Once any of these have been identified, it is still a bit difficult to rely on the flow since they are still very close to the mainline, and the flow they feel might just be the flow from the main tunnel.

The lead diver must use good judgment on how far to lay line into the new lead. If the cave is dark behind some rubble, then they can go with confidence, but sometimes a clear tunnel will not be visible. In this case, as long as the divers fit, they should try moving ahead carefully, employing good line work and sharp corners if needed. Soon bad visibility will follow, and the team members need to make decisions. If the cave does not open, they must choose a place with some visibility and space where they can communicate and turn around. However, if the

In advanced cave diving, independence and team-focused procedures are vital; close teamwork is essential, particularly in challenging areas.

team found a lead that continues, it is time to lay the line and survey it. For this part of the dive, the team roles have not really changed: the second diver in the team will survey the new line, and the lead diver will install the new line and look for the best way onward.

During exploration of new areas, the last diver will need to deal with notes as well—they may be a bit delayed compared to the lead diver. Good tension and a straight heading on the new line is important to properly survey it. This could be problematic in big caves, as the distance between stations can be longer, and the team members are further apart. It is often debated between explorers as to what is more difficult: exploring a large or a small cave. We were lucky enough to experience both, and they both have unique challenges. In a big cave, it is easier to have good conditions for longer, but it is harder to decide which direction to take in a massive black room. In small caves, the way forward is more obvious, but the conditions in the new tunnel are likely more complex with silt and restrictions.

Small or large scooter

While working in long and shallow Mexican cave systems, divers need to prepare to deal with complications—like long bottom times, long penetration distances, and restrictions. Even though many of the Mexican systems have multiple entrances, not all of them can necessarly be used as entry/exit points, as they can be in swampy areas and/or far into the jungle. With the dive equipment available today, committing to longer underwater travel is often a good choice. DPVs of different brands and sizes can be of immense help to the explorers. There are different considerations when choosing DPVs for a project. Choosing a bigger scooter with a lot of battery power often sounds like the best idea, but there are a couple of problems with this approach. There might be a temptation to take fewer DPVs on a specific dive since the divers trust the larger, stronger, more reliable ones that they have. The second potential problem is that the bigger DPVs are harder to navigate in small caves and restrictions. Multiple smaller

> **Driving DPVs fast increases battery power consumption significantly while maybe only saving five minutes over a 3 km/1.8 mi distance. Since Mexican caves are shallow, saving five minutes makes almost no difference in gas consumption.**

Complex caves often bring unforeseen challenges to curious explorers. Hidden corners in caves are most often found behind restrictions.

DPVs can be carried by the diver in small or restricted parts of the overhead. The cave will not stay big forever, especially in today's exploration where many of the main passages are known, so it makes sense to use equipment small enough to push through restrictions. The drawback with smaller models is that their battery capacity is limited. For most divers, the range of DPVs will not be limiting, but the long distances traveled encourages divers to build their own lithium batteries for the DPVs. These special DPVs require a lot of testing, but the challenging dives conducted with them (often more than 6 km/3.7 mi of penetration) allowed a lot of learning from the process.

You might feel it is a good idea to drive the DPVs fast. You will use less gas, and you will arrive at your desired exploration area sooner. In reality, the higher speeds are deceiving. Driving DPVs fast increases battery power consumption significantly while maybe only saving five minutes over a 3 km/1.8 mi distance. Since Mexican caves are shallow, saving five minutes makes almost no difference in gas consumption. Going slow also means less stress on the DPV, other equipment, and on the body and mind of the diver. Even going relatively slow, enough motor power to carry a fully geared-up diver with multiple stages and extra DPVs is needed.

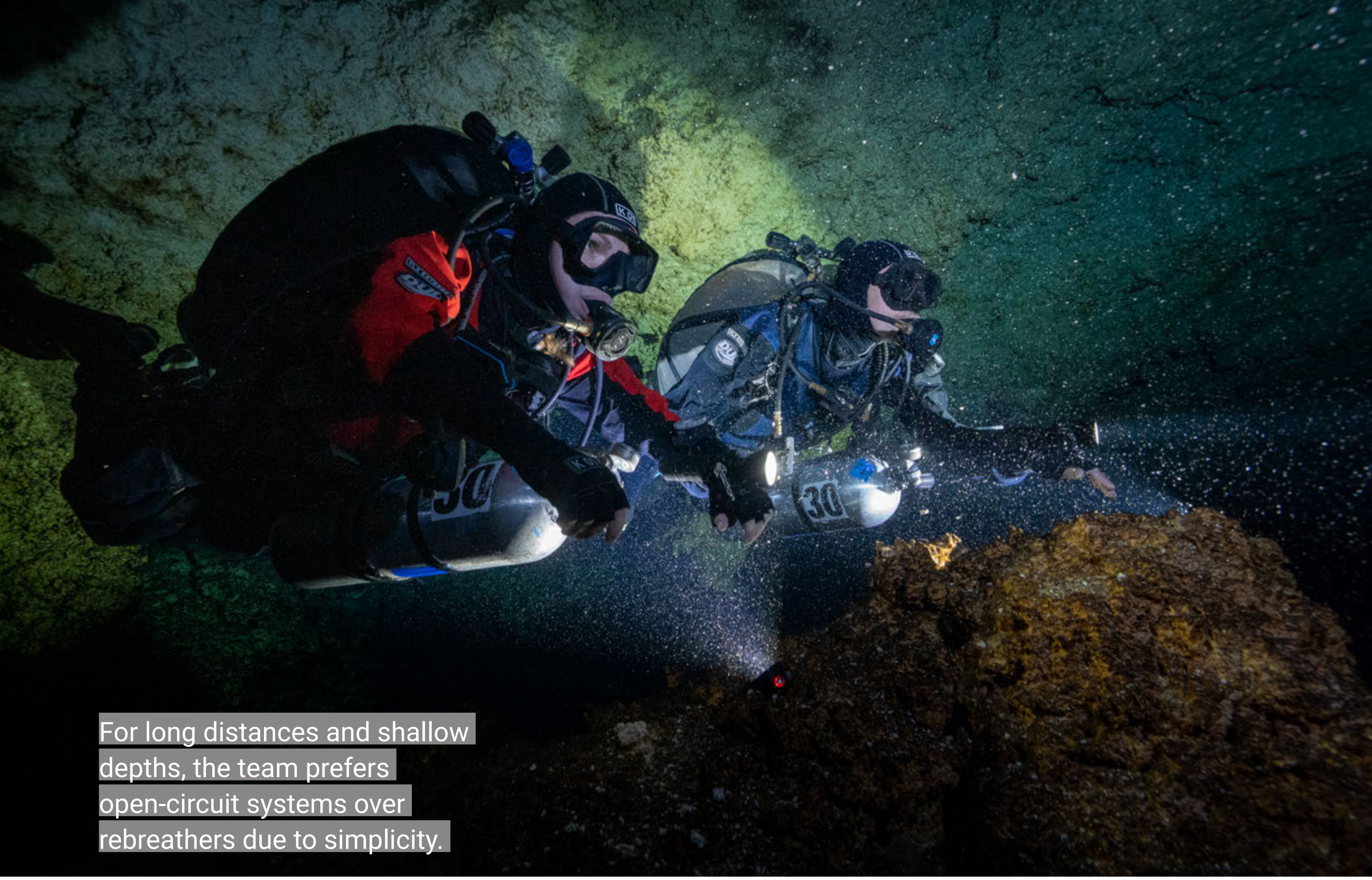
In the end, we decided to carry four DPVs in a team of two divers for the longer distance dives. This way both divers have two each, and they can rotate between them to maximize the penetration. In most of the cases, the dives would have been safely doable with three DPVs for the team, but we still decided we would stick with four since one diver would have to tow anyway. Also, if one DPV failed, we could still do the dive we had planned, since the fourth DPV was not strictly needed. Of course, it is not that simple since losing one DPV out of four would make your dive a three-DPV dive, so points of rotation would change as well. For this reason, a team must always come up with multiple plans for the dive. If planned properly, they might not need to end the dive after a failure.

Another important aspect of using DPVs on a long distance cave exploration project is the communication between divers while on the trigger. Long dives can be tiring, and constant focus is needed, especially toward the end of the exit. Team separations and navigational mistakes are more likely to happen while scootering, since they are faster. For this reason, it is a good idea to follow some simple rules. The lead diver sets the speed, and the second diver will communicate actively if it is too slow or too fast. In large caves or while traveling through cenotes, team members can be staggered or side by side for more team integrity, and they should always use clear passive communication. If the light of a teammate disappears while scootering, the risk of moving further before realizing this is less than while swimming.

Gas

Breathing gases are another important consideration for exploration. Today's diving trends are moving toward using rebreathers for any kind of exploration dives, even if the dive site is relatively shallow. There are many good arguments in favor of rebreathers, even on shallow projects like the ones in Mexico—long bottom times, easier safety bottle placement, and, in case of difficulties, practically limitless gas supply. A rebreather also minimizes the amount of percolation from the ceiling due to less escaping gas. However, diving a rebreather is not a simple task. It requires a lot more care than open-circuit and has more failure points. At shallow depths, the oxygen percentage in the breathing loop of a rebreather is less stable than at deeper depths, so special care is needed in caves such as Ox Bel Ha. The cost of scrubber material is also a consideration.

In contrast, traditional open-circuit equipment for cave exploration is more work to carry through the cave, but it is based on a very simple and reliable design. Even at long distances, the shallow depths mean that both open-circuit and rebreathers could be sensible solutions. In the end, we chose open-circuit because of its simplicity. Even with a relatively small sidemount rebreather, some additional space is taken up, as compared to open-circuit. We often appreciate the small size of just sidemount bottles for pushing small leads to check for the possibility of the cave getting bigger.

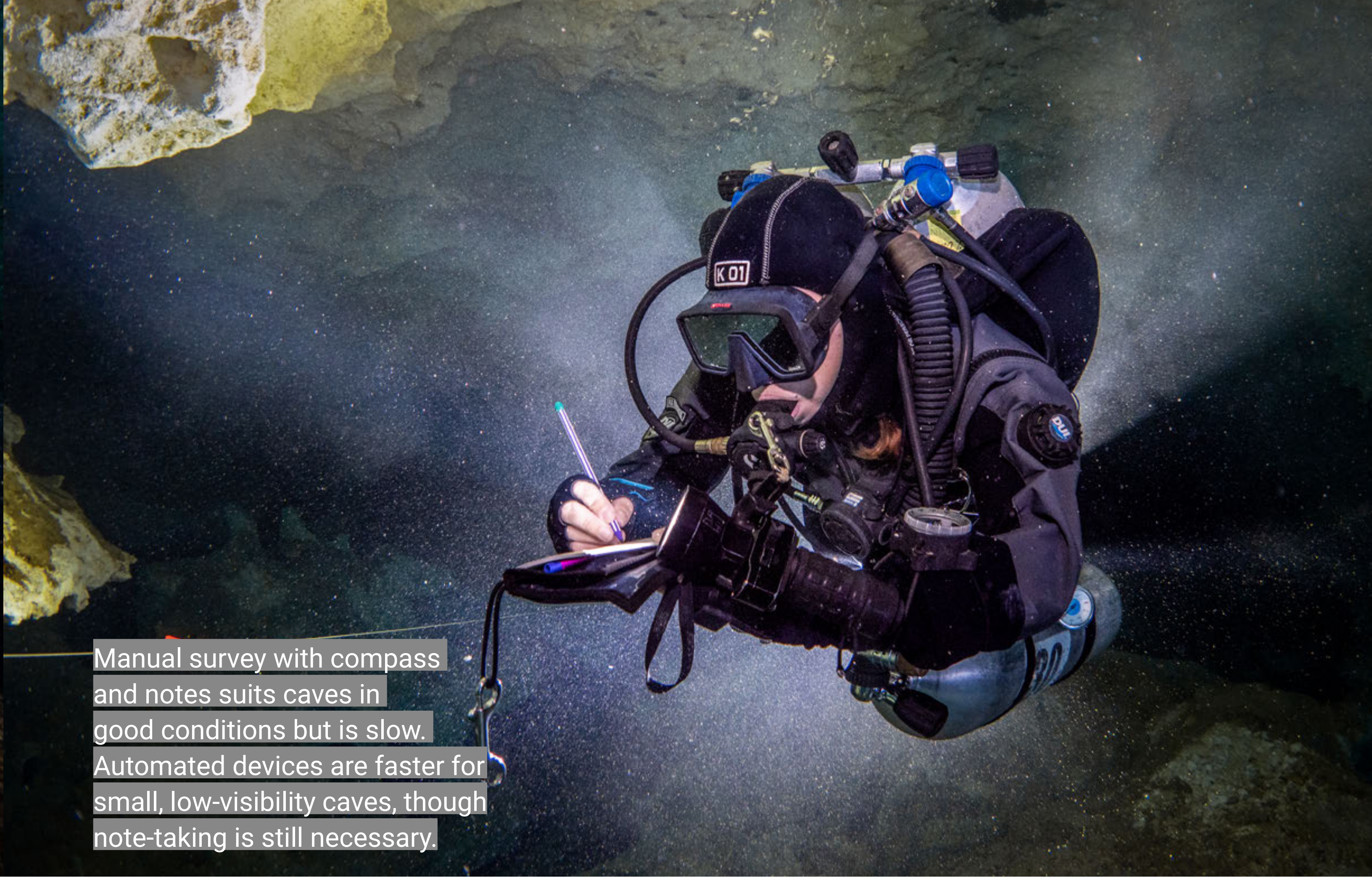

For long distances and shallow depths, the team prefers open-circuit systems over rebreathers due to simplicity.

Although the bottom times can quickly increase with experience, it is still very difficult to run into any significant decompression in most caves in Quintana Roo. Even if it happens, it means nothing more than a few minutes of oxygen at the cave entrance coming from a shallow depth, and most likely using nitrox 32. However, what surprised us recently is that reaching CNS limits on long shallow cave dives is quite possible. If a diver looked at a dive with an average depth of 13 m/42 ft for eight hours using nitrox 32, they would need to do a few minutes on O_2 before ascending. In our case, we scooter for quite some time at very shallow depth out from the cave, so by the time we arrive at the entrance there is not much decompression left to do.

On the other hand, arriving at the O_2 a diver can have a CNS% above 90. Switching to O_2 at this point will quickly put them above 100% which, theoretically, increases chances of oxygen toxicity. So, the divers are faced with a choice: do they choose the next lower oxygen content bottom gas to stay further away from CNS% limits (with longer decompression) or do they keep the bottom gas and do deco on O_2 or on nitrox 32? Of course, it is also important to note that divers can always use gas breaks on O_2, but not while on the bottom. In reality, all options are probably fine, since even these depths and times are far from extreme, but it shows that some diving limits can be reached, even in shallow caves.

Cave features

Now that you are far in the cave and have all the gas you need to explore, there shouldn't be any challenges left to overcome, right? Well, complex caves can always present unexpected difficulties to curious explorers. As discussed before, the most likely places to find hidden corners of a cave can be behind restrictions. If you already have long tunnels behind you and the depth has increased, you need to approach small sections of the cave with more caution. It is difficult to decide what is worse—not finding anything, or finding something that you know is there but is buried behind a silty, narrow restric-



Manual survey with compass and notes suits caves in good conditions but is slow. Automated devices are faster for small, low-visibility caves, though note-taking is still necessary.

tion. At first, getting rid of all unnecessary gear and just swimming through a major restriction with the reel is a good idea. This gives the team a good first impression of whether the cave opens after the restriction, but you are not so task loaded, as you only have your main gas supply with you.

If the cave is not opening up, you can tie down your line there and you will never have to come back again. If the cave opens, it creates more complications since you need to come back to the same place if you would like to explore the rest. When this happens, the best approach is often to limit the gear carried and try checking both sides of the restriction for a bypass tunnel nearby, which should be bigger and might allow you to avoid navigating the restrictions each time you are there. Restrictions are always complex: you may not have visibility, you can get entangled in the line, ultimately you might have to carry gear through it, and it is hard to communicate. If a bypass tunnel does not exist and the team would still like to explore the rest of the cave, you will need to prepare to deal with the challenging small section. Cave exploration is a sport: you need to build up the difficulty, and you need to practice the learned steps to be more efficient each time. First, you would need to try carrying one additional bottle through. Try both sides of the restriction (entry and exit) since your profile with more gear might only fit one way. Ideally, avoid unclipping anything at long ranges or greater depths since it will cost the team time. If your initial attempt was successful, you can try the same restriction with more gear. Finally, the biggest challenge in a restriction with gear could be that you have no more free hands left. Obviously one hand is needed for the line, the other lifts the main DPV in front, but often you would need a third hand to lift stages up for better position. Not to mention your legs could be busy, not just with swimming through this section, but also controlling a backup DPV.

Planning

Any level of cave diving is a challenging activity, so even the simplest dives require a solid plan, and exploration dives even more so. Once the first success for the team happens, you are looking at multiple dives in a certain area. It is preferred that you focus the team's attention fully on one area only until it is done. The more you dive the same place and travel the same route, your dives might be more boring, but you will deal with the processes of the dive much better: you recognize navigation more quickly, you deal with equipment faster, and so on. This adds to the overall efficiency of the dive, and the more efficient you are with the travel, the more time will be left for exploration. Also, trying to keep just one cave map in your head is much easier than switching from area to area. It is important to understand that being more efficient and practicing does not mean to rush! The problem is that simply trying to be faster will create more difficulties. For this reason, plan ample reserves, try to be clean with your procedures, and speed will come naturally.

Try not to look at surveying as the necessary evil of exploration. It is true that this part of your project is less exciting than finding new tunnels, but every time you plan an exploration dive your accurate survey will be a great asset. From the map, you will quickly know by heart where to drop stages, where to rotate DPVs, and in which direction to push the cave.■

"Try not to look at surveying as the necessary evil of exploration. It is true that this part of your project is less exciting than finding new tunnels, but every time you plan an exploration dive your accurate survey will be a great asset.

Cave explorers can greatly benefit from DPVs. When selecting DPVs for a project, there are several factors to take into account.

Bjarne Knudsen

Bjarne began diving in 1993, taking his first tech classes in 1997 and his first GUE cave and tech classes in 1999, so has been part of the GUE community since the early days. In the early 2000s, he spent several years in Florida, where he was a part of the WKPP. During this time, he also pushed Sheck Exley's end of line in the Cathedral Cave system. Bjarne is currently on a world cruise with his wife on their sailboat. For the last few years, they've been stuck in Mexico.

Emőke Wagner

Emőke Wagner is originally from Hungary and began diving at a young age. She has been an active instructor since 2014. After a couple of years spent traveling around the globe, she moved to Mexico in 2017. While living in Mexico, cave diving became her real passion, and she began exploring more of the local cave systems. Since 2016, Emőke has been working as a full-time GUE instructor and is currently teaching the cave, foundational, and recreational curriculum.

László Cseh

László Cseh is from Hungary and has always been fascinated with the underwater world. He became a recreational diving instructor in 2012 and began teaching and traveling. After becoming a GUE instructor in 2016, he moved to Mexico to look for new diving challenges. Local cave exploration possibilities helped him achieve his GUE Cave instructor certification.

VANESSA MIGNON

Dances with whales

Vanessa is an award-winning wildlife photographer and trip leader based in Australia. She has been organizing and guiding small group trips all over the world for close to 15 years. Throughout her career, she has been published in various media outlets and awarded in many international competitions.

She is known for her genuine love for animals and interest in marine megafauna. She is especially passionate about whales. Everything about them fascinates her: their level of consciousness, their charisma and, of course, their size. Vanessa works as a whale guide for several species and enjoys sharing that experience with people. In her words, "Swimming with whales is addictive and makes you feel so alive."

One of Vanessa's main focus areas is conservation, and she hopes her photography and experience sharing can inspire others, increase their awareness of how diverse and beautiful nature is, and remind them how essential it is to protect it.

She regularly donates pictures to support wildlife organizations in their conservation work, including but not limited to: International Fund for Animal Welfare, Humane Society International, Australian Marine Conservation Society, and Whale Dolphin Conservation. She was named the 2015 IFAW Animal Action Award – Marine Photographer of the Year in recognition of her work and efforts to promote conservation and raise awareness.

In her downtime, she also volunteers at a wildlife sanctuary, helping with the care and rehabilitation of Australian native animals.

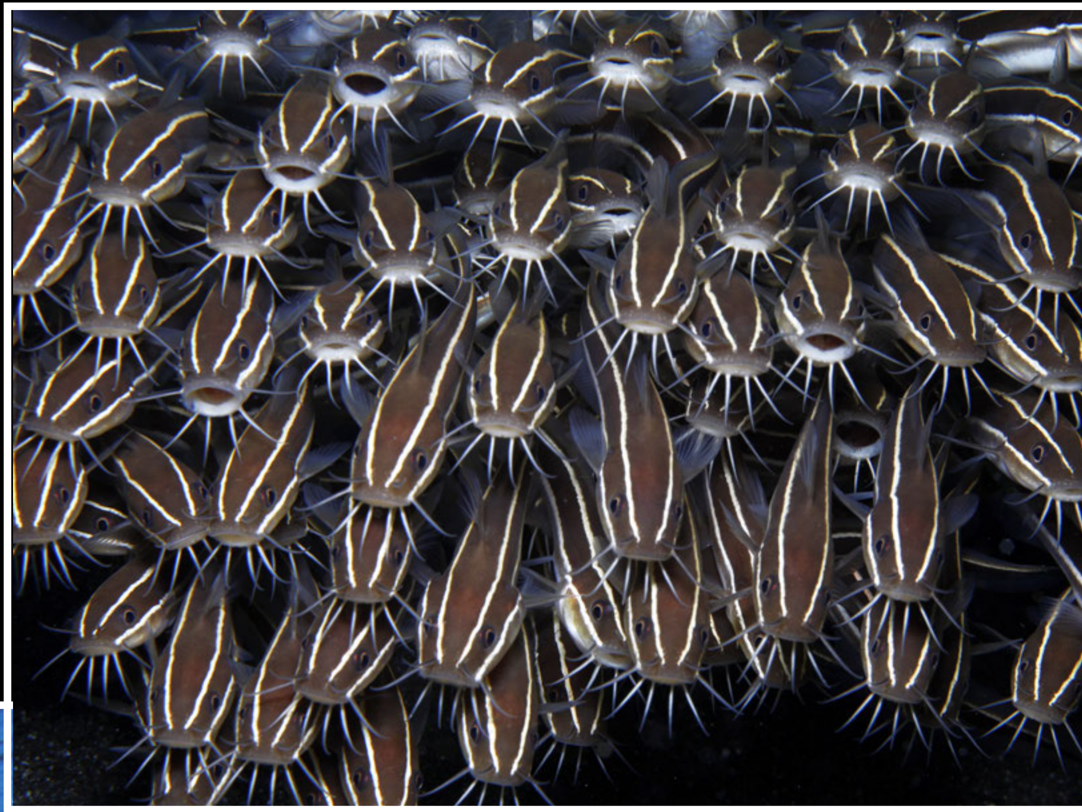
www.vanessamignon.com

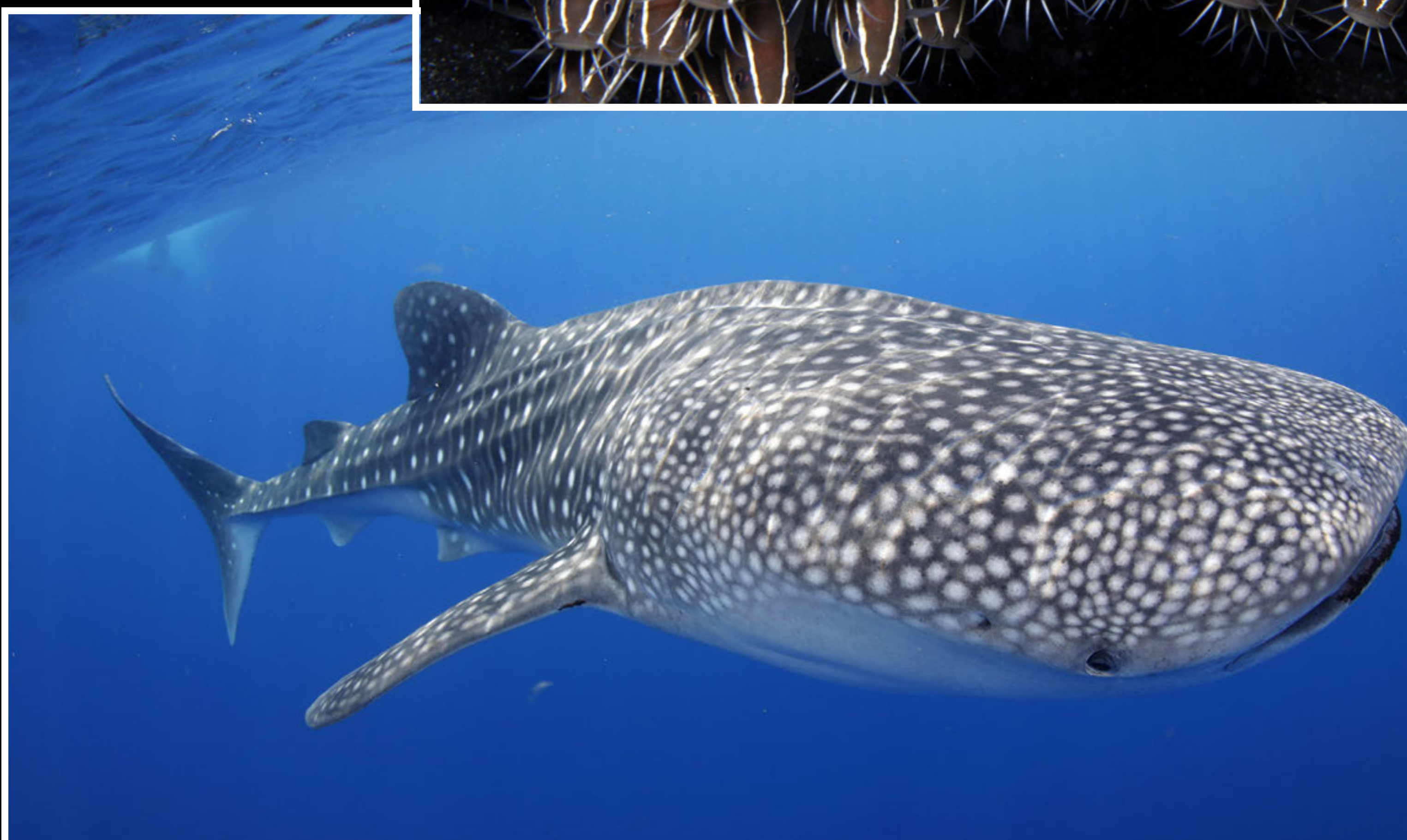
TITLE Mother and calf
LOCATION Kingdom of Tonga
CAMERA Canon 5D mark IV
HOUSING Nauticam
LENS Canon 16-35mm f4
EXPOSURE 1/400, f4, ISO 200
FLASH Natural light
COMMENTS Humpback whales gather in Tonga every year to breed. It is possible to swim with them under strict regulations.

TITLE Giant of the deep
LOCATION Indian Ocean
CAMERA Canon 5D mark IV
HOUSING Nauticam
LENS Canon fisheye 8-15mm
EXPOSURE 1/320, f4, ISO 200

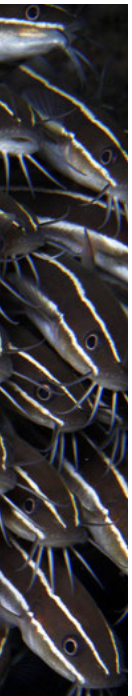
FLASH Natural light
COMMENTS Sperm whales are resting vertically under the surface. Picture taken under all required permits and authorizations. Sperm whales are listed as vulnerable on the IUCN red list.

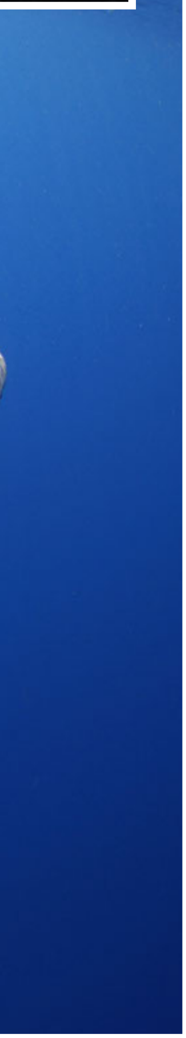
TITLE Togetherness
LOCATION Indonesia
CAMERA Canon 5D mark IV
HOUSING Nauticam
LENS Canon 50 mm macro lens f2.5
EXPOSURE 1/200, f20, ISO200
FLASH Inon strobes
COMMENTS Catfish are very fun to watch as they move in tight groups. I had to be patient to get a shot from the front.





TITLE Giant encounter
LOCATION Australia
CAMERA Canon 5D mark IV
HOUSING Nauticam
LENS Canon fisheye 8-15mm
EXPOSURE 1/250, f5, ISO 400
FLASH Natural light
COMMENTS Every year, whale sharks gather in Christmas Island, Australia, hoping to feed on the red crab larvae. Whale sharks are listed as endangered on the IUCN red list.





TITLE Puppy of the sea
LOCATION Australia
CAMERA Canon 5D mark IV
HOUSING Nauticam
LENS Canon fisheye 8-15mm
EXPOSURE 1/320, f14, ISO400
FLASH Natural light
COMMENTS Australian sea lions are endemic to Australia and listed as endangered on the IUCN red list.

TITLE Port Jackson in Kelp
LOCATION Australia
CAMERA Canon 5D mark IV
HOUSING Nauticam
LENS Canon fisheye 8-15mm
EXPOSURE 1/200, f5, ISO200
FLASH Natural light
COMMENTS Every winter, it is possible to observe the Port Jackson shark breeding aggregations in various locations on the Australian East coast.

TITLE playful sea lions
LOCATION Mexico
CAMERA Canon 5D mark IV
HOUSING Nauticam
LENS Canon fisheye 8-15mm
EXPOSURE 1/500, f4, ISO320
FLASH Natural light
COMMENTS We visited a colony of sea lions in Baja California, Mexico. They were quite curious about us.

TITLE Dwarf minke whale
LOCATION Australia
CAMERA Canon 5D mark IV
HOUSING Nauticam
LENS canon fisheye 8-15 mm
EXPOSURE 1/320, f4.5, ISO 200
FLASH Natural light
COMMENTS Every year, dwarf minke whales gather in the Great Barrier Reef for a few weeks. It's the only known predictable aggregation of this type in the world.

TECHNIC DIVER L

– THE FINAL PART OF GUE'S TECH TRILOGY

Divers conducted a beta test of the revamped GUE Technical Diver Level 3 course in April 2023. This new course, reborn from its initial inception, pushes the frontiers of diving exploration. Tailored for the experienced diver, it integrates complex skills and deep technical dives, and in this class it was under the guidance of GUE Tech 3 Instructors Graham Blackmore and Mario Arena. Far from a mere depth-chasing adventure, Tech 3 prepares divers for significant exploration—from historic wrecks to archaeological wonders. Join GUE Instructor Kees Beemster LEVERENZ in Greece, where the legendary *Britannic* wreck awaits, embodying the course's essence of meaningful underwater exploration.

CAL
LEVEL 3

TEXT **KEES BEEMSTER LEVERENZ**
PHOTOS **KEES BEEMSTER LEVERENZ & STEFFEN SCHOLZ**

PHOTO **STEFFEN SCHOLZ**

The SS *Monrosa* is largely intact and overgrown with colorful sponges. It made for a delightful last course dive.

> **We were in Greece for a reason—not to reach the training depth in warm and clear water, but to dive at a site worth all the effort: the magnificent wreck of *Britannic*.**

In late April, 2023, I found myself at the Scubalife dive center in Palaia Fokaia, Greece. Several friends and I had set out to dive one of the world's most famous and challenging shipwrecks: HMHS *Britannic*, the sister ship of the even more famous RMS *Titanic*. The 269 m/882 ft long wreck of the passenger liner-turned-hospital ship *Britannic* lies on her side in 115 m/380 ft of water off the Greek island of Kea.

I arrived a day later than I had originally planned, after having been waylaid for 18 hours in Istanbul on my flight in. As I traveled, I was checking the weather forecast and saw that it grew worse as the date of the dive approached. The original plan was to dive several progressively deeper wrecks, building up to a final dive on *Britannic*. Now, however, it wasn't clear if this would be possible.

While the dive shop was abuzz with activity and preparations, the small fishing town of Palaia Fokaia was quiet. It was not yet the tourist season and, aside from our busyness, the waterfront restaurants and little shops that dotted the town laid mostly deserted.

As the team prepared our equipment for an evening checkout dive, our final teammate Steffen Scholz arrived from Germany. He walked into the dive center with an extra-large, bright yellow duffel bag in each hand. While Steffen was the last to arrive, he still got in a full day before we had planned to begin diving. He was greeted first by Nikos Vardakas, the proprietor of Scubalife, with a warm cup of coffee.

"Prepare your equipment, Steffen. We are starting the class early," Mario Arena said casually, his usual manner. *"The weather forecast is poor, so if we're going to dive* Britannic*, we'll have to do it tomorrow. We should have a check dive tonight in the harbor."*

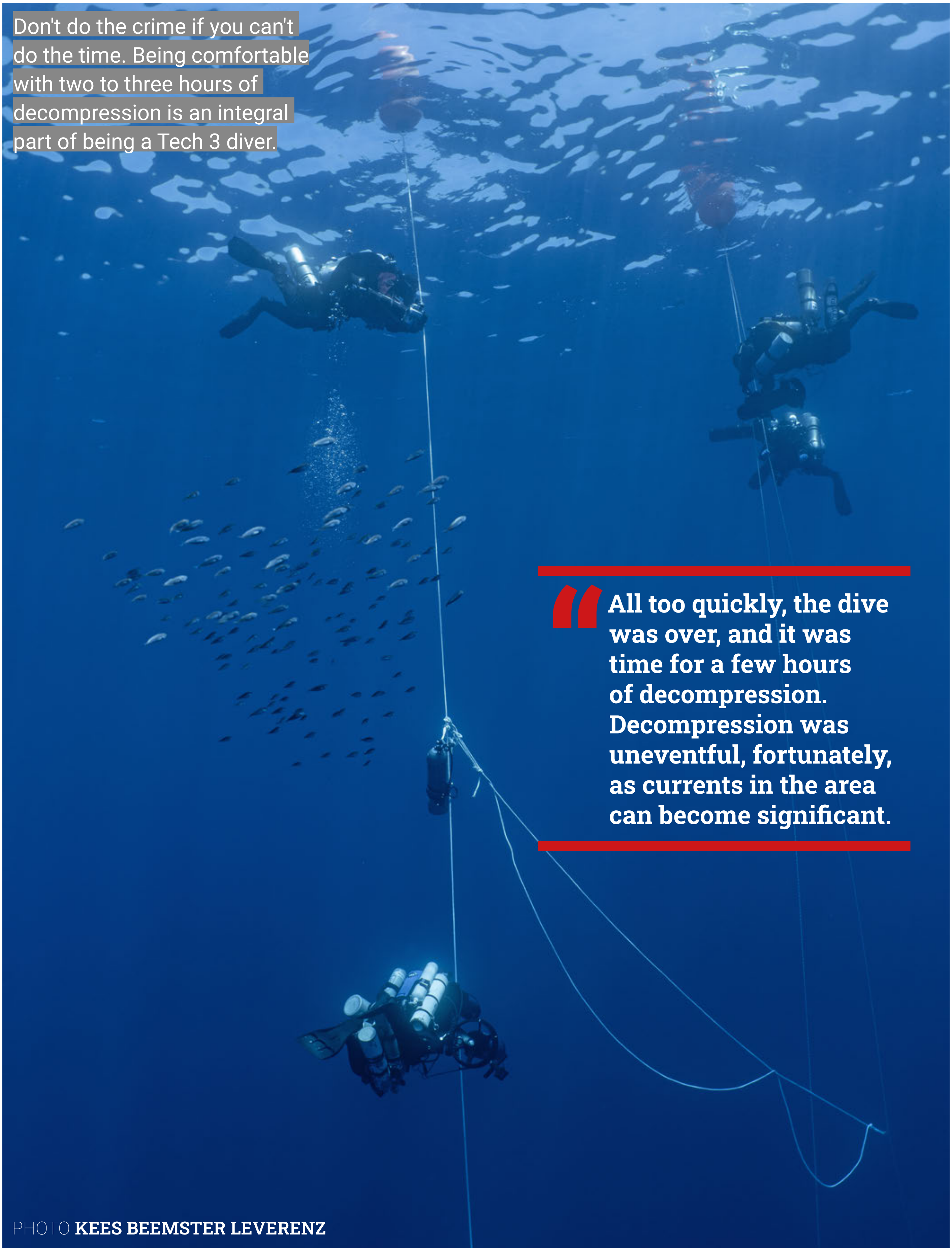
It was official. The weather had other plans, and now, so did we.

Steffen's eyes widened slightly, he perked up, and quickly joined me, along with the other students, in unpacking, assembling, and checking gear. Thus began the first GUE Technical Diver Level 3 course taught in many years.

Technical Diver Level 3

In any normal situation, diving a 115 m/380 ft deep wreck on the first official day of a class would be odd, to say the least. Fortunately for everyone involved, the students in this course were well-qualified, having been invited specifically because we had already been diving and exploring together for years. This would not be anyone's deepest dive nor our first dive together, but we all still had lots to learn.

The intention of this beta class, like other GUE beta classes, was to run an experimental course with experienced students. This is a long-standing approach to testing new courses and allows the instructors to mold the format and content of the class while getting feedback from students that are already diving at a similar level. A beta course can be thought of as a dress rehearsal conducted before a proper performance.



Don't do the crime if you can't do the time. Being comfortable with two to three hours of decompression is an integral part of being a Tech 3 diver.

> All too quickly, the dive was over, and it was time for a few hours of decompression. Decompression was uneventful, fortunately, as currents in the area can become significant.

PHOTO **KEES BEEMSTER LEVERENZ**

Validating the decompression schedules with DecoPlanner.

PHOTO **KEES BEEMSTER LEVERENZ**

Although a GUE Technical Diver Level 3 ("Tech 3") course was offered many years ago, the class never really took flight the way that GUE's Tech 1 and 2 programs have. The new Tech 3 course is intended to expand the limit to which GUE divers are officially trained and to combine the skills learned in other courses and through experience. Prerequisites for divers applying to take the Tech 3 class are extensive and include the requirement to be an experienced GUE rebreather diver, to have formal GUE training on a diver propulsion vehicle (DPV), and more. See page 49 for more information on the prerequisites.

As it currently stands, the Tech 3 course offers experienced technical diving students access to some of GUE's most experienced technical instructors and an opportunity to both practice and demonstrate mastery of technical diving techniques. The course allows students to pick the minds of active explorers for days on end and to learn from their experience and mistakes while also learning firsthand in the water during a series of deep technical dives.

Lesson number one of the course is that the Tech 3 program is not intended to prepare anyone to dive to significant depth in a quarry, or on a wall, or just to see a larger than usual number on their dive computer. Tech 3 is intended to prepare a diver to explore significant wrecks, to document sites of archaeological interest, or to see things that are otherwise uncharted or unexplored.

We were in Greece for a reason—not to reach the training depth in warm and clear water, but to dive at a site worth all the effort: the magnificent wreck of *Britannic*.

Britannic

The *Britannic* was the third and final Olympic-class ship produced by the British White Star Line. She was preceded by two other nearly identical ocean liners: the RMS *Olympic* and the infamous RMS *Titanic*.

The *Titanic* sank in 1912, just two years before *Britannic* was launched. The ocean liner *Titanic* famously struck an iceberg during her first trans-Atlantic crossing as an ocean liner carrying paying civilian customers. She sank at sea in waters far too deep to dive without a specialized submersible or remotely operated vehicle (ROV).

The *Britannic*, on the other hand, was dealt a very different hand. The outbreak of World War I saw the *Britannic* drafted into military service as a hospital ship, never entering commercial service. She was launched not with the White Star Line's deep black and brilliant red, but instead painted a stark white with a slash of green, dotted with large red crosses down her hull. This signified her status as a hospital ship, on a mission of mercy, not to be targeted by anyone on any side.

However, not all weapons of war discriminate. The *Britannic* was the victim of a mine planted by German U-boat *U-73.* After striking the mine, she started to take on water. Captain Charles Alfred Bartlett steered the *Britannic* toward the island of Kea in an attempt to beach her. However, his effort was in vain. The vessel sank fast beneath the waves, submerging just 55 minutes after she was struck. Just 30 of the over 1,000 people onboard perished in her sinking, a much smaller death toll than her sister ship, *Titanic*.

Historically, diving *Britannic* has been a challenge, as the wreck was protected by a lengthy permitting process. That process has recently been changed, allowing more dives to take place on the wreck, including through our course.

The check dive

To keep on schedule, we splashed that evening in the Palaia Fokaia harbor. We used the same boat we would use for the remainder of the class, diving our full kit as is standard to ensure our equipment had survived transit in good condition. Once in the water, we made a series of ascents and descents, practiced gas switches while moving "on the trigger" using a DPV, and worked through several other skills that were both useful and allowed the course's two instructors to be sure that the team was up to the task of an early-morning visit to *Britannic*—much earlier in the course than planned.

We identified several issues in the process of the check dive. Most noticeable for me was that my drysuit was doing its best wetsuit impression; it had sprung a rather impressive leak in the left knee. While, in my imagination, the Greek Mediterranean is warm, our dive was in April, and the water was quite cool. Fortunately, Nikos (who runs Scubalife) is very nearly my size and had also just purchased a new drysuit. He took pity on me and let me take his nearly new drysuit on an adventure.

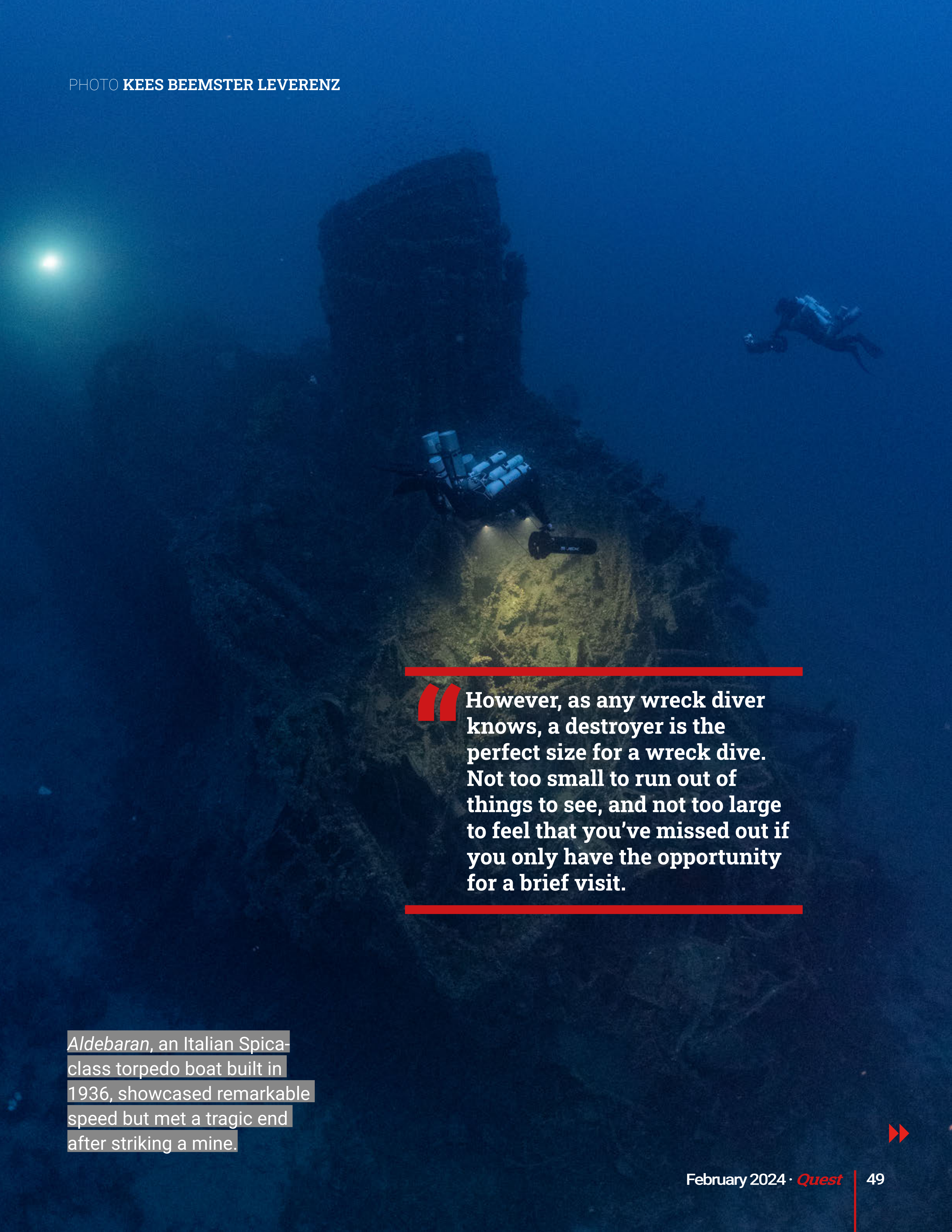
After our check dive and a short drive back to shore, we repacked our rebreathers, settled into a simple dinner, ate some ice cream, and then went to bed early. We would have to leave early if we wanted to splash on time and beat the weather.

The first dive

The logistics for a big dive are always complex. *Britannic* is no different. We loaded dozens and dozens of tanks, our rebreathers, and drysuits into Nikos's van and trailer. We walked to the harbor, dotted with small white-and-blue painted fishing boats, and Nikos beat us there. Then, we unloaded the tanks off of the van and onto the boat across a little gangway barely wide enough for one. We strapped the tanks in—every captain has a preferred method, and every method is different—and we were set for the long run out under the rising sun.

Shipping lanes have not changed much in the past hundred years. As enormous cargo and container ships passed in the same shipping lanes that *Britannic* once navigated, we fiddled with gear, discussed the dive, and drank coffee. Graham, who arrived early, pointed out an ancient temple perched atop a hill on a peninsula. The temple is dedicated to Poseidon, the god of the sea and of the storms. The simple stone structure dates to 700 BC, positioned so that ships could see it on their way to or from the sea. It is a reminder that it is possible that shipping lanes have been similar for a bit more than just the past hundred years. We arrived. We geared up. We splashed.

PHOTO **KEES BEEMSTER LEVERENZ**



"However, as any wreck diver knows, a destroyer is the perfect size for a wreck dive. Not too small to run out of things to see, and not too large to feel that you've missed out if you only have the opportunity for a brief visit.

Aldebaran, an Italian Spica-class torpedo boat built in 1936, showcased remarkable speed but met a tragic end after striking a mine.

> **“Half of the divers on the team were good friends at the start of class and remained so. The other half were good friends by the end.**

It took close to 15 minutes to descend to the *Britannic* and inspect the propellers. The divers proceeded to the bow. After capturing swift photos, the team examined the hull and the scattered artifacts.

PHOTO **STEFFEN SCHOLZ**

As we descended, the familiar diffused blue light of the deep Mediterranean began to surround us. The water cooled as we got deeper, and the wreck faded into view at 75 m/250 ft. It seems near, but only because of its immense scale. We took a right and scootered toward the ship's three propellers, each around 5 m/16 ft tall. All in all, the trip to the bottom and over to the propellers took nearly 15 minutes. It became apparent that we would need to move with speed to see the bow on the same dive. After a few quick photographs, we made our way to the bow with our team and examined the smashed hull of the ship and the artifacts and equipment that had spilled off the wreck.

All too quickly, the dive was over, and it was time for a few hours of decompression. Decompression was uneventful, fortunately, as currents in the area can become significant.

We dodged the weather and made the dive. Success!

Aldebaran and *Monrosa*

As predicted, the weather turned sour and the exposed site of the *Britannic* became undiveable. Fortunately, there are numerous other very worthwhile wrecks to dive in the area. The day after *Britannic*, we found ourselves on a decidedly smaller, but similarly deep, wreck: the Italian torpedo boat *Aldebaran*. By any measure, it's a large ship, but it felt petite in comparison to *Britannic*. However, as any wreck diver knows, a destroyer is the perfect size for a wreck dive. Not too small to run out of things to see, and not too large to feel that you've missed out if you only have the opportunity for a brief visit.

Aldebaran was an Italian Spica-class torpedo boat built in December 1936. Nearly ten times longer than it was wide, the Spica-class was slim and fast, lightly armored but built for speed. *Aldebaran* could reportedly reach a top speed of 34 knots, as evidenced by the aggressive propeller design that looks very different from the broad, efficient propeller of *Britannic*. Five years after her construction, *Aldebaran* struck a mine laid by the British submarine HMS *Rorqual*. The mine obliterated the bow and quickly sank the warship. Reports vary, but between seven and 14 of her 150 crew died. *Aldebaran* now rests at 107 m/350 ft.

Our final dive of the course was on the relatively sheltered wreck of the Italian steamship SS *Monrosa*. Despite being escorted by armed destroyers, the ship was attacked and sunk by the English submarine HMS *Triumph* in 1941. Following the attack, the HMS *Triumph* slipped away without damage.

The wreck was discovered by a Greek team in 2003, lying in 85 m/280 ft of water. The SS *Monrosa* is a spectacular sight: it's largely intact and has become overgrown with colorful sponges. It made for a delightful conclusion to the course.

Final thoughts

Tech 3 is an unusual course: It formalizes instruction for experiences that divers previously worked up to through years of mentoring or experimentation. Half of the divers on the team were good friends at the start of class and remained so. The other half were good friends by the end.

While at times it felt like we were "just diving," there was one very notable exception: It was easier than usual to approach both Graham and Mario and ask how they tackled the challenges of the dives—what worked best, what was most efficient, where time could be saved, and where extra diligence was required. On a project, Graham and Mario would of course be happy to assist when time allowed, but their days would also certainly be filled leading the logistical efforts: they'd be busy making sure that tanks were filled, equipment was loaded, and boat fees were paid. However, because this was a class, and because the logistics were being handled by the Scubalife team, both instructors had free time available to answer many questions from all the divers involved and even, at times, from each other.

The experience was quite fun and incredibly valuable. Regardless of previous experience (small or large), any diver at any level can benefit from the critical eye of a more experienced instructor. Having an occasion to pick the brains of some of Mario and Graham, some of GUE's most experienced deep ocean project divers was well worth the effort—and highly recommended.■

FACT FILE // THE NEW TECH 3 CURRICULUM

Initially taught by Jarrod Jablonski and a few others in GUE's early days, Tech 3 was always envisioned as the culmination of GUE's technical trilogy. With establishing a robust rebreather program and the growing popularity of rebreathers in technical diving, the timing is ideal for offering this class, supporting GUE divers and global projects.

The Tech 3 program focuses exclusively on rebreathers, specifically the JJ-CCR and RB80, and aims to enhance the range and capabilities of GUE Level 2 rebreather divers. The program includes one day of setup, one day of skill verification, and three days of diving, reaching depths of up to 120 m/393 ft with decompression times of up to three hours. The knowledge component will be delivered through online lectures and practical discussions. The program may require up to seven days to complete depending on weather conditions.

Prospective participants must meet the following prerequisites:

- GUE CCR 2 or PSCR certification
- DPV 1 certification
- A minimum of 50 Tech 2 dives with 25 dives exceeding 75 m/250 ft
- CCR divers with extensive experience may request special consideration regarding the CCR 2 requirement.

For those interested in joining a class, we currently have four Tech 3 instructors:

- Graham Blackmore – gb@gue.com
- Mario Arena – mario@gue.com
- Kirill Egorov – kirill@gue.com
- Gideon Liew – gideon@gue.com

Aspiring Tech 3 instructors are required to complete an application and gain approval from the Board of Directors (BOD). The prerequisites for instructor certification include recent, regular, and significant deep and project-oriented diving experience and substantial teaching experience (e.g., having taught 20+ CCR 2, PSCR, or Tech 2 courses and over 100 GUE classes). A draft set of instructor milestones is available for those interested in pursuing this path.

Join GUE and embark on the final part of GUE's technical trilogy. For more information about the Tech 3 class or to inquire about becoming a Tech 3 instructor, please visit www.gue.com or contact GUE.

Kees Beemster Leverenz

Kees is a technical diver and passionate GUE instructor based in Seattle, Washington. He's an active explorer and regularly participates in diving projects around the world. Recently, he has been working with the Italy-based organization Society for the Documentation of Submerged Sites (SDSS) and the Australia-based Major Projects Foundation (MPF) to document shipwrecks in the Mediterranean and Pacific Islands, respectively. Kees actively contributes to the development of GUE's educational materials and serves as GUE's Assistant Technical Program Director.

BRIDGING PEDAGOGICAL CONCEPTS IN DIVE TRAINING

– A student's perspective on learning with GUE

TEXT **MARCUS DOSHI**
PHOTOS **MARCUS DOSHI, DERK REMMERS, BORI BENNETT & IVO CHIARINO**

I am a professor of stage design in a highly competitive MFA graduate program at Northwestern University, where I have taught since 2012 following a decade of professional practice as a lighting designer for theater and opera. In 2019, I was certified as an open water diver, and in 2021, I began the Global Underwater Explorers (GUE) curriculum with Fundamentals. In spring 2023, I completed Tech 1, and in winter 2023, I took Cave 1.

One of the fascinating—and useful for my own teaching—parts of the courses has been inhabiting the role of the student. While at Northwestern, I've engaged in deep research into teaching and learning to shape my own course design, and I have come across several concepts that I believe are directly applicable to high level scuba training; for example, the GUE curriculum. These concepts have to do with supposed contraries in the teaching process, student destabilization, and effective methods for assessment. In this article, I will tie these ideas to dive-training-specific examples, reflect on my own experience as a student diver, and offer anecdotal evidence from colleague divers and observations from my own teaching and course design.

This article is not intended as a critique of my experience in GUE courses, a critique of my instructors, or a proposal to radically alter the largely successful way the classes are taught. Rather, my goal is to investigate—using the lexicon of student-centered teaching and learning—how the concepts listed above can be mapped to GUE courses in order to explore actual practice using established theory. My proposal is that identifying and understanding these techniques and their attendant vocabulary will add to the extant toolset that instructors use while teaching as well as arming instructors with a sharper and more diverse toolset with which to improve student learning, with a likely knock-on effect impacting course design writ large.

In other words, by bringing more specificity to language used in all contexts of teaching and learning, and by overtly talking about it by identifying the concepts to students in the context of teaching, the process will be richer, more efficient, and more productive—and that is the goal,

Meet Marcus Doshi, an avid diver and a seasoned professor of stage design at Northwestern University, Chicago. In this article, Marcus draws parallels between the world of teaching and scuba training, exploring contraries, learning partners, threshold concepts, and assessments. He reflects on how these pedagogical ideas can enhance the effectiveness of scuba training, providing valuable insights for both instructors and students. Join Marcus as he navigates the intersection of education theory and underwater exploration.

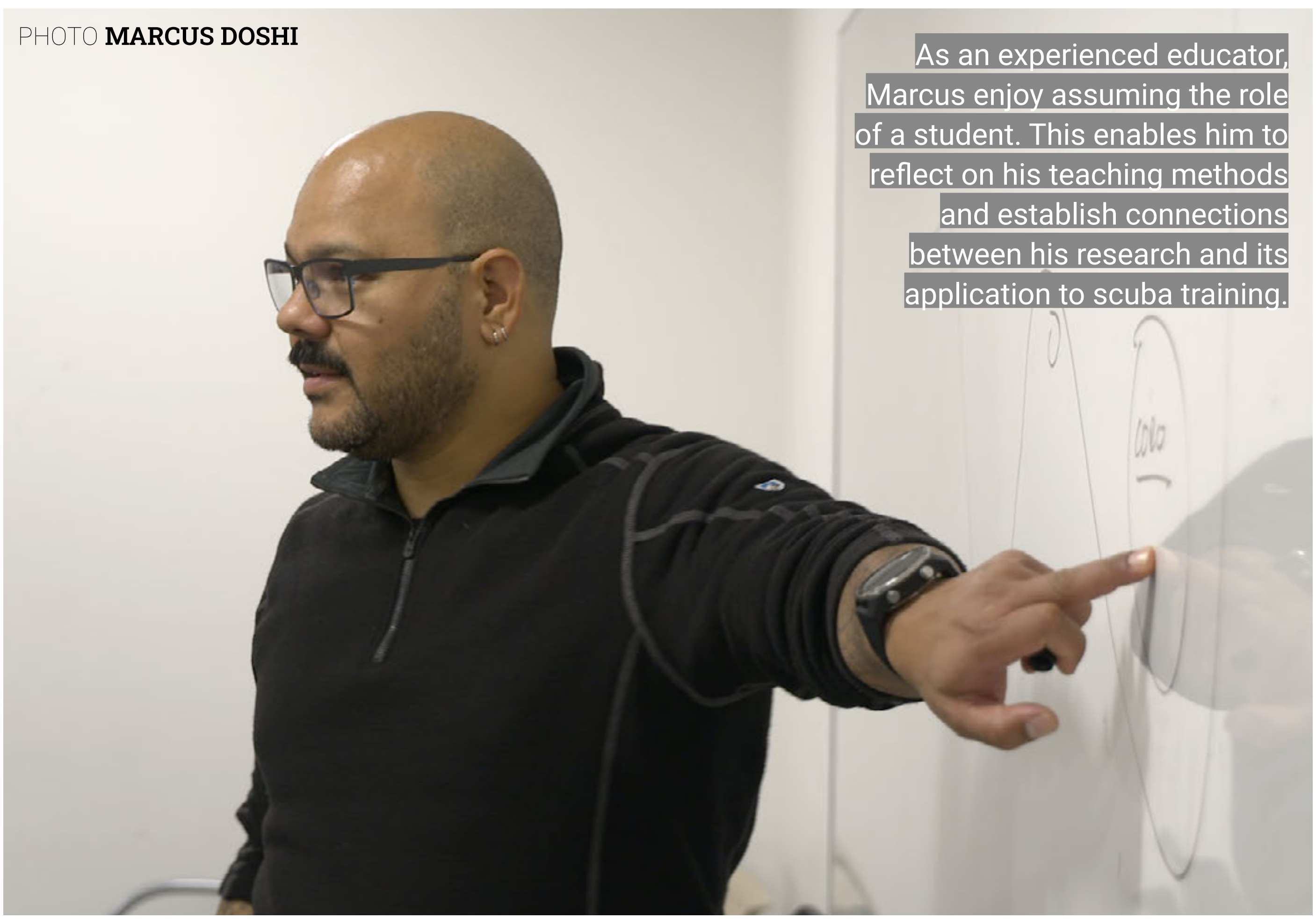


PHOTO **MARCUS DOSHI**

As an experienced educator, Marcus enjoy assuming the role of a student. This enables him to reflect on his teaching methods and establish connections between his research and its application to scuba training.

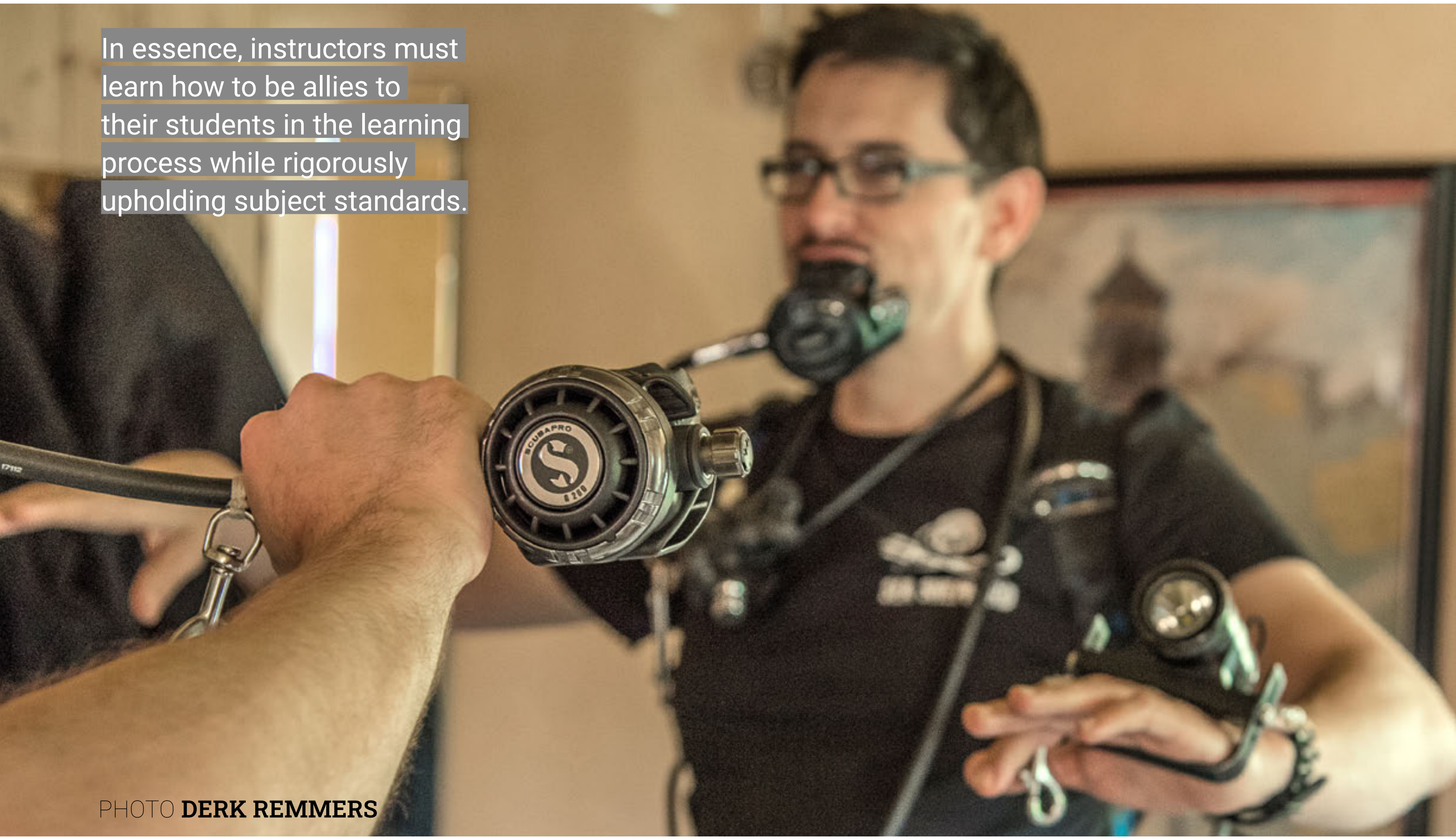


PHOTO **DERK REMMERS**

right? Plus, there is the added benefit of utilizing these tactics to accomplish more within a finite number of hours (a good thing in cold water!).

Contraries

In his article, "*Embracing Contraries in the Teaching Process*," Professor of English Emeritus at University of Massachusetts Amherst Peter Elbow interrogates the conflicting, seemingly contrary, obligations inherent to teaching: the obligation to the students and the obligation to knowledge and society. In other words, how can teachers be an ally to their students in the learning process while still strictly upholding standards of their subjects?

His conclusion is that one can't embody both positions at the same time, but being explicit with one's students about which position one is taking at any given time allows one to occupy both spaces equally without it being contradictory. This can be achieved with explicit statements to students such as, "*Right now, I'm holding you to this standard,*" and, "*Hey, I'm on your side—let's work together to meet this goal*." Thus, it is possible to hold one's students to very high standards if those standards are clearly explained in advance and while teaching.

Clearly identifying the standards allows an instructor to then occupy the role of ally-in-learning without sacrificing any of the standards to which the students are held. He writes of his own experience, "*I feel better about being really tough if I know I am going to turn around and be more on the student's side than usual.*"

Learning partners

Fortunately, GUE Standards are explicit on this front for all courses, so it is easy for instructors to clearly articulate them to students. However, given that they are rather universally regarded as the toughest standards in the scuba training space, the standards tend to create an elevated level of stress, which can get in the way of student learning (present company not excepted).

The explicit positioning of oneself as an ally is perhaps a bit more personal, but Elbow proposes

Clearly defining the standards enables an instructor to assume the role of a supportive learning ally without compromising the standards upheld for the students.

PHOTO **BORI BENNETT**

that "The more I can make it specifically clear how I am going to fulfill that commitment"—how he is going to help the students meet the expectations of the standards—"the easier it is for me to turn around and make a dialectical change of role into being an extreme ally to students."

An explicit statement I make to my students after explaining the standards I expect to be met in my classes is some version of, "*Now I am going to do everything I can to help you meet or exceed these standards*." It may sound simple, but a straightforward statement like that can help reposition a student into a less stressful, more receptive space where the instructor is not situated as an arbiter of standards, but a partner in learning. How one talks to one's students about the process of learning is as important as the information one is trying to teach.

> **"Fortunately, GUE Standards are explicit on this front for all courses, so it is easy for instructors to clearly articulate them to students.**

Threshold concepts

Another method of positioning oneself as an ally to one's students is to overtly acknowledge the destabilizing nature of the educational environment by clearly identifying why it is destabilizing. This is especially important because students engaging with GUE training often bring baggage from previous classes that they, counter-intuitively, have to "unlearn." In their remarkable work, education researchers Jan Meyer and Ray Land propose an extremely useful way of conceptualizing this destabilization in terms of threshold concepts, troublesome knowledge, and liminal spaces.

A threshold concept, simply put, is a critical concept that once learned, can't be unlearned. For example, the necessity for good trim and stability in the water. I contend that threshold concept theory can also be mapped to skills (it's one thing to know that trim and stability are important; it's another to be able to do it). Meyer and Land define it thus: "A threshold concept can be considered as akin to a portal, opening up a new and previously inaccessible way of thinking about something. It represents a transformed way of understanding, or interpreting, or viewing something without which the learner cannot progress." For instance, a student can't successfully complete a valve drill or deployment of an SMB without good trim and stability. They continue, "*As a consequence of comprehending a threshold concept there may thus be a transformed internal view of subject matter, subject landscape, or even worldview. This transformation may be sudden, or it may be protracted over a considerable period of time, with the transition to understanding proving troublesome.*"

A threshold concept has five key characteristics:

1. **It is transformative** in that it results in a shift in understanding. For example, that good trim and stability is foundational to being a good diver transforms the way students look at that skill.
2. **It is irreversible** in that it is unlikely to be forgotten. However, that is not to say that it cannot be challenged by what researcher Glynis Cousin refers to as "more refined or rival" understandings. For example, sometimes one has to break trim to move gas around a drysuit, and that is okay.
3. **It is integrative** in that it shows how multiple ideas are related and allows for "a-ha!" moments. For example, how the valve drill in Fundamentals is related to managing failures in Tech 1 and Cave 1.
4. **It is bounded**, "In that any conceptual space will have terminal frontiers, bordering with thresholds into new conceptual areas." For example, oxygen is good right up to the point that oxygen is bad.
5. **It is troublesome**, in that it is counterintuitive, alien, or seemingly incoherent. Wait, one can fin backwards!?

Meyer and Land further posit that the threshold can be seen "as the entrance into the transformational state of liminality," a transitional place between levels of understanding. This liminal space for students, with its lack of navigational markers, can be disturbing, stressful, and confusing. In my courses, I have my students read Cousin's "*An Introduction to Threshold Concepts*" on the first day of class. Then, I repeatedly acknowledge during the class that the students are occupying a state of liminality, and that it is perfectly natural and to be expected. This eases stress, lowers the stakes, and makes students more receptive and willing to try new things. That's a good thing, right?

Assessments

I contend that it is not only critical to acknowledge the concepts introduced in the sections above to students, but that it must be repetitive in order to meet the goal of improving the environment for student learning. I believe this is best done in the context of assessments during class.

A definition is in order: assessment (verb) is the collecting of information about student learning and using it for some purpose. That information can be quantitative or qualitative.

For the sake of this discussion, quantitative maps to objective (which typically means that it is standard-referenced) and qualitative maps to subjective (which means that it is referenced to the tacit knowledge of the assessor). In the world of GUE training, some standards are objective: for example, from the general training standards, "swim 375 m/400 yds in less than 14 minutes without stopping" for Technical Diver Level 1, while others are subjective as evidenced by the repeated use of the phrase "demonstrate proficiency," which relies almost exclusively on the experience and judgment of the instructor.

There are two types of assessment: formative and summative. Researchers Greg Light, Roy Cox, and Susanna Calkins, in their book *Learning and Teaching in Higher Education: The Reflective Professional,* define them thusly:

Formative assessment can be used to:

- Provide feedback to improve learning
- Motivate students


PHOTO IVO CHIARINO

Marcus with his teammate during his recent GUE Cave 1 course in Mexico. Taking GUE courses allows him to evaluate his own teaching methods.

- Diagnose a student's strengths or weaknesses
- Help students reflect critically on their learning

Summative assessment may be used to:

- Pass or fail a student
- Grade or rank a student
- Predict a student's success in other courses or employment

A convenient mnemonic to distinguish the two is that one is used in the formation of student knowledge—formative—and the other is used in the summing up of student knowledge—summative.

Student competence

Professor and education consultant Susan M. Brookhart 's definition adds some nuance: "… *formative and summative assessments describe two assessment functions. That is, they describe the use of assessment information. Whereas some information is more conducive to being used formatively and some is more conducive to being used summatively, it is the use and not the information that makes the distinction.*"

This is to say that one has to do something with the information collected during assessment, and that what one does with the info is the key. Importantly, the same info can be used both formatively and summatively, which is a very important concept to hold on to in the discussion of GUE training as evidenced by the summative assessment of both a written test (objective) and instructor evaluation (subjective) at the conclusion of a course, as well as the formative assessments students get along the way. I think every reader will agree that the formative assessments are by far the most important so, to reiterate, my goal is to not argue for their efficacy, rather it is to identify why, so that in knowing, these concepts can be applied consciously to dive training.

Why are formative assessments so important as to almost kick summative assessments out of the room? Because formative assessments are:

- About improving student capability, according to researchers Earl Hunt and James W. Pellegrino.
- About encouraging self-regulation, which, to paraphrase educational psychologist Paul Pintrich, is learning where students are in control of their cognitive process and practice—both of which are critical to mastery.
- More effective; in the words of researcher D. Royce Sadler, "Formative assessment is concerned with how judgements about the quality of student responses… can be used to shape and improve the student's competence by short-circuiting the randomness and inefficiency of trial-and-error learning."

Feedback

I propose that the two most important forms of formative assessment with regards to scuba training are authentic assessment and feedback. This proposal does not cut new ground insofar as these are the primary methods in use already. But let's learn some new vocabulary to improve them more effectively:

Authentic assessments are assessments that replicate real-world situations as closely as possible: for example, an in-water valve failure exercise. I paraphrase curricular design researcher Grant Wiggins's six characteristics of authentic assessments with corollaries to the drill:

1. It is realistic (the student hears the bubbles).
2. It requires judgment (the student needs to make a determination of where the bubbles are coming from).
3. It asks the students to go through the procedures that are typical to the discipline (valve failures are dealt with the same way every time).
4. It is done in similar situations to actual contexts where the work would be done (the drill is actually in the water).
5. It requires a wide range of skills and judgment applied to a complex problem (the corollary is self-evident).
6. It allows for feedback, practice, and second chances. (The student doesn't actually die if they mess up, and there is a discussion of how to do it better).

Viewed through this lens, it is possible to see how the exercise—via repetition and feedback from the instructor—can move the student from being a novice through a threshold to understanding how to develop their evaluative knowledge. In other words, the authentic experience of the failure allows the student to move from executing a rote set of procedures to understanding why the procedure is what it is.

> **"Feedback is the primary communication method by which an instructor comments on the performance during authentic assessments.**

Feedback is the primary communication method by which an instructor comments on the performance during authentic assessments. In the best scenario, it is a dialog between the student and instructor (often Socratic), with peer-students participating (even if only by listening), happening in real-time. This allows both the instructor and the student to shift the focus of the conversation as needed while giving students agency over their self-regulation and instructors the ability to be nimble with routes to their learning goals.

The term feedback requires special definition as I use it because classic definitions make feedback a one-way street: information transmission from assessor to assessee. There is push-back against this definition, and rightfully so. Researchers such as David J. Nichol & Debra MacFarlaine-Dick, Sadler, and many others argue that if feedback is to be useful in student self-regulation it must be conceptualized as dialog. Nichol & MacFarlaine-Dick urge that "*Feedback as dialog means that the student not only receives initial feedback information but also has the opportunity to engage the teacher*

GLOBAL Underwater Explorers

CAVE TRAINING

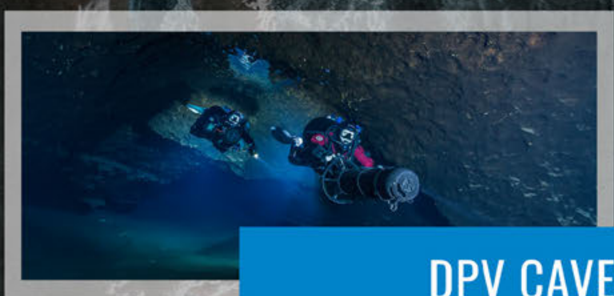
All GUE cave programs require a combination of GUE training and experience prerequisites prior to commencement of training. Consult with a GUE instructor or the website for more information.

CAVE 1

The GUE Cave 1 class provides an introduction to diving in an overhead environment. This program bolsters personal skills and awareness. Upon sucessful completion of training, the Cave 1 program allows divers to go out and enjoy cave diving with their teams.

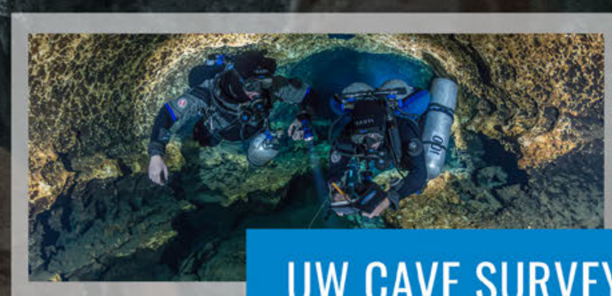
CAVE 2

The Cave 2 program hones in on environmental awareness, increased capacity with extended penetration dives, advanced navigation, use of jump spools, enhanced team awareness, advanced problem resolution, stress management, and use of a stage and/or decompression cylinder.



DPV CAVE

Reinforce the skills from GUE's DPV 1 course, management of multiple DPVs and all the ramifications of their use, stage cylinder handling, and cave environment-specific applications.



UW CAVE SURVEY

Gain the competency in basic principles of underwater cave survey; implementation of a defined team approach to underwater survey data collection, which prepares an experienced cave diver to productively assist in a coordinated cave project; and an introduction to cartography methods.

CAVE SIDEMOUNT

GUE Cave Sidemount provides an opportunity for experienced GUE Cave 2 divers to familiarize themselves with sidemount equipment configuration. This course provides an opportunity to experience and explore areas that are too small for the standard GUE backmount configuration.

CCR CAVE

Venturing deeper into caves and discovering more passages may bring the need for additional time for exploration and redundancy for for safety. Experience the CCR's advantages and expand your knowledge of gas planning, decompression, and complex failures when planning for a long exit.

in discussion about that feedback." And Sadler, again: *"Feedback is a key element in formative assessment, and is usually defined in terms of information about how successfully something has been or is being done."* This revised definition will be referred to as good feedback.

Self-regulation

Nichol & MacFarlaine-Dick further propose that feedback stimulates self-regulation and, in order for that to work, three conditions, initially proposed by Sadler, must be met. Those conditions are that students must know:

- What good performance is (i.e., they must possess a concept of the goal or standard being aimed for).
- How current performance relates to good performance (for this, students must be able to compare current and good performance).
- How to act to close the gap between current and good performance.

This can be readily mapped to any of the skills practiced in class, and I propose that if phrases like "here is what you are doing right and here is what you are doing wrong" and "here is how to close the gap" are employed, it would create a more receptive environment for feedback. Nichol & MacFarlaine-Dick go on to synthesize seven principles of feedback practice, practice designed to "strengthen students' capacity to self-regulate:"

- Helps clarify what good performance is (goals, criteria, expected standards)
- Facilitates the development of self-assessment (reflection) in learning
- Delivers high quality information to students about their learning
- Encourages teacher and peer dialog around learning
- Encourages positive motivational beliefs and self-esteem
- Provides opportunities to close the gap between current and desired performance
- Provides information to teachers that can be used to help shape the teaching.

If an instructor can stimulate the three conditions in the first list above in students, and if they also practice feedback as in the second list above, then that feedback becomes the most efficacious assessment in class. Good feedback makes the action/reaction time of sharing the instructor's tacit knowledge nimble and instantaneous, encourages self-regulation in the student, and creates a positive teaching and learning environment for both. It is important to note that dialog here is not, strictly speaking, limited to formal instructional time. In this sense, its definition is broader and encompasses banter over beers at the picnic table after class, via social media, or even a phone call months after course completion.

GUE does a good job at not soft pedaling assessments in the General Training Standards, Policies, and Procedures, and while it is not the topic of this article to get into the weeds of curricular design, I wonder if students actually know exactly what they need to accomplish when they begin a course, especially with regards to the authentic assessments (skills). I propose that it would be useful if the first day of classes, or pre-class mandatory study, could include videos of every skill to be taught in the class, so that students have an idea of the exemplars walking in the door. For example, a video of what a good Basic 5 looks like, and also perhaps a video of a bad Basic 5 that shows the most common mistakes instructors see for comparison. As Elbow points out, it's better to show what does not meet assessment standards as a comparative than to just say, "Do it right or you will fail."

Ideal outcome

My hope is that introducing ideas and vocabulary from the lexicon of student-centered teaching and learning in the context of GUE training will prove useful to instructors as they shape their teaching: that the language and concepts introduced can engender a nuanced shift in vocabulary that will create a more positive teaching and learning environment. The ideal outcome is that instructors will overtly and repeatedly acknowledge the conflicting, seemingly contrary, obligations to their students and

Effective feedback is crucial, and GUE's frequent use of dry runs fosters an environment conducive to providing such feedback.

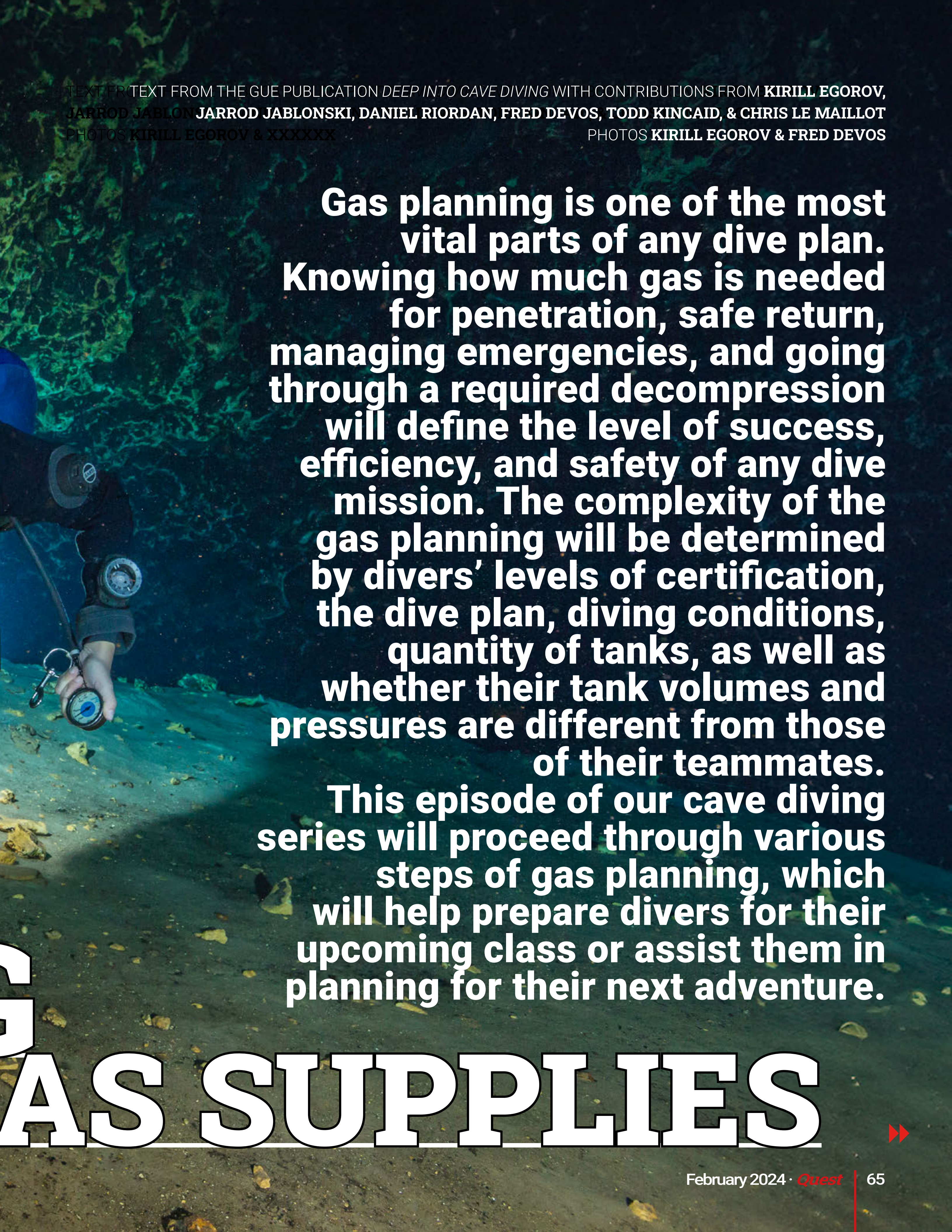
their obligation to standards and the destabilizing nature of threshold concepts and the attendant liminal space of learning via the language they use during feedback on authentic assessments. And that by doing this, instruction will be richer, more efficient, and more productive for everyone.■

> **Good feedback makes the action/reaction time of sharing the instructor's tacit knowledge nimble and instantaneous, encourages self-regulation in the student, and creates a positive teaching and learning environment for both.**

Marcus Doshi

Marcus Doshi designs lighting for theater and opera, where his work has been seen on and off-Broadway, at most major regional theaters and opera companies in the US and internationally. He is a professor of theatre at Northwestern University in Evanston, Illinois, USA, where he teaches in the Master of Fine Arts Stage Design and Directing programs. His diving career is nascent, having been first certified in 2019 followed by a GUE Fundamentals recreational pass in 2021, technical pass in 2022, and Tech 1 and Cave 1 in 2023. He is also part of the leadership team of Midwest Underwater Explorers, a GUE local community.

MANAGING BREATHING G



TEXT FROM THE GUE PUBLICATION *DEEP INTO CAVE DIVING* WITH CONTRIBUTIONS FROM **KIRILL EGOROV, JARROD JABLONSKI, DANIEL RIORDAN, FRED DEVOS, TODD KINCAID, & CHRIS LE MAILLOT**
PHOTOS **KIRILL EGOROV & FRED DEVOS**

Gas planning is one of the most vital parts of any dive plan. Knowing how much gas is needed for penetration, safe return, managing emergencies, and going through a required decompression will define the level of success, efficiency, and safety of any dive mission. The complexity of the gas planning will be determined by divers' levels of certification, the dive plan, diving conditions, quantity of tanks, as well as whether their tank volumes and pressures are different from those of their teammates. This episode of our cave diving series will proceed through various steps of gas planning, which will help prepare divers for their upcoming class or assist them in planning for their next adventure.

G
AS SUPPLIES

Learning the mathematical relationship between tank volumes, tank pressures, and gas volumes will allow divers to calculate how much gas they need for a given cave dive. In this text, we present calculations in both metric and imperial units to highlight their distinct differences and practical applications. For clarity, metric unit examples are color-coded in **blue**, while imperial units examples are designated in **red**.

In the metric system, to find the volume of gas in a given set of tanks at a given pressure use the following formula:

Vg = Vt x Pt (Where Vg is volume of gas, Vt is a tank volume, and Pt is current tank pressure).

For example, if a diver has a twinset of 12 L tanks filled to 200 bar, the calculations will look as follows:

(2 x 12 L) x 200 bar = 4,800 liters of gas.

Using the same formula, divers can calculate a pressure needed to get the desired volume of gas in a given set of tanks:

If 5,200 liters of gas are needed in a set of 12 L tanks: Pt = Vg ÷ Vt or 5,200 L ÷ 24 L = 216.6 or 220 bar

In the imperial measurement system, the capacity of the tank (the amount of gas it can hold) will depend on the tank's rated pressure and the tank's rated volume in cubic feet. For example, a single aluminum 80 cubic foot tank ("aluminum 80") is more precisely rated to 77.6 cubic feet of gas at a pressure of 3,000 psi.

With this in mind, you can calculate the amount of gas a certain tank will hold at 1 psi by dividing the tank's rated volume by its rated pressure.

Continuing with the example: 77.6 ft^3 ÷ 3,000 psi = 0.025. So, in the case of an aluminum 80, 1 psi will be equivalent to 0.025 cubic feet of gas.

It would be easier to use 100 psi increments, as that is the way the pressure gauges are marked, and it will make further calculations easier.

So, for an aluminum 80, if 1 psi = 0.025, then 100 psi will be equivalent to 2.5 cubic feet of gas.

Knowing this, tank factors for any commonly used tanks can be calculated. If they're planning to use double tanks, a diver will need to multiply the tank factor by 2.

It is quite easy to memorize tank factors for divers' most frequently used tanks. If divers switch tank sizes often, it is useful to keep a table of tank factors in their wetnotes.

In order to calculate how much gas a certain tank will hold at a given pressure, the following formula should be used:

Volume of gas (ft^3) = (Pressure ÷ 100) x tank factor

Example: How many cubic feet of gas will there be in an aluminum 80 tank filled to 3,000 psi?

(3,000 psi ÷ 100) x 2.5 = 30 x 2.5 = 75 cubic feet of gas.

Measuring consumption

Proper dive planning requires that divers accurately predict the gas they will consume during a given dive. Gas consumption varies greatly among individuals and may vary considerably with exertion level. This is particularly true of divers who are not engaged in regular fitness regimens. More aggressive diving requires increasingly more precise determination of gas consumption. Technical diving often requires that individuals estimate their gas needs for both bottom and decompression mixes as well as for emergencies/failures. Furthermore, an efficient calculation of gas consumption helps divers to understand the dive profile and to plan for contingencies.

In order to properly calculate gas consumption at various depths, divers should establish a baseline measurement of their gas consumption. This baseline is most effectively related to the volume of gas that they would consume at the surface, allowing them to

PHOTO **FRED DEVOS**

Initially, the gas calculations may seem daunting, but with time, they become easy.

calculate what they would use at a range of depths (while multiplying for each atmosphere (ATA) of diving depth). This baseline can be established at the surface, at a fixed depth, or by divers calculating/measuring an average depth on a common profile. It is recommended that divers use the latter two methods to establish consumption, as it tends to generate a more reliable measure of actual use (as opposed to walking around on the surface with cylinders). Divers should measure their consumption rate in a variety of environments and situations (e.g., at work and at rest) to gain a better feel for variation and to improve planning ability. After calculating their consumption at depth, divers can use the formulas below to establish an equivalent surface consumption. This consumption can then be estimated at depth as outlined below.

To establish a reliable baseline consumption rate at a constant depth, remain at a constant depth for a fixed time (usually 10 minutes) to calculate a cubic feet/bar-per-minute consumption rate. Alternatively, divers can calculate (or estimate) the average depth of a particular dive and measure gas consumption over time. Depth averaging often gives a more realistic estimate of workload as it represents typical diving activity. However, average depth estimates can also be less accurate in that they approximate the average depth in a multilevel profile (unless, where available, these calculations are done with an averaging meter/watch). Depth averaging is a useful exercise because it allows divers to gain experience estimating actual diving profiles—a valuable skill in later decompression exercises.

The calculated consumption-per-minute rate is then correlated to the surface, allowing divers to extrapolate to any dive/depth. Gas consumption baselines are usually called surface consumption rates (SCRs) or respiratory per minute volumes (RMVs).

Metric calculations

The formula necessary to calculate SCR is:

> **SCR = (Pg x Vt) ÷ (Time x Pd), where Pg is gas pressure used during the segment of the dive, Vt is a tank volume, Time is a duration of a dive/segment, and Pd is a pressure at depth**.

For example, if using double 12 liter tanks during a 30 m dive, divers have consumed 30 bar during a 10-minute segment of a dive:

SCR = (2 x 12 L x 30 bar) ÷ (10 min x 4 ATA) = 18 L/min

Imperial calculations

The Imperial version of the formula is:

> **SCR = (Pg ÷ 100 x TF) ÷ Time x Pd, where Pg is the pressure of used gas, TF is the tank factor, time is the duration of a segment of a dive, and Pd is pressure at depth.**

For example, if using a double aluminum 80s during a 100 ft dive, divers have consumed 600 psi in 10 minutes:

> **SCR = (600 psi ÷ 100 x 5) ÷ (10 min x 4 ATA) = 0.75 ft^3/min**

Given a constant breathing rate and divers' surface air consumption, consumption at any depth can be measured by multiplying one's SCR by a pressure at depth:

- **Metric: If divers' SCR is 18 L/min at the surface, at a depth of 20 m they will be using 18 L/min x 3 ATA = 45 L/min.**
- **Imperial: If divers' SCR is 0.75 ft^3/min, at a depth of 70 ft they will be using 0.75 ft^3/min x 3 = 2.25 ft^3/min.**

This can help to predict either the quantity of gas needed for a dive or the time available for a dive.

ALTERNATIVE CONSUMPTION CALCULATIONS

The classic approach to gas planning (i.e., using liters per minute or cubic feet per minute) requires a multi-step procedure and, not uncommonly, a calculator.

There is an alternative way that makes all calculations significantly faster and easier, especially if divers are commonly using the same set of tanks.

This method ties together the two most commonly used values—pressure and time—bypassing actual gas volume.

Metric calculations

If the surface consumption rate is known (using 20 L/min for the calculations below) and using a specific set of tanks (2 x 12 L, for example), then the bar per minute consumption can be found using this formula: SCR ÷ Vt. So, for the example it will be 20 ÷ 24 = 0.8 bar per minute.

Obviously, checking pressure every minute would not be practical, so divers should decide upon a more realistic time segment; for example, 5-minute intervals.

Then they will have a surface consumption of 4 bar every 5 minutes. To find consumption at depth, one should simply multiply this number by the pressure at depth.

Now dive planning becomes much easier:
What will the dive time be if, for a 30 m dive they can use 70 bar from double 12 L tanks?

1. 4 bar/5 min x 4 ATA = 16 bar/5 min
2. 70 bar ÷ 16 bar/5 min = 4.5 segments or 23 minutes

Using the above formula, the actual SCR, and their set of tanks, divers can calculate their personal surface consumption rate as well as consumption rate at various depths, recording these in their wetnotes for easy calculations.

Imperial calculations

If the surface consumption rate is known (use 0.75 ft^3/min for the calculations below) and using a specific set of tanks (2 x 80 ft^3, for example), then the psi per minute consumption can be found using this formula: SCR ÷ TF x 100. So,

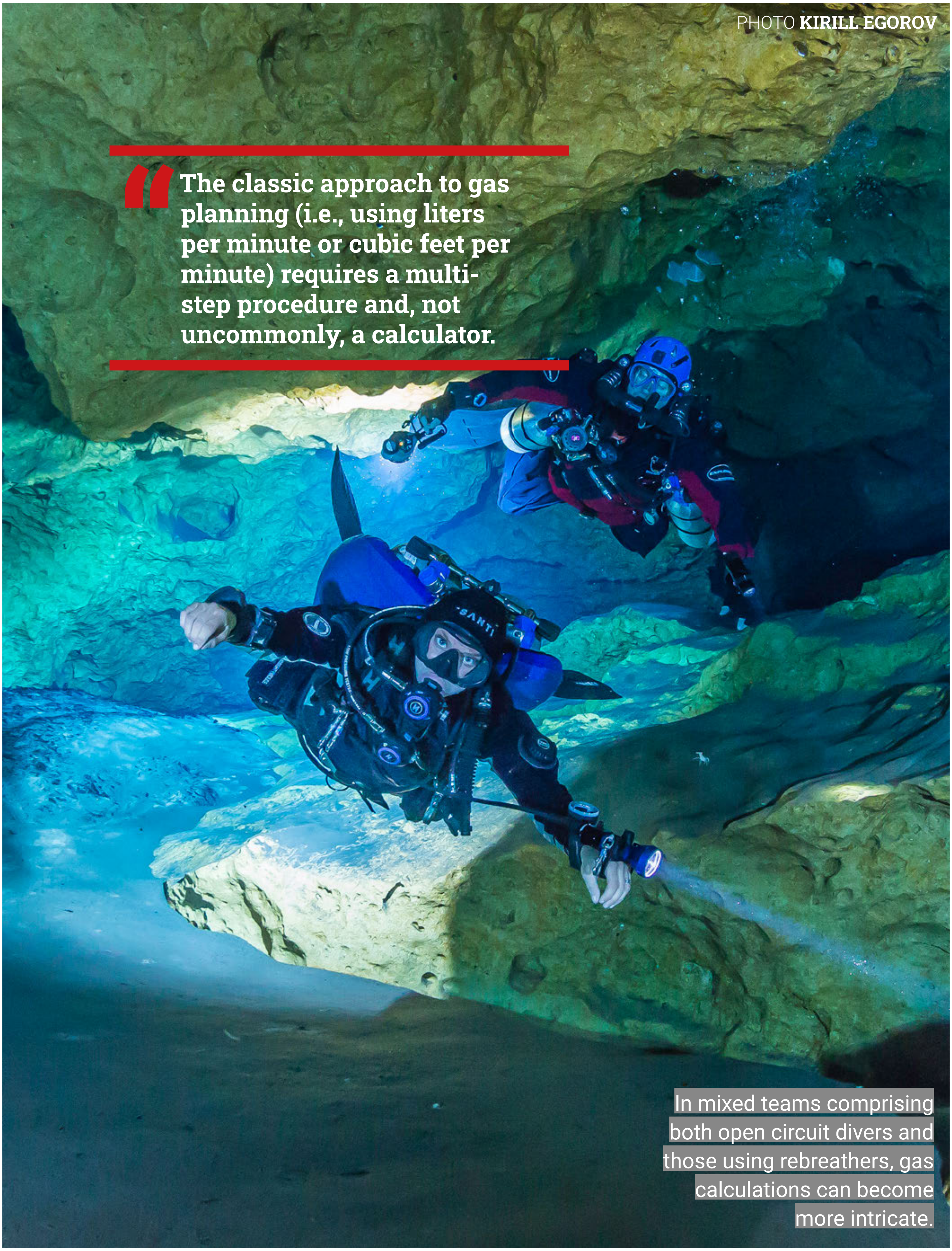


PHOTO **KIRILL EGOROV**

> **The classic approach to gas planning (i.e., using liters per minute or cubic feet per minute) requires a multi-step procedure and, not uncommonly, a calculator.**

In mixed teams comprising both open circuit divers and those using rebreathers, gas calculations can become more intricate.

Dives permitting direct ascents typically don't demand large gas reserves. Yet, as dives grow more complex, gas management becomes increasingly crucial.

for the example, it will be 0.75 ft³ ÷ 5 x 100 = 15 psi per minute.

Using the more realistic 5-minute segment, divers will have a surface consumption of 75 psi every 5 minutes. To find consumption at depth, simply multiply this number by the pressure at depth.

Now dive planning becomes much easier:
What will the dive time be for a 100 ft dive if 1,000 psi from double 80 ft³ tanks is used?

1. 75 psi/5 min x 4 ATA = 300 psi/5 min
2. 1,000 psi ÷ 300 psi/5 min = 3 segments or 15 minutes.

Using the above formula, the actual SCR, and the divers' set of tanks, they can calculate their personal surface consumption rate as well as consumption rate at various depths, subsequently recording these in their wetnotes for easy calculations.

SCR rates are an especially valuable way for divers to anticipate gas requirements and to track varying consumption rates.

For example, divers can monitor improvement in fitness and diving comfort by tracking changes in SCR rates. In general, divers will find that better fitness is especially valuable in times of duress or in times of exertion, as their SCR rates will remain more similar to resting rates. With practice, divers will find that they can accurately predict their gas needs on a given dive, the result being that they greatly extend both their efficiency and safety.

The "one-third" gas rule

Environments that allow divers to make an immediate ascent to the surface do not usually require that large emergency gas reserves be maintained. However, as the complexity of a dive increases, so must divers' attention to gas management. When a diver's ability to make a free ascent to the surface is limited or barred, then they must maintain a greater reserve of gas. Any number of factors may limit a free ascent to the surface. Overhead barriers, such as shipwrecks, ice, and caves, are obvious obstacles to an immediate ascent and thus

PHOTO **KIRILL EGOROV**

require reserve supplies. Less obvious examples include deeper open water dives and/or decompression dives.

To maintain sufficient gas reserves, cave divers established the Rule of Thirds. This rule enables divers to easily manage their gas while leaving ample reserves for exiting and for emergencies. In overhead diving such as cave, wreck, or ice, the initial third is used for penetration, while the remaining two thirds are reserved for return and emergencies. When diving thirds, it is imperative that divers carefully monitor their gas and always maintain a sufficient volume to allow them to exit safely from the farthest point in the dive. This reserve volume also takes into account the unlikely event that a team member could experience a catastrophic gas loss at the farthest point.

Similar tanks (tanks of the same size)

Assuming that all divers on a given team are using the same type of cylinder, calculating thirds for penetration is simple. Assuming a 210 bar/3,000 psi fill, divers can use 70 bar/1,000 psi for penetration, 70 bar/1,000 psi for the return and 70 bar/1,000 psi for emergencies. This means that they must turn the dive at a pressure of 140 bar/2,000 psi. However, in the case of a 220 bar/3,100 psi fill, one-third of which is 73 bar/1,033 psi, rather than work with amounts less than 10 bar or 100 psi, divers will round down their fill pressure to the first number evenly divisible by three. In this case, this means that to calculate thirds, divers would first round down their fill pressure to 210 bar/3,000 psi. Then, once they establish that one-third of this is 70 bar/1,000 psi, they would then subtract this value from the actual fill pressure. In this case, they would subtract 70 bar/1,000 psi from 220 bar/3,100 psi. This then establishes their turn pressure as 150 bar/2,100 psi.

Gas calculation note: The one-third consumption rule is a maximum value. There are many reasons a cave diver would leave more available gas. Divers being new to a cave, experiencing difficult conditions, diving in two-man teams, using new or advanced equipment, or working with new buddies are well advised to leave additional reserves. Likewise, new cave divers are required by various agency rules to reserve more than the typical one-third for exit.

While wreck diving or diving a cave that starts at depth, it might be necessary to calculate a minimum gas reserve first and subtract it from total gas volume prior to calculating thirds.

DISSIMILAR FILL PRESSURES

Divers often have different gas consumption rates and must ensure that each one has an adequate volume of gas to assist an out-of-gas team member. This is done by team members agreeing on a set volume of usable gas that no team member can draw on unless it is an emergency. This usable volume is based upon the diver with the least amount of gas. For instance, consider a three-member cave diving team that dives the same type of cylinder but finds itself with three different fill pressures: 220 bar/3,200 psi, 215 bar/3,100 psi, and 225 bar/3,300 psi. The diver with 215 bar/3,100 psi has the lowest volume and therefore determines the team's available gas for penetration. First, 215 bar/3,100 psi is rounded down to the first value evenly divisible by three, or 210 bar/3,000 psi. One-third of this value is 70 bar/1,000 psi. This means that all team members are limited to 70 bar/1,000 psi of gas for penetration. Whoever uses 70 bar/1,000 psi first must signal the team and all divers must exit. This system ensures that each diver has sufficient gas for exiting and for bringing out another team member. The thirds calculation procedure can be summarized as follows:

1. Determine the tank with the lowest pressure
2. Round this pressure down to the first number evenly divisible by three
3. Calculate one-third of this adjusted volume
4. Subtract this value from every diver's available pressure

GAS MANAGEMENT WITH DISSIMILAR TANKS

Divers using different cylinder sizes will find that calculating usable volumes is slightly more complicated because they must ensure that each diver is allotted the same volume of gas. When divers have the same size cylinders, determining who has the most gas is simply a matter of checking fill pressures. However, divers with different tank sizes must manage this discrepancy by establishing a common way to compare the amount of gas between these cylinders. This is because psi and bar do not accommodate the differences in tank size. In this case, divers will need to use a more universal value for volume that is measured in cubic feet (imperial) or liters (metric).

To calculate turn pressures for a dive team using dissimilar tanks, first determine which diver has the least amount of gas. Though typically this will be the diver with the smallest tanks, dissimilar fill pressures can result in a diver with larger tanks actually having a smaller volume of gas. If members of a dive team are wearing different size cylinders, then calculating the available volume can be more complicated because equivalent pressures no longer indicate equal volumes. However, the goal is still preventing any one person from consuming more than the rest of the team, thus ensuring that each member has a sufficient reserve for emergencies.

Always limit the team's penetration to one-third of the smallest available volume!

Metric example

Diver A is using double 16 L tanks filled to 210 bar, while Diver B is using double 12 L tanks filled to 250 bar. What are the turn pressures for both divers?

1. Find the diver with the lowest gas volume: Diver A: 2 x 16 L x 210 bar = 6,720 L; Diver B: 2 x 12 L x 250 bar = 6,000 L. Diver B has the smallest volume.
2. Find Diver B's third and turn pressure:
   250 bar ÷ 3 = 80 bar
   TP = 250 bar – 80 bar = 170 bar
3. Convert Diver B's third into liters:
   80 bar x 2 x 12 L = 1920 L
4. Find usable pressure for Diver A:
   1920 L ÷ 2 x 16 L = 60 bar
5. Find Diver A's turn pressure:
   210 bar – 60 bar = 150 bar

PHOTO **KIRILL EGOROV**

As cave dives become more technically complex, with longer distances covered using rebreathers and/or DPVs, inadequate planning can lead to life-threatening situations.

Imperial example

Diver A is using double 104 ft³ tanks filled to 3,000 psi, while Diver B is using double 85 ft³ filled to 3,600 psi. What are the turn pressures for both divers?

1. Find the diver with the lowest gas volume: Diver A: 3,000 psi ÷ 100 x 8 = 240 ft³; Diver B: 3,600 psi ÷ 100 x 6 = 216 ft³. Diver B has the smallest volume.
2. Find Diver B's third and turn pressure: 3600 psi ÷ 3 = 1200 psi
   TP = 3600 psi – 1200 psi = 2400 psi
3. Convert Diver B's third into cubic feet: 1200 psi ÷ 100 x 6 = 12 x 6 = 72 ft³.
4. Find usable pressure for Diver A: 72 ft³ ÷ 8 x 100 = 900 psi.
5. Find Diver A's turn pressure: 3,000 psi – 900 psi = 2,100 psi.

USING A STAGE CYLINDER

Adding additional gas volumes opens up more possibilities, including longer bottom times, longer penetration distances, and more tasks that can be performed in a cave. But as always, there is a tradeoff for this: Gas planning will become somewhat more complicated.

The most commonly used strategy when adding a single stage bottle is called "half minus 10" (metric) or "half minus 200" (imperial). What this means is that divers will use half of their stage bottle pressure minus 10 bar or 200 psi for penetration, leaving the other half for the exit and 10 bar or 200 psi for a gas switch and other possible small delays.

But what if on the way back divers find their stage bottle empty? Not a great scenario if their back gas reserves are not adjusted for this event.

To have enough gas to compensate for a loss of stage bottle during the exit, create an extra back gas reserve—the volume of gas used from the stage bottle on the way into the cave.

Metric example

Divers are planning a cave dive at an average depth of 30 m, with double 16 L tanks filled to 240 bar and an 11 L stage bottle filled to 200 bar. What are the drop pressure and turn pressure?

1. Drop Pressure (DP):
   a. 200 bar ÷ 2 = 100 bar
   b. 100 bar – 10 bar = 90 bar
   c. DP = 200 bar - 90 bar = 110 bar

2. Turn Pressure (TP):
   a. Adjust for the gas used from the stage:
      1. 90 bar x 11 L = 990 L
      2. 990 L ÷ 32 L = 30 bar
   b. Calculate TP:
      1. 240 bar – 30 bar = 210 bar
      2. 210 bar ÷ 3 = 70 bar
      3. TP = 240 bar – 70 bar = 170 bar

Imperial example

Divers are planning a cave dive at an average depth of 100 ft while using double 104 ft³ tanks filled to 3,400 psi and an 80 ft³ stage bottle filled to 3,000 psi. What are the drop pressure and turn pressure?

1. Drop Pressure (DP):
   a. 3,000 psi ÷ 2 = 1,500 psi
   b. 1,500 psi – 200 psi = 1,300 psi
   c. DP = 3,000 psi – 1,300 psi = 1,700 psi.
2. Turn Pressure (TP):
   a. Adjust for the gas used from the stage:
      1. 1,300 psi ÷ 100 x 2.5 = 32.5 ft³
      2. 32.5 ft³ ÷ 8 x 100 = 400 psi
   b. Calculate TP:
      1. 3,400 psi – 400 psi = 3,000 psi
      2. 3,000 psi ÷ 3 = 1,000 psi
      3. TP = 3,400 psi – 1,000 psi = 2,400 psi

REBREATHER AND/OR DPV DIVES

With the increased technical complexity of dives, when distances covered in a cave dramatically increase due to use of rebreathers and/or DPVs, divers may find themselves in a life-threatening situation if dives were not planned conservatively and thoroughly. That is why rebreathers and DPV training from highly active and experienced instructors is very important.

Even leaving specific details of planning such dives to these experienced instructors, it should be mentioned that while utilizing these complicated devices, divers should be ready for them to fail and should have enough gas to exit the cave while swimming and using open-circuit

When planning a cave decompression dive, divers need to ensure they have enough decompression gas reserves.

PHOTO **KIRILL EGOROV**

equipment. In certain cases, besides extra gas, divers may need to use backup DPVs and bail-out rebreathers.

DECOMPRESSION CYLINDERS

When planning a decompression dive in a cave, divers should remember that—besides bottom gas reserves—they will need sufficient decompression gas reserves.

Typically, an additional one-third is considered sufficient to allow for any problem resolutions (including the loss of gas by a teammate).

Metric example

How much oxygen is needed for a dive requiring 25 minutes of decompression? (Considering deco SCR of 20 L/min and using a 5.5 L decompression cylinder).

1. 25 min x 20 L/min x 1.6 ATA = 800 L
2. 800 L x 1.5 = 1,200 L
3. 1,200 L ÷ 5.5 L = 218 bar

Imperial example

How much oxygen is needed for a dive requiring 25 minutes of decompression? (Considering deco SCR of 0.75 ft^3/min and using a 40 ft^3 decompression cylinder).

1. 25 min x 0.75 ft^3 x 1.6 ATA = 30 ft^3
2. 30 ft^3 x 1.5 = 45 ft^3
3. 45 ft^3 ÷ 1.25 x 100 = 3,600 psi

Safety margins

Unquestionably, the most important skill to master when cave diving is knowing how to establish, track, and manage individual and team gas requirements. Knowing one's SCR, conformity to the Rule of Thirds, and attention to dissimilar tank sizes and their respective fill pressures and volumes will go a long way to ensuring diver safety. Furthermore, it is important to always remember it is the divers with the least volume in their tanks that set the benchmark for the volume of gas allowable for each diver's penetration. Though some of this might seem cumbersome at first, especially when using imperial units, practice will enable divers to easily take full advantage of the safety margins provided by these practices. If in doubt, one should always err on the side of conservatism, leaving plenty of gas for emergencies.

NEXT TIME Emergency situations

GUE PREMIUM DIVE CENTERS

Area 9 Mastery Diving – Kralendijk, Bonaire
➲ www.masterydiving.com

Base1 – Sardinia, Italy
➲ www.baseone.it

Deep Dive Dubai – Dubai, UAE
➲ www.deepdivedubai.com

Dive Centre Bondi – Bondi, NSW, Australia
➲ www.divebondi.com.au

Duikcentrum de Aalscholvers – Tilburg, Netherlands
➲ www.aalscholvers.nl

Eight Diving – Des Moines, WA, USA
➲ www.8diving.com

Exploration Diver – Hangzhou, China
➲ www.facebook.com/qiandaolake

Extreme Exposure – High Springs, FL, USA
➲ www.extreme-exposure.com

Islas Hormigas – Cabo de Palos, Spain
➲ www.islashormigas.com

Living Oceans – Singapore
➲ www.livingoceans.com.sg

Plongée Nautilus – Quebec City, QC, Canada
➲ www.plongeenautilus.com

Scuba Academie – Vinkeveen, Netherlands
➲ www.scuba-academie.nl

Tec Diving – Luzern, Switzerland

➲ www.tecdiving.ch

Tech Korea – Incheon, South Korea

➲ www.divetechkorea.com

Third Dimension Diving – Tulum, Q. Roo, Mexico

➲ www.thirddimensiondiving.com

Zen Dive Co – Los Angeles, USA

➲ www.zendive.com

Zero Gravity – Quintana Roo, Mexico

➲ www.zerogravity.com.mx

GUE DIVE CENTERS

Buddy Dive Resort – Bonaire
➲ www.buddydive.com

China Dive Club – Hainan Province, China

Dive Alaska – Anchorage, AK, USA
➲ www.divealaska.net

Diveolution – Kessl-Lo, Belgium
➲ www.diveolution.com

Faszination-Tauchsport – Sauerlach, Germany
➲ www.faszination-tauchsport.de

Innovative Divers – Bangkok, Thailand
➲ www.facebook.com/innovativedivers

KrakenDive – Tossa de Mar, Spain
➲ www.krakendive.com

Living Oceans Malaysia – Kuala Lumpur, Malaysia
➲ www.livingoceans.com.my

Moby Tek Dive Center – Pahang, Malaysia
➲ www.moby-tek.com

Paragon Dive Group – Arizona, USA
➲ www.paragondivestore.com

Scuba Adventures – Plano, TX, USA
➲ www.scubaadventures.com

Scuba Seekers – Dahab, Egypt

➲ www.scubaseekers.com

Tauchservice Münster – Münster, Germany

➲ www.tauchservice.info

Tech Asia – Puerto Galera, Philippines

➲ www.techasia.ph

Unique Diving Center – Shanghai, China

➲ www.uniquediving.cn