ALERT DIVER

THE MAGAZINE OF DIVERS ALERT NETWORK

SUMMER 2016

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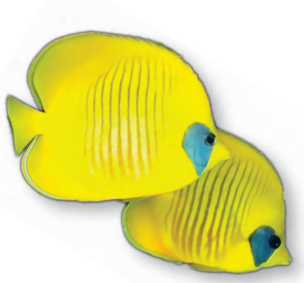

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ALERT DIVER

THE MAGAZINE OF DIVERS ALERT NETWORK — SUMMER 2016

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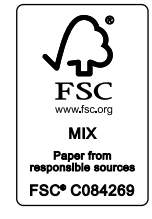

VISION

Striving to make every dive accident- and injury-free. DAN's vision is to be the most recognized and trusted organization worldwide in the fields of diver safety and emergency services, health, research and education by its members, instructors, supporters and the recreational diving community at large.

DAN
YOUR DIVE SAFETY ASSOCIATION

MISSION

DAN helps divers in need of medical emergency assistance and promotes dive safety through research, education, products and services.

Divers Alert Network® (DAN®), a nonprofit organization, exists to provide expert medical information for the benefit of the diving public.

DAN's historical and primary function is to provide timely information and assistance for underwater diving injuries, to work to prevent injuries and to promote dive safety.

Second, DAN promotes and supports underwater dive research and education, particularly as it relates to the improvement of dive safety, medical treatment and first aid.

Third, DAN strives to provide the most accurate, up-to-date and unbiased information on issues of common concern to the diving public, primarily — but not exclusively — for dive safety.

ALERT DIVER'S PHILOSOPHY

Alert Diver® is a forum for ideas and information relative to dive safety, education and practice. Any material relating to dive safety or dive medicine is considered for publication. Ideas, comments and support are encouraged and appreciated.

The views expressed by contributors are not necessarily those advocated by Divers Alert Network. DAN is a neutral public service organization that attempts to interact with all diving-related organizations or persons with equal deference.

Alert Diver is published for the use of the diving public, and it is not a medical journal. The use and dosage of any medication by a diver should be under the supervision of his or her physician.

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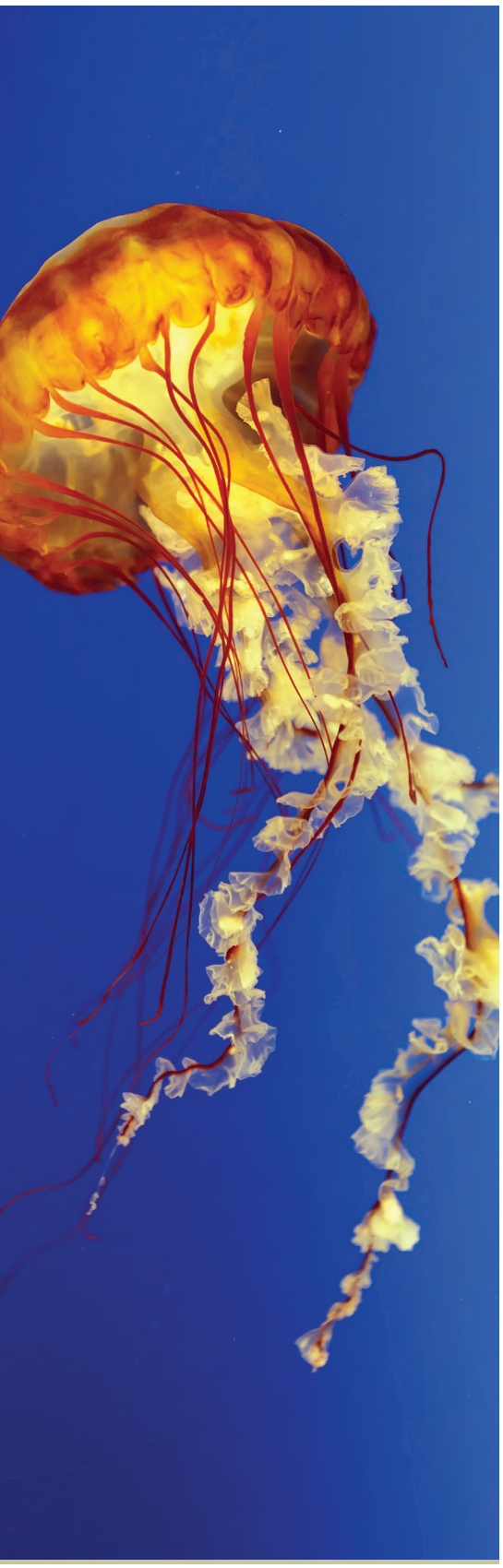

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- Diving Emergency Management Provider

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Summer 2016

ON THE COVER: Flower tree soft corals (*Umbellulifera* sp.) up to 3 feet tall create an otherworldly forest on Indonesian sand at 100 feet. Brandon Cole took this photo using a Canon EOS 5D Mark III with a Canon 16-35mm f/2.8 II lens in a Seacam housing with Ikelite DS161 strobes (2) and an exposure of 1/125 sec @ f/11, ISO 1600.

THIS PAGE: The *Benwood* was a casualty of World War II. Running without lights at night to avoid detection by U-boats operating off the Florida coast, it collided with another freighter and sank in 25-40 feet of water off Key Largo, Fla. Photo by Stephen Frink

DEPARTMENTS


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Summer 2016

Key Largo's most popular dive spot, Molasses Reef, offers considerable dive opportunities in 25-30 feet of water. There are also three seaward mooring buoys designating "Deep Molasses," which lies in 45-65 feet of water. Angelfish such as these gray angels (*Pomacanthus arcuatus*) are quite common there. Photo by Stephen Frink

DEPARTMENTS

Cocos Island's brave and well loved dive boat the former Undersea Hunter is moving to

Guadalupe and Socorro Island!

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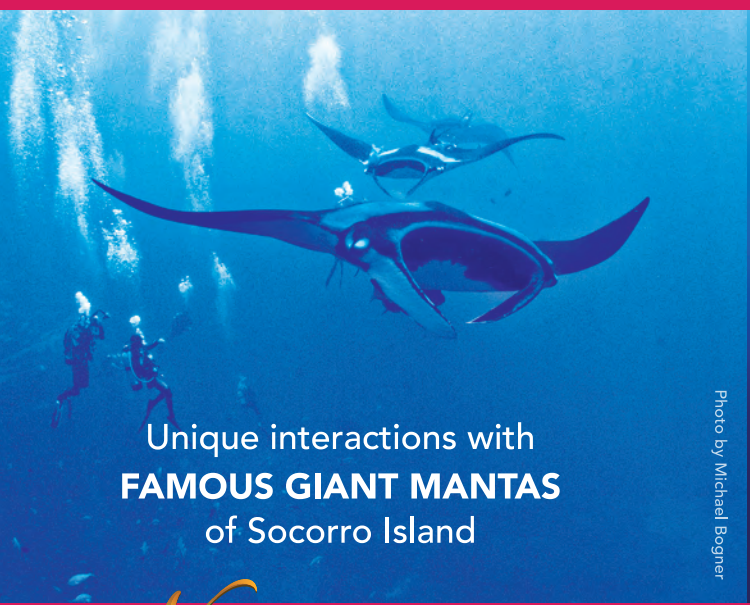

Unique interactions with
FAMOUS GIANT MANTAS
of Socorro Island

Photo by Michael Bogner

Dive to 30 ft with
GREAT WHITE SHARKS
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ENGAGING OUR DIVING COMMUNITY

By Bill Ziefle

Since DAN® was founded in 1980, our purpose has been clear: to provide resources to assist divers in need. Over the years we've evolved and developed different approaches to helping divers, and we've dedicated considerable effort to researching how to prevent dive accidents.

For years DAN medics and researchers have collected and analyzed case reports to identify common factors in dive accidents. This work has been summarized in DAN's annual dive accident report since 1988. Based on these data, DAN has created educational materials designed specifically to address the most common hazards divers face. Knowing our responsibility did not end there, we then strategized about how best to make these resources available to all divers. Our solution: Get out into the field and share our information with those on the front lines of recreational diving.

Much of DAN's early outreach efforts were directed at medical professionals and first responders. DAN organized workshops and conferences on topics such as decompression sickness (DCS), dive fatalities, flying after diving, DCS management in remote locations, technical diving, nitrox, rebreathers, patent foramen ovales (PFOs) and immersion pulmonary edema (these workshop proceedings can be found at *DAN.org/research/workshops*). DAN has given hundreds of seminars, presentations and lectures to recreational divers at dive shows, dive club meetings and other events around the world. We welcome opportunities to share our knowledge and expertise, and we encourage you to contact DAN (*DAN.org/email*) if you need a speaker for your event.

We also recognize the vital roles of dive professionals and dive operators in diver safety. It is critically important to provide these key players with the tools they need for incident prevention and management. We recently set about revitalizing our field representative program. Our field representative based in Durham, N.C., spent months on the road visiting stores and instructors in high-volume areas to meet face to face, discuss their dive-safety-related concerns and provide them with the resources and materials we've developed.

Starting in California and Florida — California has more divers than any other state, and Florida has the most dive accidents and fatalities — our field rep met with more than 300 dive professionals at more than 200 facilities. We provided our new Health and Diving reference materials to every facility and showed them how to access DAN's digital resources. Our goal is to build and strengthen alliances through which we can better provide safety messages to new divers.

To ensure consistent contact with these key players, DAN hired additional field representatives who live and work in the areas where the most diving takes place. Having DAN staff in the field who are attending local events, giving presentations and advocating dive safety will help us achieve our goal of reducing the number of dive accidents and fatalities each year. We believe our physical presence in these vital areas can enhance the entire community's safety awareness.

DAN Research recently developed a series of presentations for the largest two-day recreational diving event in the world: Florida's spiny lobster sport season ("mini-season"). Thousands of divers participate in this event each July, and, on average, two die every year. Our presentations cover the relative risks of diving during mini-season, compare lobster hunters with nonhunters and highlight important factors hunters should consider. DAN staff gave presentations throughout southern Florida in an attempt to reduce incidents and continue our engagement with the community.

We know there's no better way to connect with people than meeting them where they are, face to face. Through our community-engagement efforts, we will continue to promote safe diving, improving the sport for every diver.

For more information on DAN events in your area, visit *DAN.org/Events*. AD

DAN
YOUR DIVE SAFETY ASSOCIATION

Engage Smarter

With DAN Educational Resources

Your Go-To Resource for Dive Safety Information

We believe a smarter diver is a safer diver, so we want to arm you with the information needed to stay safe both in and out of the water. Available online and in print, DAN's Educational Resources address topics relevant to the new and experienced diver. Engage smarter, and join DAN in the goal of making every dive accident-free.

- *Health & Diving* Reference Library
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- Webinars, Safety Quizzes and Online Seminars

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CONSCIOUS CONSERVATION

By Stephen Frink

On World Oceans Day I saw a social media post from National Geographic that featured a number of classic images by underwater photographer David Doubilet. They were legacy photos, representing a few highlights from a life well spent documenting the world beneath the sea. As strong as the photos were, the quote at the end resonated with me most:

> "Every day is World Oceans Day. Small changes can make a big difference. Eat sustainable seafood. Recycle and minimize plastic in your world. Become a citizen scientist. And meet the ocean — set a date with the sea."
>
> DAVID DOUBILET

This came from a guy who has been diving and shooting for more than half a century (*alertdiver.com/David_Doubilet*), and it reinforced a persistent thought I've had over the past few years: Any of us who have spent decades as passionate scuba divers will have seen changes in our marine environment, rarely for the better.

Some events were sudden. I remember the singular week in the summer of 1983 when I noticed all of the long-spined sea urchins (*Diadema antillarum*) that I'd been cussing every time they punctured me on a night dive were now nothing more than circular clumps of debris on the seafloor, victims of a mass mortality that covered the entire Florida Keys and Caribbean. I didn't know then how crucial they were to the health of the coral reef, but they were grazers that helped keep algae under control. (To learn more about the importance of grazers, see "Parrotfish: Grazers of the Reef" on Page 38.)

BRUCE DICKSON

Have you ever noticed how hard it is to get a drink without a straw? At this seaside restaurant in Key Largo, despite asking the server multiple times for no straw, each drink came in a plastic cup with a fresh straw.

Most of the changes have been subtler — fewer fish here, less clear water there. It's more of a death by a thousand cuts than a decapitation. This is not to say there aren't amazing underwater adventures ahead, for there are. But clearly we can't be cavalier about the health of the ocean, and as divers and good global citizens we should do our part to preserve and protect it.

I think about that when I go to a bar or a restaurant and wonder why the drinks are served in plastic cups and why it is so hard to get a drink served without a straw. For the same reason, I ask Starbucks to not give me the green plastic stopper they inevitably do each time I get a coffee at the drive-through. I don't need

plastic straws, and I don't need plastic coffee-cup stoppers. I can bring reusable bags to the grocery store, and when they ask "paper or plastic?" I can happily say "neither." Doubilet says to eat sustainable seafood, which I think is a fair position, but since I can't quite figure out what is sustainable and what isn't, I find it easier to simply not eat seafood. I don't mean for this to just be about me; I mean for it to be about thoughts each of us might have when we think how we might live better to help our oceans flourish longer.

We can drive more fuel-efficient cars. We can take shorter showers. We can look into solar or wind alternatives to the electricity we consume. We can all chip away at it, making subtle (or extreme) changes in our lifestyles to reduce our carbon footprints. I think of this each time I go to a banquet for some marine conservation or dive group and see massive bowls of shrimp. I'm astonished by the disconnect between a fishing practice that is so extraordinarily wasteful in terms of bycatch and people who profess a love for the sea.

On the other hand, sometimes I see something that seems small but is such a good idea it makes me feel optimistic and proud to support it. One such concept is from Saltwater Brewery, a small craft brewery in Delray Beach, Fla., that is making biodegradable and edible six-pack rings from barley and other ingredients left over from the process of making their beer (*alertdiver.com/edible_rings*).

There is absolutely no reason not to use edible six-pack rings. Plastic rings are actually kind of barbaric when you consider the sea life killed and maimed because of them. It is not enough to cut plastic six-pack rings with scissors; even if turtles don't get them around their necks they, along with fish and seabirds, can still ingest the plastic. This is an idea that I hope gains massive momentum — beyond the local impact it will have with the divers, anglers and surfers who drink their beers. When Budweiser adopts edible six-pack rings the needle will have moved significantly.

One step at a time, small efforts can chip away at a big problem. But such efforts evolve from awareness of the need to protect our oceans and a logical and thoughtful analysis of the personal actions we take and how they might influence marine conservation. We can't change the world all at once, but we can change *our* world by thinking about the consequences of our actions. AD

Stephen Frink

WHAT'S NEW ON ALERTDIVER.COM

BRANDON COLE

ALLURING ALOR

Discover a new Indonesian frontier in Brandon Cole's "East of Flores" (Page 66), and go online to see more spectacular images in his bonus photo gallery.

CAPTIVATING CURAÇAO

Leave the crowds behind and venture to Curaçao with Andy and Allison Sallmon (Page 74), then see more of its undersea glamor in their online photo gallery.

ANDY SALLMON

COURTESY GARY GENTILE

DIVING THE *DORIA*

After reading Michael Menduno's retrospective on the challenges of diving the *Andrea Doria* (Page 16), go online to watch videos of several dives on it over the years.

FREEDOM FROM GRAVITY

Learn how scuba has helped Cody Unser and others with paralysis (Page 106), then watch the trailer for a documentary about her journey.

MARLA BROSE/ALBUQUERQUE JOURNAL

ALL THIS AND MUCH MORE AWAIT AT ALERTDIVER.COM

DON'T FEED THE 'CUDA

Stephen Frink's article "Don't Try This at Home" (Publisher's Note, Spring 2016) makes good points about the dangers of feeding wild animals and about the consequences of sensationalizing dangerous behavior. But he misses one additional point: Hand feeders train wild animals that food is attached to divers. It is not hard to see why this is a really bad idea.

My buddy and I were diving the *City of Washington* wreck a few years ago. As soon as each diver did a giant stride, a huge barracuda was right in the diver's face. My buddy got a great close-up photo, but we didn't know at the time that our faces were being treated as potential snacks thanks to feeder training.

— Harvey S. Cohen, Ph.D., via email

COURTESY PAT FORD

Here's the barracuda bite story Stephen Frink referred to in his article "Don't Try This at Home": In 1986 we were filming a video (*Dive Pennekamp*) for the park, and they wanted footage to show that the "dangerous" marine creatures were not all trying to kill you. I was feeding "Smokey" from my mouth a la Capt. Slate. We shot well the first day and then came back to finish up. I was descending with a bag of ballyhoo as Smokey came over. I usually fed him several free-floating ballyhoo initially so he'd get calm. I put out the first 'hoo and intended to just float it in the water column, but I took my eye off the barracuda and held the bait too long. His front teeth got my index finger and the back of my thumb. The thumb healed up fine, but all the tendons in my index finger were cut. After two operations it still doesn't bend. I was very lucky that Smoky only nipped me — I could easily have lost most of my hand and bled to death before I could get back to shore.

— Pat Ford, via email

SENIOR DISCOUNT?

In response to the question in the Spring 2016 issue about aging and diving (From the Medical Line, Page 54): There are dive shops that do discriminate based solely on age. I ran into this problem during a 2015 Caribbean cruise with my wife and grandson. I am a 67-year-old experienced and active diver with many certifications, and I'm in reasonably good health. I do not take any medications, and I carry a doctor's release to scuba dive. The dive shop's age limit was 65. I never even got to fill out a medical questionnaire or present my certifications; they saw the birthdate and said I could not dive with them. To my knowledge, none of the dive certifying agencies have an age limit. I would recommend to any senior diver to check with a dive operation before booking dives or a trip.

— Ronald Culbertson, via email

A RUDE AWAKENING

The point of Stephen Frink's article "Fit to Dive?" (Publisher's Note, Winter 2016) was vividly brought home recently. In mid-March I was on a liveaboard trip in the Channel Islands off Santa Barbara. Our trip

was cut short when halfway through the first day a diver surfaced facedown in the water. Despite the rapid response of the other divers and crew to get him back on board as well as vigorous, relentless CPR, he was simply gone. Though I was not privy to the final word from the coroner, we all pretty much guessed that he died of a heart attack.

He was an experienced diver, having started in the 1980s, but had been away from diving for many years. This was to be his first splash back in the water after a long time. He had the look of somebody who could've taken better care of himself, and that has certainly inspired me to start taking better physical care of myself as well. Having never seen anyone actually die in front of me, much less in the context of diving, this was a rude awakening. We get used to hearing the stories of misfortune befalling other people. But when you see it in front of you, you suddenly realize that it could happen anywhere, to anyone, and it inspires you to do what you can to tilt the odds in your favor. Shedding a few pounds and doing a little more exercise is a small price to pay for improved odds.

— Niles Szwed, via email

RINSE YOUR LEAD

I began diving when there were no buoyancy compensators or tank pressure gauges, and we often made our own weights by melting lead and pouring it into molds. The fumes from the molten lead must have been dangerous. My question: Are uncoated lead weights a hazard to divers?

— Thomas Blandford, via email

Molten lead does not really give off fumes until it passes 900°F. Our melting furnaces had thermocouples that would shut down the equipment if the lead temperature exceeded 800°F.

If we are talking occasional handling, there's really no issue, but if you want to take additional precautions I recommend making sure the weights are rinsed in freshwater and allowed to dry thoroughly. Salt takes moisture from the air and can increase oxidation, promoting formation of lead oxide. This is critical with soft weights, as the surface area to create lead oxide is huge.

The only real issue is hand-to-mouth transfer of lead. Wash your hands after handling and before eating or smoking (lead can get on the cigarette paper, burn and be inhaled). Lead used in weights cannot be absorbed through osmosis. The body can uptake lead only as fast as it can take up calcium. As I told my employees, you can eat a lead weight and it will be uncomfortable; lick it every day, and it will kill you. AD

— Lee Selisky, founder, Sea Pearls diving weights; member, DAN board of directors

WRITE US

Tell us what's on your mind by writing us at:

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ONLINE
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All letters included in this column are subject to editing for length and content.

DIVE SLATE

REMEMBERING THE *ANDREA DORIA*

By Michael Menduno

In June 2016, the ocean exploration company OceanGate conducted three nearly four-hour submersible dives and multiple sonar scans of the SS *Andrea Doria* — arguably the world's most iconic shipwreck — in commemoration of the 60th anniversary of its sinking. The expedition was cut short because of high seas and the dense fog common at the site, which lies 110 nautical miles east of Montauk, N.Y., and 45 miles south of Nantucket, Mass. The company's findings were consistent with reports of divers familiar with the wreck: The "Grand Dame of the Sea" is rapidly deteriorating.

"In the old days she was largely intact. You could go inside and recover artifacts," explained Gary Gentile, who has made 200 dives to the wreck and written two books about the 700-foot Italian luxury liner that sank on July 26, 1956, after colliding with the MS *Stockholm*. "Today every place I explored inside the wreck no longer exists. The insides are gone — collapsed."

What remain are the wreck's storied past and the fact that the improbable loss of the *Doria*, which has subsequently claimed the lives of 17 scuba divers, irrevocably changed the nature of wreck diving.

It was prescient that the first divers on the wreck — investment-banker-turned-explorer-and-filmmaker Peter Gimbel and editor Joseph Fox — were amateur scuba divers. The two plunged 160 feet through the dark, frigid, oily water using primitive scuba gear to get the first underwater pictures of the *Doria* for *Life* magazine. Gimbel, 28, had negotiated the assignment two days earlier by phone as the sinking steamer was being evacuated.

Over the next 25 years, the *Doria* was visited infrequently. Gimbel led five expeditions, recovered the purser's safe in 1981 using commercial diving equipment and produced two documentaries and a TV show. There was a French filming expedition and an Italian expedition with cinematographer Al Giddings, who compared diving the *Doria* to climbing Mount Everest, leading to the wreck becoming known as the "Mount Everest of diving." There were also several unsuccessful salvage operations that used saturation diving systems.

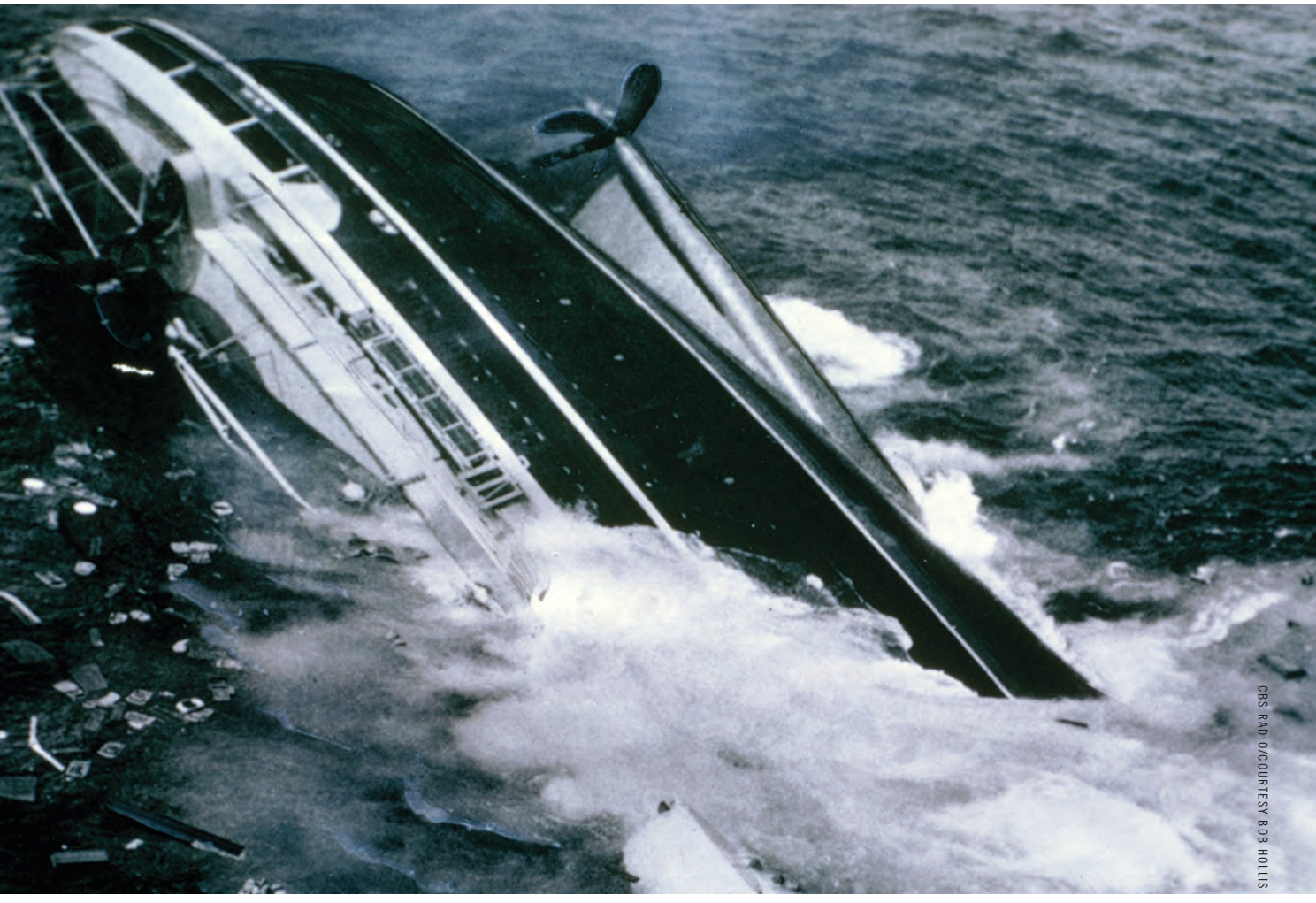
BRAVING MOUNT EVEREST

It was only a matter of time before the first wreck divers ventured out to test their mettle on the famous, art-laden shipwreck. In 1966 Michael deCamp, considered the father of Northeast wreck diving, chartered a fishing boat and ran the first of two trips. The following year on deCamp's second trip, Evelyn Bartram Dudas became the first woman to dive the *Doria*.

But it wasn't until the early 1980s, with the introduction of a reliable, diver-friendly means of getting to the wreck, that *Doria* diving became accessible. "We changed the dynamics," said Capt. Steve Bielenda, who built the 55-foot RV *Wahoo* (which could sleep 26 and had a galley) for that purpose. "I wanted a dive boat that could run offshore and stay for a couple of days." *Wahoo*, along with *Seeker* and *Sea Hunter*, began running up to three trips each season.

Diving the *Doria* on air was a perilous proposition. Not everyone could tolerate the debilitating narcosis at the 160- to 250-foot depths, which was compounded by the cold, murky North Atlantic and disorienting interior of the wreck, which lies on its starboard side. In addition, there was the risk of oxygen (O_2) seizures, and air decompression was unreliable — divers routinely got decompression sickness (or "the bends"). Conditions offshore are also volatile, which necessitates limiting dive profiles to two hours or less.

Clockwise from top: **The 700-foot luxury liner *Andrea Doria* sinks beneath the waves at 10:09 a.m. on July 26, 1956. Joseph Fox poses with a lifeboat on the *Andrea Doria* at 145 feet on July 27, 1956. The *Andrea Doria* was the pride of the Italia Line. The ship sank during its 100th transatlantic voyage.**



CBS RADIO/COURTESY BOB HOLLIS

"MOUNT EVEREST OF DIVING"

COURTESY ITALIA LINE

PETER GIMBEL/SILVERSTEIN-WEYDIG COLLECTION

As a result, the *Doria* became the tipping point that led Northeast wreckers to adopt mixed-gas technology to improve their safety and performance. Eventually others followed. The catalyst: Technical diving pioneer Capt. Billy Deans began developing mix protocols after losing his best friend, John Ormsby, on an air dive on the *Doria* in 1985. That same year Deans helped Bielenda install an O_2 decompression system on the *Wahoo* that got divers out of the water faster and with fewer bends. Soon everyone was decompressing with oxygen.

In 1991, with Deans' support, the *Wahoo* hosted the first mixed-gas expedition on the *Doria*. Led by explorer Bernie Chowdhury, it signaled the eventual demise of deep air diving. "[Mix] put divers on par with those who could tolerate the narcosis," Gentile said. "It enabled them to make dives they couldn't have before." Before long, mixed-gas classes were booming, and the *Doria* became tech divers' No. 1 destination.

Peter Gimbel and his wife, Elga Andersen, pose with the contents of the *Doria*'s safe, which was opened on live television in 1984.

RESCUING THE CHINA

Although there were always rival factions, *Doria* divers formed a close-knit community, which still persists to this day. Expedition leader Joel Silverstein, who has 60 dives on the wreck, said that the relationships he formed while diving the *Doria* had the biggest impact on him. "We share a common bond having gone down that anchor line," Silverstein said. "We carry rust from the *Doria* on our drysuits." He estimates that perhaps as many as 1,500 divers have dived the *Doria*, but only about 50 divers have more than 10 dives on the wreck. By comparison, about 4,000 people have climbed Mount Everest.

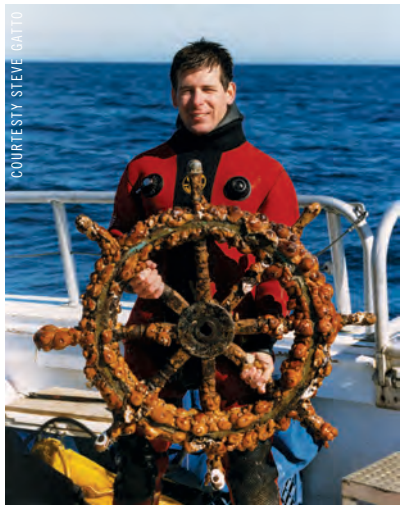
That community has helped keep alive the memory of the *Doria* and has recovered some of its artifacts: two bells, two Guido Gambone friezes, a bronze statue, the helm, the compass and thousands of china dishes, among others. "Recovering artifacts has been my primary motivation," said *Doria* historian John Moyer (120 dives), who has an "admiralty arrest" on the wreck, giving him ownership of specific contents. "We have to rescue what we can before it's irretrievably lost." Moyer hopes to create a permanent *Doria* museum.

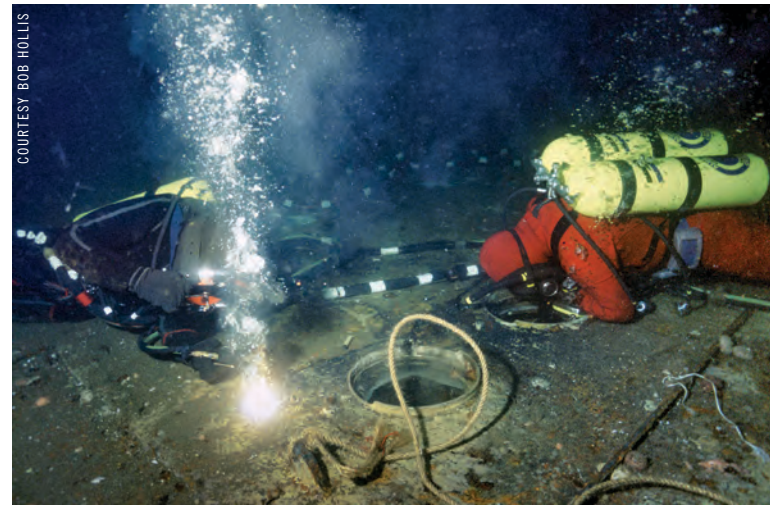
Today there's a drastic reduction in the number of divers venturing to the *Doria*, and it can be difficult to fill a single charter. Not surprising, rebreathers have replaced open-circuit scuba as the technology du jour. Last year *Doria* veteran Bart Malone (179 dives) was the only open-circuit diver on a private charter of 12.

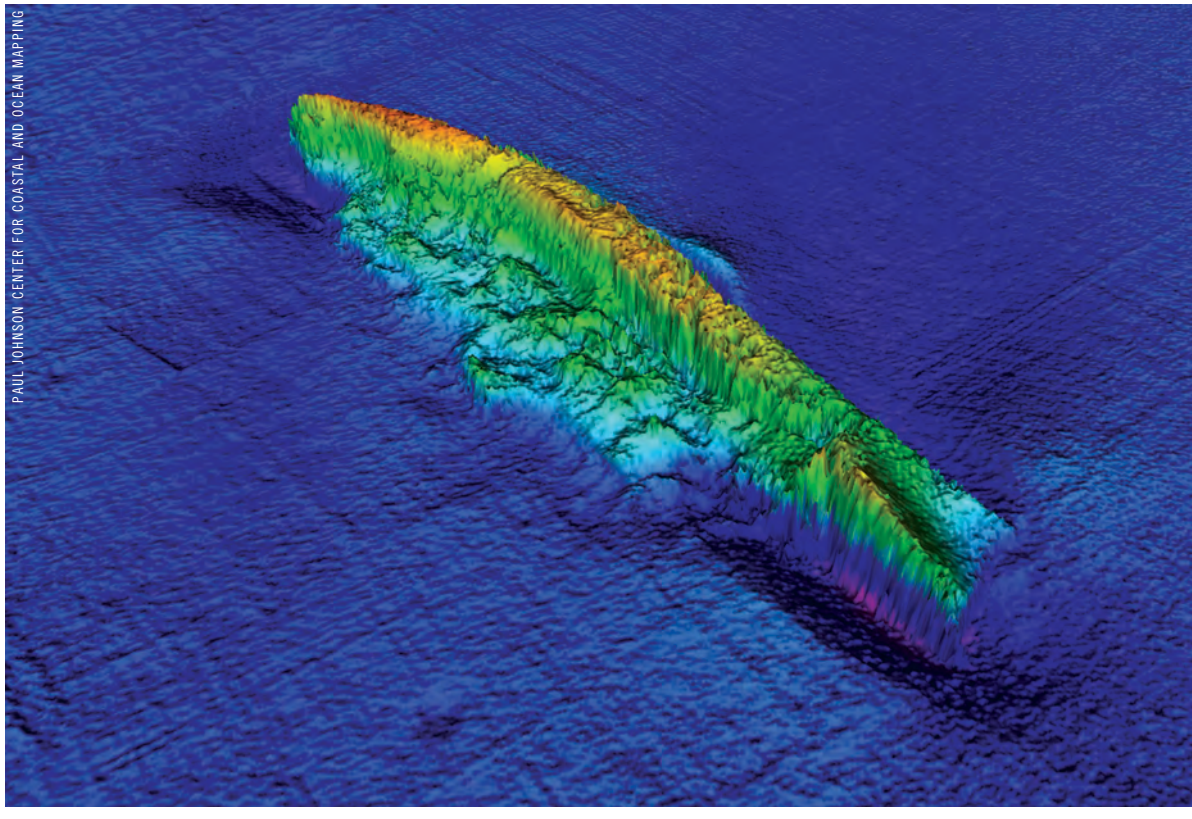
The prospects of finding artifacts have also changed. In the old days divers were almost guaranteed a souvenir; today they are much harder to find. But that hasn't deterred longtime divers such as explorer and photographer Steve Gatto, who plans to conduct his first rebreather dive on the wreck this summer.

Gatto has made close to 250 dives on the *Doria*, including the deepest penetration with Tom Packer (150+ dives), and both divers signed the "arrest" claim on the *Doria* along with Moyer. Gatto said that the deterioration of the ship is a double-edged sword. "While closing off old areas, it is opening up new ones," he said. "There will always be something to find." AD

"THERE WILL ALWAYS BE SOMETHING TO FIND."


COURTESTY STEVE GATTO

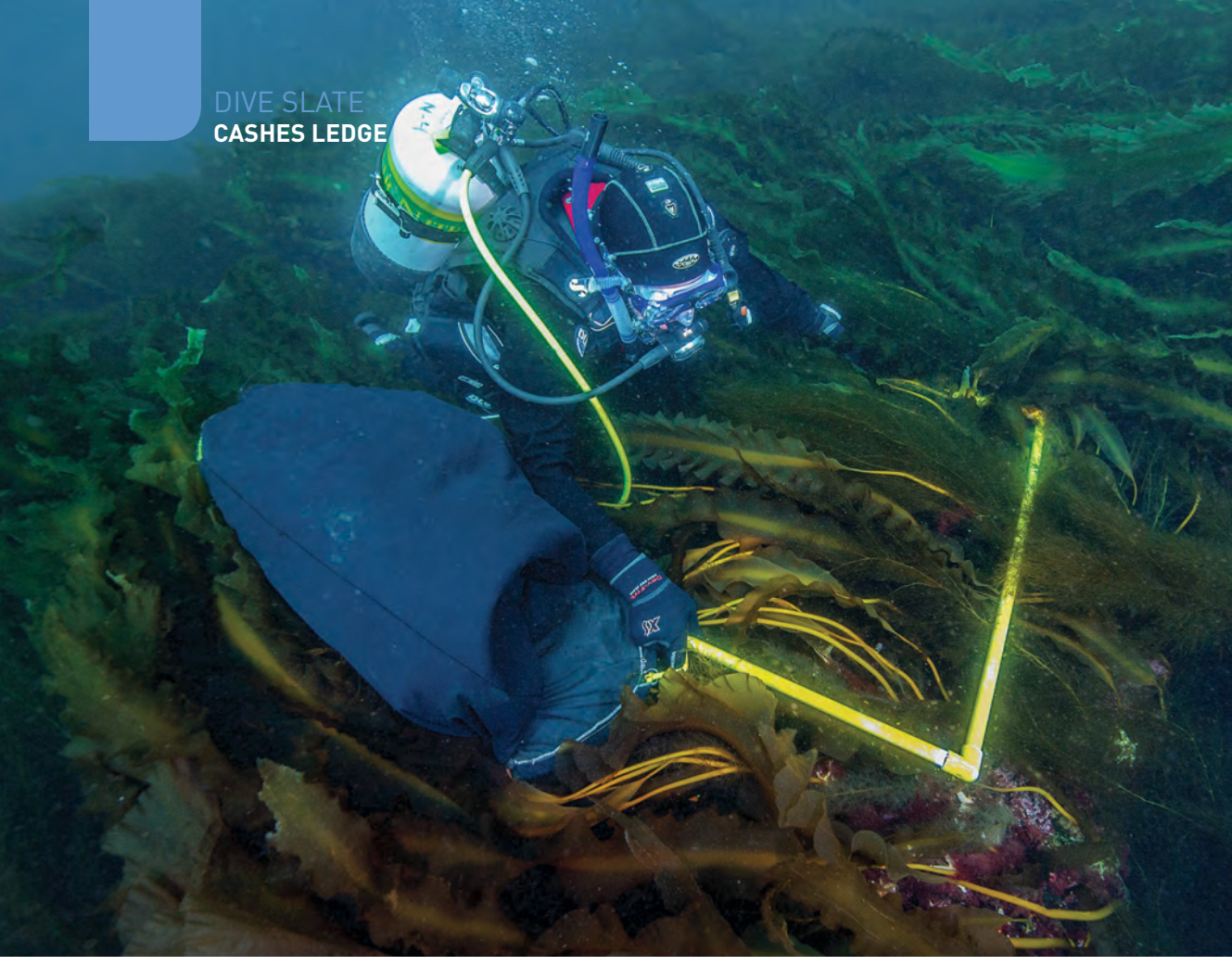

COURTESY BOB HOLLIS


PAUL JOHNSON CENTER FOR COASTAL AND OCEAN MAPPING


SILVERSTEIN-WEYDIG COLLECTION


COURTESY GARY GENTILE

Clockwise from top left: **Steve Gatto holds the *Doria*'s aft helm in 1987. Bob Hollis, founder and CEO of American Underwater Products, assists Don Roddocker, co-founder of Saturation Systems Inc., who is cutting an entry hole in the *Doria*'s foyer doors in 1973. Sidescan sonar image of the *Doria* from the Paul Johnson Center for Coastal and Ocean Mapping, University of New Hampshire (used with permission). Shipwreck historian and author Gary Gentile holds the *Doria*'s stern bell in 1985. Peter Gimbel, using a surface-supplied band-mask, uncovers plates and cutlery on the *Andrea Doria* in 1981.**



Cashes Ledge is an underwater mountain range located 100 miles offshore of New England and notable for its dense populations of kelp, lobster and other marine organisms.

CASHES LEDGE

THE YELLOWSTONE OF THE NORTH ATLANTIC

Text by Evan Kovacs | Photos by Brett Seymour

Off the coast of New England, 80 miles from Cape Ann, Mass., lies an anomaly. An ecosystem that is unexpected, beautiful and unrivaled in the North Atlantic exists there — it would seem less out of place in the Caribbean or amid the kelp forests of the West Coast. Fisheries biologists and fishermen have long been aware of its existence because the rich ecosystem serves as a nursery for many species of fish, most notably North Atlantic cod. It is one of the few places on the East Coast considered by scientists to be unique, flourishing and in need of permanent protection. Dubbed "the Yellowstone of the North Atlantic" and designated a Hope Spot by Sylvia Earle, the underwater mountain range called Cashes Ledge is a place that should be on everyone's radar, both as a one-of-a-kind dive spot and, I hope, the first Marine National Monument in the Atlantic.

Several years ago my friend Luis Lamar, a cinematographer, came back from an expedition with National Geographic photographer Brian Skerry to document an underwater mountain range in New England that very few people knew existed. Lamar spoke of mesmerizing kelp, caves filled with lobster, and schools of fish unlike anything we had seen in the area before. He spoke softly and eloquently, almost reverently, about Cashes. The trip had been sponsored by the Conservation Law Foundation (CLF), which seeks to photograph and protect unique and beautiful places around New England. Fortunately for me more trips were in the works, and they wanted to expand the underwater efforts to include high-resolution 4K video.

Getting to Cashes Ledge is an adventure unto itself. Diving nearly 100 miles off shore from relatively small boats can be a challenge and not suitable for those with delicate stomachs. Fortunately for our dive team, Priscilla Brooks, CLF's vice president and director of ocean conservation, had chartered the RV *Tioga* from Woods Hole Oceanographic Institution, and it made a wonderful dive platform. Most important, it cruised at

16 knots, which allowed the team to sneak in dives whenever an appropriate weather window presented itself, which was not very often. South of Newfoundland's Grand Banks and still susceptible to many of the weather patterns that can create very dangerous conditions (remember *The Perfect Storm*?), we spent many days waiting. Over three years of diving, we made it out on only six of the approximately 30 potential days and were rarely out for more than a single overnight at a time. But in the many hours of sitting at the dock or in a quaint little home in York Harbor, Maine, I met and listened to a passionate coastal biologist who has become the heart and soul of Cashes Ledge: Brown University biology professor Jon Witman, Ph.D.

Cashes Ledge would likely be little more than a name on the charts if not for Witman. He and his team began diving and studying the biodiversity

there in the 1980s, and what they found astounded them. They likened it to a time capsule from the 17th century — the cod were often as big as divers and were more plentiful there than anywhere else they had studied — as plentiful as in some of the early Pilgrim settlement accounts.

Compared with other coastal regions in the 1980s, Cashes Ledge was an outlier, in a good way, and word soon got out. By the late 1990s destructive fishing practices had devastated the area, and fish populations were collapsing. Laudably, the New England Fishery Management Council (NEFMC) imposed a ban on the most detrimental practices — bottom trawling and dredging — though it left the area open to others such as midwater trawling. With the ban in place, the populations have slowly started to rebound.

Hearing Witman tell stories about Cashes Ledge in the '80s — when schools of cod, pollock, cunner and other fish could be seen with myriad sharks, whales and other pelagics among the kelp — was both poetic and disheartening. He had the privilege of studying Cashes in its modern heyday, and he helplessly watched its subsequent destruction to the brink of collapse. Now he is documenting and quantifying its recovery with the help of CLF. The recovery, however, is not guaranteed; the ledge could be opened to all fishing and other exploitative activities at any time. CLF's mission was clear: They wanted to showcase the underwater world through imagery to reveal the magic of the ledge today and its potential for tomorrow.

Diving Cashes Ledge had been built up so much in my mind by Lamar, Skerry, Brooks and Witman that I was afraid it might be a letdown, like so many underwater places are these days. But it was a surreal dream of swaying kelp, playful cod, schools of pollock skirting the edge of vision and scenes of life I could barely have imagined. My eyes never left the camera

From left: **A scientist measures kelp to document its health. The biomass of kelp at Cashes Ledge is 50 times greater than that of other sites in the region. A sculpin hides in plain sight along a sponge-encrusted outcropping. Cashes is a magnet for marine mammals, including gray and harbor seals, and it may be a breeding ground for the North Atlantic right whale.**

"I FOUND MYSELF BENEATH THE KELP, FILMING ITS SOOTHING DANCE BACKLIT BY THE BLUE-GREEN SEA."

screen, and before I knew it I found myself beneath the kelp, filming its soothing dance backlit by the blue-green sea. I was rolled and tossed among its long golden-red stalks in harmony with their ebb and flow. In a blink it was time to ascend. Wide-eyed and transformed I surfaced, and for the first time ever I felt a need — an obligation — to help protect a place.

I asked Witman and his collaborator, Robbie Lamb, for bullet points about why, from a scientific point of view, Cashes should be protected. One thing in particular stuck out to me: Cashes Ledge currently has 500 times the fish biomass of any other nearby coastal site. That's a figure that should be incredible to anyone who has dived in New England and wondered where the fish are and, most important, where fish will come from in the future. When I first dived the ledge and saw all the tiny mussels and fish under the kelp, I thought of a nursery, and in many ways that is what Cashes is for its resident species. Perhaps a more important question is why so many adult fish remain there. Certainly the lack of fishing over the past 15 years has helped, but in other areas with the same type of protection the results are not the same.

What sets Cashes apart is its extraordinarily high density and sheer biomass of kelp — 50 times that of other nearby coastal areas. It is continually fed by cool, nutrient-rich water generated by a standing wave that occurs with great regularity at the site. This wave has been called a productivity engine; it creates constant upwelling and changes the water from cool with good visibility to warm with reduced visibility. It can be a strange and disorienting yet marvelous part of diving here. As the kelp thrives, it provides food and protection for the many fish that call it home. Then during its seasonal die-off, the detritus feeds species deeper in the water column.

Marine mammals of all sorts flock to the ledge, and there is evidence that it may even be a breeding ground for the highly endangered North Atlantic right whale. On any given day on the ledge you might encounter five or six different whales, schools of dolphin and even basking sharks. At the end of diving days we often wondered what was more unbelievable: the growing schools of cod and pollock playing in the kelp or the whales and dolphins feeding all around us on the surface?

As magnificent as Cashes is, it still has a long way to go. The fish populations are nowhere near where they were when Witman started studying them in the 1980s. Cod, which fed the United States and Europe for centuries, barely has a foothold on the ledge, especially when compared to historical numbers. The NEFMC ban has proven that Cashes has the ability to rebound, but scientists the world over have shown that permanent areas of protection are essential if we want fish populations to thrive, especially in the context of heavy fishing pressure.

CLF continues to urge legislators for permanent protections at Cashes Ledge. One of the biggest challenges it faced in the past was trying to protect an area that no one had heard of. With incredible foresight and in the spirit of older journalistic traditions of using science and imagery to create a movement, the efforts of Brooks, Witman and Skerry on behalf of CLF are slowly making headway in the push for protection. Because of their tireless efforts and with a little help from the images and story our team created, many people are now aware of Cashes Ledge's exquisite beauty and vital importance for our future fisheries. AD

LEARN MORE

For more information or to learn how to help Cashes Ledge, visit the following:
clf.org/making-an-impact/permanently-protect-cashes-ledge/
clf.org/blog/campaign/permanently-protect-cashes-ledge/
witmanlab.com/conservation-protection-for-cashes-ledge-gom.html

"The first time I met a sperm whale, it just blew my mind. But I was not able to adequately describe the experience to my wife and my children. You have to live it. Since virtual reality is always point-of-view, you are in the middle of the action. You are the actor."

— Fabrice Schnöller, researcher/diver, *The Click Effect*

FRED BUYLE/NEKTOS.NET

SHOOTING *THE CLICK EFFECT*

By Sandy Smolan

Over the past 25 years I have made films in just about every imaginable environment: the Sahara desert, the mountains of Peru, Nepal's hinterland, remote villages in East Africa and others. But until recently I had never directed a film underwater.

Last year I was invited to the Virtual Human Interaction Lab at Stanford University for an introduction to virtual reality (VR). The demonstration, in which viewers put on a headset to see a fully rendered 360-degree film image, made me completely believe I was suspended 30 feet in the air when I was still standing on solid ground. Being in VR felt exactly like being in the real world, and I was stunned by what I had experienced. I immediately realized that this technology had the potential to become a powerful form of storytelling, and I couldn't wait to make a film in this new medium.

Around the same time, I read James Nestor's book *Deep: Freediving, Renegade Science, and What the Ocean Tells Us About Ourselves* and realized that the story of two freediving researchers studying the language of whales and dolphins would be perfectly suited to VR.

Shortly after reading *Deep*, I partnered with Nestor, the Los Angeles-based VR startup company Vrse (now called Within), freedivers and researchers Fabrice Schnöller and Fred Buyle, and the Sundance Institute to produce *The Click Effect*, a VR film that allows viewers to make a deeper connection to the beauty of the world and to some of the world's most intelligent creatures: dolphins and whales.

The film follows Buyle and Schnöller as they freedive deep beneath the ocean's surface to record the "click"


FRED BUYLE/NEKTOS.NET

Six GoPro cameras are mounted within a single housing to achieve a 360-degree view. Special filming techniques were developed to accommodate this unique field of view.

communication of cetaceans. One of the first VR films to be shot almost entirely underwater, *The Click Effect* includes never-before-seen 360-degree footage of face-to-face encounters with bottlenose dolphins, pilot whales, humpback whales and sperm whales, which are among the world's largest predators.

VR films are made using multiple cameras shooting in every direction and then using advanced software to stich together the images from all the cameras into a continuous 360-degree shot — like taking a panoramic shot and stretching it in every direction.

Schnöller had shot all of the necessary whale and dolphin encounters, but we still needed footage that told the story of their research and that would allow others to experience diving underwater. With time of the essence, we needed a single destination that would provide excellent variety and quality of diving; we selected Grand Cayman. The water was extraordinarily clear, and the dive sites were all close to shore and within minutes of each other, allowing easy access to multiple sites each day. The island has several significant wrecks including the USS *Kittiwake*, which we knew would photograph well and have great presence in VR.

Our dive team consisted of my partners, Nestor, Schnöller and Buyle; my son, Reed, who is a dive instructor; local guide Graham Johnson and our boat captain, Brad Nelson. In our first day of scouting we identified five primary dive sites, which included the wrecks *Kittiwake* and *Doc Polson* as well as Devil's Grotto, Eden Rock and an above-water remote location on the north side of the Island.

After deciding on these sites, we planned how we would shoot sequences in each location. VR is a new medium, and many of the traditional rules of underwater cinematography no longer apply. This uncharted film language and new shooting methods are in the early stages of development, and we broke new ground in VR while shooting *The Click Effect*.

Schnöller had worked with the French company Kolor to develop an underwater VR rig that uses six GoPro cameras mounted in a bubble housing. He used this rig to shoot all of the dolphin and whale footage, and we brought two of these units with us.

Since the cameras photograph in every direction, we needed to rethink many of the normal conventions of filmmaking. The director and crew can no longer be "behind" the camera, since

everything is visible in the shot. We had to carefully plan the placement of the camera and the action that would happen around it. I also knew camera movement was critical. We experimented with various methods, including tethering the camera to a long pole held in front of one of the divers, adjusting the buoyancy of the rig and weighting it just enough to allow it to slowly rise or fall through the water or allowing it to hover or settle onto the ocean floor.

Each of the six cameras had to be turned on individually while on the boat, and then the rig had to be sealed and lowered into the water, where we would have approximately 30 minutes of shooting time for each set of takes.

In 360-degree filming even divers on the surface can be seen, so I had to establish each scene and then swim out of the shot. Reed, Johnson and I would accompany the freedivers down to determine the shooting positions for each location and then rise to near the surface to watch the first take before getting back aboard the boat while the freedivers continued filming. It was a laborious process and equivalent to shooting blind, since these early rigs don't allow for director viewing monitors.

Every film opens a door of discovery, and this was especially true in shooting *The Click Effect* in VR. We had to learn how transitions would work from shot to shot (since you can't cut from a close-up to a wide shot), figure out how to draw the audience's attention to different parts of the frame with sound and image, and determine how traditional dissolves and narration would work. It's rare to be on the ground floor of a new storytelling medium when there aren't yet any rules. But with this comes a huge responsibility to figure out how to create a new language to tell powerful stories that audiences are going to want to watch.

We returned to Los Angeles and for the next six weeks worked with our team of engineers, editors, composers and visual-effects artists to finish the film. It was finally completed at 2 a.m. the morning of its initial launch at Sundance in January 2016.

The Click Effect was extremely well received and was also showcased at the Tribeca and Seattle International film festivals. The first Op-Doc VR film published by *The New York Times*, it is available now as a free download on the Within and NYTVR websites.

At the Sundance Film Festival a paraplegic man in a wheelchair took off the headset after watching the film, and tears were streaming down his face. We asked if anything was wrong, and he replied, "No, it's just that I have always dreamed of swimming with dolphins, and I just have." AD

Below, from top: **Bonnie Toth was awarded the Historical Diving Society's E.R. Cross Award in 2014 for distinguished service. Toth lines up for a perfect whale shark photo in the Philippines. Bonnie and Doug Toth in the Women Divers Hall of Fame booth at Beneath the Sea in 2007, the year of her induction.**

Opposite, from top: **While diving Utila on a WDHOF trip, Toth was rewarded with an intimate encounter with a green moray eel. Toth is a highly skilled creative designer, and many of the hours she spends working on her computer above water are for the dive industry, often for the nonprofit sector.**

BONNIE TOTH

By Maurine Shimlock

Hometown: San Clemente, Calif.
Years Diving: 37
Favorite Dive Destination: Socorro Islands
Why I'm a DAN Member: It gives me great peace of mind.

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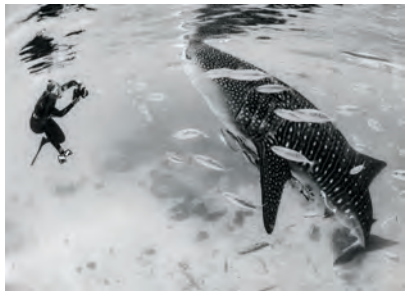


ERIN O'NEILL

COURTESY BONNIE TOTH

At the Diving Equipment and Manufacturing Association (DEMA) Show in November 2016, the Academy of Underwater Arts and Sciences will award Bonnie Toth with scuba diving's highest honor: the New Orleans Grand Isle (NOGI) award for distinguished service to the dive industry. Musing about what this prestigious award will mean for her, Toth says she was totally surprised and hardly expected to make the short list of nominations, let alone win. But this is a woman who has dedicated her life to making the world a better place, or "paying it forward" as she likes to say, by "using diving as the vehicle — the way I transform my beliefs into reality."

Toth's love affair with the ocean began after her service in the Air Force. "When I joined the Air Force after high school, I started skydiving and completed more than 200 jumps," she explained. "After I came back to California, skydiving became too complicated to arrange, so I thought I should learn to scuba dive. I went from air space to sea space when I became a certified diver in 1979."

The more Toth learned about the marine world, the more she wanted to become an ambassador for the environment she loved. "I studied graphic design and spent lots of time underwater along California's central and southern coasts," she said, "so I thought about how these two important aspects of my life could come together."

During the 1980s, California was a hotbed of scuba innovation, and Toth's design company led the way in influencing public perception about the sport. Today we all know about branding — the way media constantly promotes products and influences sales — but 30 years ago the process was a bit more subtle. Through her designs for clients such as Scubapro, Aqua Lung, Sea Quest and many others, Bonnie Toth Design helped countless divers decide which buoyancy compensator or regulator they would depend on.

Her passion for the marine environment and her lively designs are rooted in her positive attitude. "When I meet with a client, I try to determine who their market is and why those people want to interact with the ocean," Toth said. "Invariably people want to immerse themselves in an unknown world and exert a positive influence through their interactions."

A two-day encounter with a female humpback whale and her calf — "who just stayed with our liveaboard in Socorro," she said — strongly reinforced Toth's connection to the ocean. "That was a life-changing experience for me," she said. "I was dumbstruck by how the mother humpback kept her baby close yet obviously wanted it to engage with and get to know the curious humans who swarmed around the pair every chance they had. After that experience, I began to work even harder to use my design to send messages of hope and the potential for favorable changes, especially for the younger generation. That's one of the reasons I now do a lot of pro bono work for the Ocean Institute at Dana Point; they are focused on educating children through inspirational interactions with the ocean."

Toth said the success of her design business has allowed her to focus her attention on clients and areas of specialty that matter to her and

KAREN STRAUS

COURTESY BONNIE TOTH

have an impact on the future of our planet. After being inducted into the Women Divers Hall of Fame (WDHOF), she decided to use her organizational and design skills to initiate change within the organization. She has served on the board and as president of WDHOF, using her position to guide and mentor individuals who are working toward careers that involve diving.

"I feel that those of us who have been successful in the dive industry have an amazing opportunity to engage with and help the next generation of marine scientists, journalists, educators and artists realize their goals," she said. "When the WDHOF scholarship program started in 2002, we awarded about $1,500 total. In 2015 more than $62,000 went to recipients who I believe will work for the betterment of the marine world."

One of Toth's other favorite dive trips inspired her to work with the Historical Diving Society, and she recently designed a poster commemorating the 100th anniversary of the U.S. Navy Mark V diving helmet. "We dived at Bikini Atoll, and the experience of diving in that historical spot really motivated me to learn more about the history of diving," she said. "Without knowing about our past, we cannot adequately prepare for the future."

When asked why she became a DAN member, Toth replied, "It gives me great peace of mind when I travel to places that lack proper facilities and medical support." While she hasn't had to use DAN's emergency services during her nearly 40-year diving career, she sees a lot of similarities between her work and DAN's mission. "We're both 'divers helping divers,'" Toth said, "and we agree that through education we can support the sport we love." AD

PUBLIC SAFETY ANNOUNCEMENT

LIONFISH AWARENESS

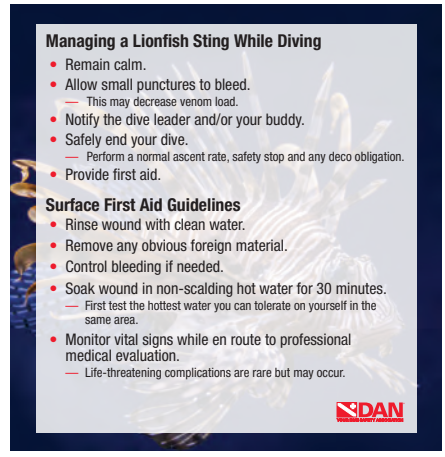
Lionfish, also known as zebrafish or turkeyfish, are venomous reef fish of the genus *Pterois*. Native to the Indo-Pacific region, lionfish are now found in oceans across the globe. Lionfish pose little threat to divers, but invasive populations have wreaked havoc on juvenile reef-fish populations in the western Atlantic. To combat the spread of these greedy predators, recreational divers in the Americas have started aggressive campaigns to hunt them. In the process, divers are occasionally stung by a lionfish's sharp spines, which can cause very painful and sometimes complicated wounds.

As a diver, here is what you should know about lionfish.

Lionfish Are Often Underestimated.
Lionfish have no natural predators and are therefore generally docile. Their docility allows divers to approach closely and makes them easy targets for spearfishing, but it also means that divers may underestimate these fish. While rarely fatal, lionfish envenomation can cause extreme pain.

Lionfish Are Hazardous.
Most incidents occur as a result of careless handling, usually during spearfishing or while preparing the fish for consumption. Lionfish have needlelike spines along the dorsal, pelvic and anal fins, and punctures can lead to rapid development of localized edema (swelling) and subcutaneous bleeding. Pain can last for several hours, swelling typically subsides in two to three days, and tissue discoloration can last for four or five days. Punctures on fingers can restrict blood supply to the tissues and lead to necrosis.

Most Stings Are Preventable.
Lionfish are by no means aggressive, so to prevent injuries you can simply maintain a prudent distance. If you want to engage in spearfishing activities, do so only after you learn from more experienced divers how to capture and handle these animals. Be aware that lionfish spines may puncture leather gloves.



Rapid Response Can Make a Difference.
In case of lionfish envenomation, adhere to the following protocol:

- Rinse the wound with clean freshwater.
- Remove any obvious foreign material.
- Control bleeding if necessary.
- Soak the wound in hot water for 30 to 90 minutes. Repeat if necessary. If you are assisting a sting victim, try the water on yourself first to assess tolerable heat levels. Test the water on the same area of your body as where the diver is injured.
- Monitor vital signs while en route to professional medical care.

For more information, visit *DAN.org/Health*.

EDUCATION SPOTLIGHT

DIVING EMERGENCY MANAGEMENT PROVIDER TRAINING

DAN's Diving Emergency Management Provider (DEMP) course consolidates DAN's four basic first-aid courses: Basic Life Support: CPR and First Aid, Neurological Assessment, Emergency Oxygen for Scuba Diving Injuries, and First Aid for Hazardous Marine Life Injuries. In DEMP, these four courses have been streamlined to focus on dive-related content, and information that is common across the courses is delivered only once.

DEMP provides divers and people who support divers with targeted expertise in first aid for diving incidents. It provides the breadth of skills necessary for responding to an emergency once a diver is out of the water. This consolidated course is the most cost-effective and time-efficient way to obtain comprehensive training in diving first aid.

Course participants complete their DEMP training by drafting an emergency assistance plan so they will know how to access resources in the areas where they dive.

"It is part of being a prepared diver," said Patty Seery, DAN director of training. "Not all diving is done under the supervision of dive professionals. When we dive independently with our dive buddies, we need to be prepared to handle whatever comes along and be self-reliant for first aid. DEMP equips divers with all the skills necessary to respond to diving emergencies."

DAN's new online eLearning platform features a section dedicated to DEMP training, making it easier than ever to acquire the vital skills you need to keep your community of divers safe. DEMP certification along with rescue diver training qualifies the provider to apply for the DAN Diving Emergency Specialist recognition. For more information, visit *DAN.org/Training*.

MOSQUITO SAFETY

Scuba divers go to exciting destinations all around the world. When seeking adventures below the surface, remember to consider the topside hazards associated with travel. Tropical environments in particular carry risks for mosquito-borne diseases such as malaria, chikungunya, dengue fever, Zika virus and others. Prevention is the best way to stay safe from the effects of a mosquito-borne disease. Follow these tips to reduce your risk of being bitten by an infected mosquito.


DOUG4537/ISTOCKPHOTO.COM

Protect Your Body.
Prevent mosquito bites by applying insect repellant, wearing clothing that minimizes exposed skin and treating your clothing and gear with permethrin, a widely used insecticide and insect repellant. Use insect repellents that are registered by the Environmental Protection Agency (EPA) for safety and efficacy and that have one of the following active ingredients: DEET, picaridin, IR3535, oil of lemon eucalyptus, or para-menthane-diol. If you are traveling to an area known to have a large mosquito population or where mosquito-borne diseases are endemic, it is especially important for adults to wear repellant that is at least 30 percent DEET; children should not exceed 30 percent DEET.

Secure Your Environment.
While clothing and repellant may prevent mosquitoes from biting you, these precautions aren't 100 percent effective. You should therefore limit your exposure to mosquitoes by securing your sleeping quarters and other areas you frequent. Remove standing water, employ bed nets and mosquito screens, and, if possible, try to sleep in air-conditioned rooms with tightly sealed windows and doors.

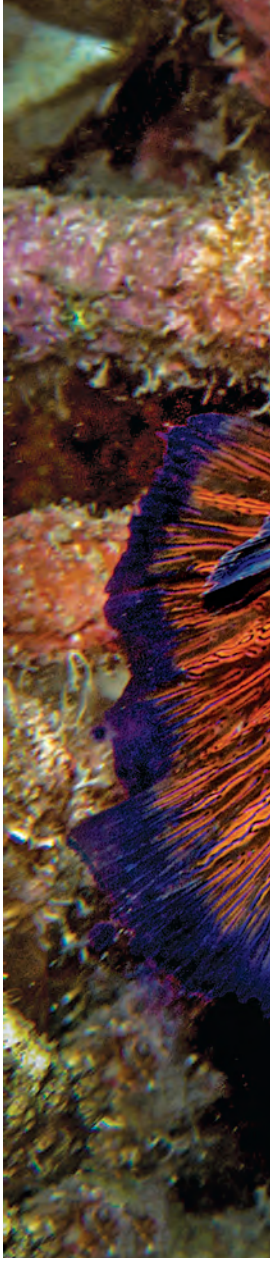
Stay Aware.
Mosquito behavior is relatively predictable; doing some research and taking a few precautions can go a long way toward protecting you from the diseases these insects can carry. Different species of mosquitoes have varying behaviors, so make sure you research mosquito activity in the specific region you intend to visit. Precautions may include avoiding some environments or limiting outdoor activities during certain times of the day.

Take Medication.
Some mosquito-borne diseases such as malaria can be prevented with prophylactic medications. Before traveling to a destination where you might contract one of these diseases, consult your doctor or visit a travel clinic to find out whether such a medication might be appropriate. It's important to take the medication exactly as prescribed and to finish the entire course. Note that the most effective medication will vary by location.

Before you go, familiarize yourself with common symptoms of mosquito-borne diseases at your destination. Seek medical care immediately if you experience any symptoms; if symptoms appear after your return home, let your doctor know you traveled recently. For more information, visit the websites for the Centers for Disease Control and Prevention (*CDC.gov*), the World Health Organization (*WHO.int/en*) or, if you're a DAN member, Worldcue Planner (*DAN.org/worldcue*). AD

PRETTY BOYS

Text and photos by Ned and Anna DeLoach



This spring Anna and I spent much of our underwater time looking for beautiful fishes being as beautiful as they could be — a hallmark of sexual selection. We came away with an eyeful of dazzle and were once again reminded that when it comes to interpreting animal behavior, things are seldom as straightforward as they seem.

Charles Darwin introduced the concept of sexual selection along with its central tenet, female choice, in his 1871 publication *The Descent of Man, and Selection in Relation to Sex.* The book appeared just as the educated public was beginning to accept his mind-altering idea of evolution by natural selection, published a decade earlier in *On the Origin of Species*. But this time around, Darwin's conclusion that peahens (or any other females) could hold the trump card in the selection of mates was too much for the male mind of Victorian times. Perhaps even more unsettling to his readers was the idea that female animals choose mates for beauty's sake. This flew in the face of most people's understanding of natural selection, in which conspicuous adaptations such as a peacock's showy feathers would get you killed. Naturalists of Darwin's day accepted the use of oversized features such as antlers as weapons to fight for females, and that was about as far as serious thinking on the matter went for the next hundred years.

Rekindled interest in sexual selection in recent decades, coupled with the advent of computerized number crunching, support much of Darwin's early writings. Without question, females of many species select mates based on an array of eccentric features: croaks for frogs, enlarged tail feathers for birds and flashy fins for fish. Research shows that despite these potentially life-inhibiting encumbrances, males with the loudest croaks, the longest plumage and the most elaborate fins enjoy superior reproductive success. The precise reason the females of many species choose beautiful mates has been distilled down to two schools of thought: Either peahens and their ilk are on genetic treadmills to produce ever-sexier sons that in turn produce ever-sexier sons, or as the competing argument goes, bright colors and ornamental handicaps are reliable indicators of good health. Whichever way one looks at it, we're happy to report that the use of flamboyant displays and courtship rituals (which predate the dinosaurs) are alive and well beneath the sea.

We began by snooping around at Lembeh Strait, a 12-mile stretch of Indonesian ocean that Anna and I have been visiting since 1999. One of the strait's highlights just happens to be flasher and fairy wrasses — the ocean's answer to the peacock's tail. Although fairly common throughout the Indo-Pacific, the lovely wrasses are easy to overlook. For much of the day the two-inch males and the smaller unadorned

From left: **A pair of rival male Tono's fairy wrasses (*Cirrhilabrus tonozukai*) race in mirror image. Threadfin sand divers (*Trichonotus elegans*) circle one another in a display of comparative beauty.**

Opposite: **Male mandarinfish (*Synchiropus splendidus*) flaunt their beauty in the early afternoon.**

females slink around algae- or rubble-covered terrain below 50 feet with their colors muted and their fins collapsed. All this changes for 20 spirited minutes in the late afternoon when the wrasses, powered by sexual selection, go into their reproductive mode.

The daily event begins subtly as egg-swollen females congregate in small clusters. Within seconds, males flying their gaudiest colors blast off from the bottom like testosterone-fueled fighter jets. At the peak of the action it is difficult to sort out exactly what is happening. This is even the case later when we slow down Anna's video, but from what we can make out, the most lavishly adorned males appear as intent on using their ornamentation to intimidate rival males as to woo females. It often seemed to us that the most brilliant colors, tautest fins and greatest speeds belong to males that race side by side in contests of comparative beauty. As it turns out, these dramatic displays help establish and maintain favored reproductive status among competitive males, mitigating the use of life-threatening combat.

Next we tracked down a colony of sand divers — small, colorful, soda-straw-thin fishes sporting awkwardly large fins. Like flasher wrasses, male sand divers also show off for females and compete with rivals. Instead of dashing about as apparent mirror images of one another, antagonistic males spin around each other in carousels of colors.

One late afternoon we we settle in on a most puzzling bit of stagecraft that once again ran contrary to our expectations of sexual selection. Inside a shallow pocket of coral, three male mandarinfish, flaunting their pretty-boy best, bobbed together for several minutes. There was no nipping, no bluster and no tension. The finely costumed trio appeared as companionable and self-assured as the dandy Dutchmen in Rembrandt's *The Night Watch*. All we could do was watch and wonder — so that was exactly what we did. AD

FITNESS MYTH OR FITNESS FACT?

By Jessica B. Adams, Ph.D.

When planning an effective fitness program, it is important to separate fact from fiction. Fitness folklore spreads quickly because many people are drawn to promises of magical quick fixes. The reality is that fitness is a way of life. A surefire path to success includes proper nutrition, hydration, sleep and exercise, all incorporated into your daily life. You should make time for these things each day just as you manage to find time to shower, brush your teeth and eat.

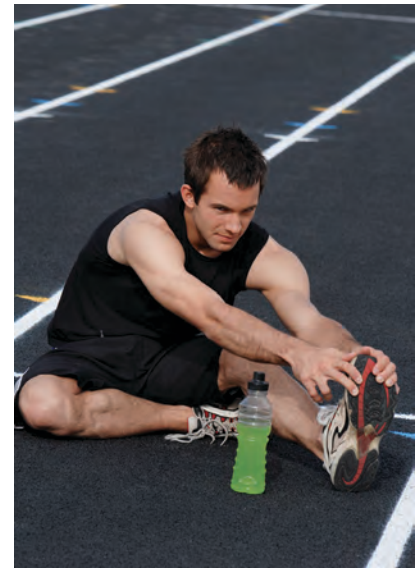
1. Drinking cold water during or after exercise is bad for you. — *Myth*

Cold water has actually been shown to be absorbed more quickly, so it can effectively rehydrate the body during or after exercise. An additional benefit of cold water is body-temperature regulation, which is particularly important on hot days. Hydration is the priority, and the water temperature is secondary. If you are freezing following a dive, drink warmer water. If you are sweating topside, drink cooler water. Pay attention to how you feel, and ingest fluids according to your thirst.

ALL PHOTOS FROM ISTOCKPHOTO.COM

2. There is no benefit to a short workout. — *Myth*

One of the largest barriers to exercise is time. Therefore, any amount of time that you can squeeze in some physical activity is beneficial. The greatest health benefits of exercise are shown between inactivity and some activity. In other words, every step counts. Three 10-minute workout sessions are just as beneficial (if not more so) than a single 30-minute session.



3. If you are working out, you need a sports drink. — *Myth*

A tendency to drink sweet beverages when exercising places many exercisers (especially new exercisers) in a positive caloric balance, which leads to weight gain (fat not muscle). A typical 32-ounce Gatorade contains 200 calories and 56 grams of sugar. If you consumed the whole bottle you would need to run at least two miles to break even. A good rule of thumb is that if an exercise session does not exceed 90 minutes in duration, water should be your drink of choice.

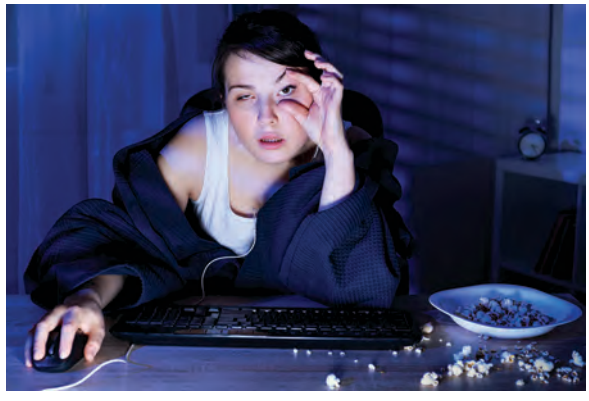
4. Sit-ups and crunches eliminate belly fat. — *Myth*

There is no factual basis for spot reduction of body fat. Sit-ups and crunches will firm up muscles that lie under the fat, but there is no connection between this

muscle development and local fat cells. The only way to reduce body fat is to burn more energy than you store. Unfortunately, where you lose and gain weight first is genetically determined. Feel free to blame your parents. Sit-ups and crunches target very specific muscles and are not high energy expenders. So I am sorry to say that these exercises will not do much to improve your overall body composition or eliminate that extra weight around your middle.

5. Weight gain can be caused by lack of sleep. — *Fact*

Have you ever found yourself eating more when you are tired? This behavior is not because of a personal lack of control, but rather there is a physiological basis for it. Lack of sleep creates a hormone imbalance: The levels of the hormone leptin (which tells your body to stop eating) fall, while levels of ghrelin (which makes



you think you are hungry) rise. Have you noticed that you choose high-carb, high-sugar foods when you are tired? This is because the brain runs on glucose, the simplest form of sugar. When the brain is tired, it wants sugar. This combination of increased caloric intake in the form of high-sugar foods leads to weight gain. Proper sleep is vital to maintaining caloric balance and having energy for exercise.

6. You have to stay in the "fat-burning zone" to burn fat. — *Myth*

Many exercise machines indicate that low levels of exertion are considered the "fat-burning zone." It is true that as much as 90 percent of your energy at this low level is fueled by fat. But keep in mind that the rate at which calories are burned will be low — 90 percent of a little is still a little. Would you rather have someone give you 90 percent of $1 or 25 percent of $100? When exercising at higher intensities, a smaller percentage of your activity is fueled by fat, but the total calories burned at that higher intensity will be much greater than during a low-intensity workout of the same duration.

7. Exercise improves brain function. — *Fact*

Pay attention to your productivity. I have found solutions to many work and personal challenges following an exercise session. Brain scans have shown that exercise boosts blood flow to the brain and increases brain activity. An additional benefit of exercise is neurogenesis, the building of new brain cells and new connections between brain cells. Yes, exercise can make you smarter.

It doesn't matter how you fared in this test of fitness folklore. By simply reading this article you are now better informed about some common misconceptions about exercise. Keep in mind that everything you hear at the gym isn't necessarily true. Consider the science behind the statements, and remember that much advice is well intentioned and framed in partial truths. There is no magic bullet for wellness. AD

NOTE: To avoid an increased risk of decompression sickness, DAN® recommends that divers avoid strenuous exercise for 24 hours after making a dive. During your annual physical exam or following any changes in your health status, consult your physician to ensure you have medical clearance to dive.

DIVING GEORGIA'S JEWEL

GRAY'S REEF NATIONAL MARINE SANCTUARY

By Sarah Fangman

Gray's Reef lies in the tropical-temperate transition zone, which makes for a colorful community of marine life not often found coexisting.

Opposite: **A black sea bass perches among Gray's Reef's vibrant sponges and soft corals.**

Gray's Reef, located 40 miles south of historic Savannah, Ga., is home to such a diversity and abundance of marine life that it is protected as a national marine sanctuary. Visitors are consistently amazed by the unexpected explosion of life they encounter there.

Bathed in rich waters whose temperatures range from the low 50s to the high 80s (°F), the sanctuary is a great destination for macro photography. The reef's mix of temperate and subtropical species is a product of its location in the middle of the tropical-temperate transition zone. The result is a colorful community of marine life not often found coexisting. Bottom depths at Gray's Reef range from 55-75 feet. As you reach the seafloor you enter a realm of octopuses, basket stars, scallops, helmet conchs, Florida horse conchs and a variety of soft corals.

The reef's complex bottom provides hiding places and hunting grounds for an abundance of fish. At times there are so many fish it can be dizzying. The visual chaos of a giant school of scad can be enough to make you look down at the sea floor to stop your head from spinning with all the motion. In spring and early summer, the water column is bursting with babies such as barracuda, tomtate and sea bass — and this, of course, attracts the bigger fish.

Although it encompasses only 22 square miles, the sanctuary hosts a surprising number of shark species, including scalloped hammerhead, nurse, bull, white, tiger, sandbar and lemon sharks. Divers also encounter large stingrays and cobia as well as manta rays and sea turtles. Sea turtles like to use ledges at Gray's Reef as a sort of turtle garage: They hunker down head first under an overhang, so all you see are their backsides sticking out. Visits by pods of bottlenose dolphins are rare but wonderful treats. These encounters are always brief — just a quick fly-by to see what we are up to — but memorable.

When the visibility declines (15-foot visibility is not uncommon), you'll want to examine the reef up close. Sea spiders and nudibranchs can be found crawling around everywhere you look. Brightly colored tunicates make for a vivid backdrop. It is easy to spend an entire dive within a 20-foot area, observing the various inhabitants of a small slice of the reef.

As superintendent of Gray's Reef National Marine Sanctuary, I almost always collect data on my dives on the reef. We monitor the organisms found there so we can keep track of the health of the community and take action if something is amiss. On one particularly memorable dive, my buddy and I were identifying and counting fish and taking measurements of the habitat. My job required looking down a lot, so at first I noticed a huge shadow suddenly cast upon the seafloor. Looking up I saw the largest manta ray I have ever seen in my life — it had to be 15 feet across. I would not have believed mantas could get that big

NATIONAL MARINE SANCTUARIES

Gray's Reef National Marine Sanctuary is a national treasure. National marine sanctuaries encompass more than 170,000 square miles of marine and Great Lakes waters from Washington state to the Florida Keys and from Lake Huron to American Samoa. Sanctuaries seek to preserve the extraordinary scenic beauty, biodiversity, historical connections and economic productivity of our most precious underwater treasures.

had I not seen it for myself. Giddy with excitement, I exchanged looks of disbelief with my buddy, who was also awestruck by the sight. Needless to say, the science was temporarily forgotten while we admired this majestic creature. It seemed to enjoy hovering right above us, letting our bubbles bounce across its belly. It stayed with us for probably 10 minutes, flying past and above us with entrancing grace.

A dive on the reef does not end when you leave the bottom: More entertaining and fascinating marine life awaits you on your way up. It is not uncommon for a school of amberjack to follow you off the bottom, circling tightly. Or you may encounter a giant school of Atlantic spadefish as you make your way to the surface. They too like to swim in circles around divers, providing an enjoyable distraction while you make your safety stop. More than 200 species of fish have been documented in the sanctuary, which makes Gray's Reef popular among anglers.

Recently, another species of fish was added to the list: Invasive lionfish, though still relatively uncommon, can now be found on the reef. These fish, native to the Indo-Pacific, were first spotted on Gray's Reef in 2007. That year it was just one fish, and another wasn't seen until 2012. Since then divers have spotted them on occasion, but not in the numbers reported at sites further offshore of Georgia in waters bathed by the warm Gulf Stream. We had hoped Gray's Reef's cooler temperatures during the winter would provide some protection from a full-on lionfish invasion. In January 2016, however, our team was recovering research instruments and observed two very small lionfish on the reef even though the water temperature was in the 50s°F.

Gray's Reef has many jellyfish, and I particularly like to watch for sea nettles — not for the obvious reason of avoiding their stinging tentacles but to see if I can spot a shrimp hitching a ride on the bell or a school of juvenile fish swimming among the tentacles. This appears to be a dangerous


GREG MCFALL

business, but I guess being amid the tentacles is less dangerous than swimming alone in the open ocean. Interestingly, the jellies often congregate at different depths; on one dive the "jelly layer" might be at the surface, while on another you don't encounter them until you are at the bottom.

Diving Gray's Reef National Marine Sanctuary is full of surprises, which begin as you descend and continue until you are all the way back to the surface. After diving, you can share stories of your adventures and admire your beautiful photographs in one of the many excellent watering holes of Savannah. AD

HOW TO DIVE IT

Getting There

Numerous boat ramps and marinas along the Georgia coast (*coastalgadnr.org/node/2100*) can be used to access the sanctuary, which is located 16 miles due east of Sapelo Island. Navigating Georgia's waterways can be challenging; tidal swings of 8-10 feet are common, so study your charts, and gather local knowledge.

There are no regularly scheduled dive charters to Gray's Reef. Contact local dive operators to find a charter or request a dive trip. If diving from a personal boat, be sure to bring a proper marker buoy and dive flag. Spearfishing and anchoring are prohibited within Gray's Reef. The southern third of the sanctuary is a designated research area where diving and fishing are not permitted.

Gray's Reef is home to a variety of invertebrates including gorgonians, sponges, corals and more.

GREG MCFALL

Live boating is the only way to dive the reef as there are no mooring buoys within the sanctuary. Divers should have a line reel and inflatable surface marker buoy to mark their location during ascent. The vessel operator should be proficient in deploying, monitoring and recovering divers while live boating.

Conditions

Wave action, currents and limited visibility are common at Gray's Reef. For optimal conditions, ask the dive operator to provide suggestions on the best time of year and moon phase to schedule trips.

Bottom depths average 60-70 feet depending on the tidal stage. The water temperature can dip into the 50s°F in the winter, while during the summer it is well into the 80s°F. Even though summer diving conditions are warm, wetsuits are recommended due to the occasional jellyfish. Visibility can be unpredictable: The average tends to be 15-25 feet, with extremes from 5 feet or less to greater than 50 feet.

The only permanent figure at GRNMS is data buoy 41008, which provides near real-time meteorological and oceanographic data. This buoy data can also be accessed online at *ndbc.noaa.gov/station_page.php?station=41008* and on certain chartplotters equipped with weather service.

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PARROTFISH: GRAZERS OF THE REEF

By Sarah Egner

Parrotfish are more than just pretty faces — they may be vital for healthy coral reefs. These "beaked" and brightly colored fish delight divers, but there is much more to them than their visible characteristics.

For example, the colors, patterns, shape and even sex of an individual parrotfish can vary as it moves through multiple life phases. Parrotfish are hermaphroditic, and many parrotfish species begin life as females with the ultimate goal of becoming "supermales." Another interesting parrotfish fact is that at night some species cover themselves in a mucous cocoon that they secrete from an organ on their head. The fish remain motionless inside the cocoon, which is thought to protect them from predators and/or parasites.[1]

Parrotfish teeth are fused into beaks that allow the fish to scrape food from the reef. Along with their food, the fish swallow limestone, which is ground up by the pharyngeal mill (teeth in the back of the throat) and excreted as fine sand. Most of the sand on the reef, and even on nearby beaches, is actually parrotfish poo.

What these fish ingest is also important. Parrotfish spend 90 percent of their time feeding,[2] and many species of parrotfish are algal grazers. Herbivory is a key process on coral reefs that can assist reef-building corals, and more than 80 percent of herbivores on Caribbean reefs are parrotfish.[3] Herbivores remove the algae that is in constant competition with corals. The clear tropical waters that create the perfect environment for corals also provide the perfect conditions for algal growth. Macroalgae and corals are the dominant benthic groups in coral reefs and compete intensively for the available space. When corals face any kind of disturbance (e.g., bleaching, disease, hurricanes), macroalgae quickly colonize the newly available space. Today we see increasingly more reports that indicate a phase shift from coral-dominated to algae-dominated reefs.

Parrotfish use their beaklike teeth to graze on algae that can enshroud a coral reef.

Top: **Locally harvested parrotfish are displayed for sale at a fish market in Pohnpei, Caroline Islands, Micronesia.**

Macroalgae and dense algal turfs can affect coral growth, settlement and survival. Algae can outshade, overgrow and abrade nearby corals.[4] Thick algal turfs can trap settlement, smothering corals.[3] Some algae can even compete allelopathically, causing coral mortality via the production of harmful chemicals.[4] Parrotfish grazing can facilitate coral recruitment by removing macroalgae. This creates space for growth

of coral or encrusting coralline algae,[3] which can promote coral larvae settlement and metamorphosis.[5]

In July 2014 the Global Coral Reef Monitoring Network (GCRMN) of the International Union for the Conservation of Nature (IUCN) released a report with data collected by 78 principal investigators at 90 Caribbean reef locations in 35,000 reef surveys over 42 years, from 1970 to 2012.[6] Along with noting a 50 percent decline in living corals throughout the study period, the report also suggests that the loss of parrotfish and other grazers has had a greater negative impact on Caribbean reefs than climate change has. The study reported that the healthiest reef locations are where parrotfish are protected from overfishing (e.g., Flower Garden Banks National Marine Sanctuary, Bermuda and Bonaire). As for management, the study concluded that promoting parrotfish population growth would lead to greater resilience in coral reefs to disturbances such as warming temperatures and ocean acidification.

We have already seen how a lack of herbivores can affect our reefs. Coral cover began declining throughout much of the Caribbean in the early 1980s after multiple stressors — hurricanes, coral disease and, finally, macroalgae overgrowth with the loss of the herbivorous urchin *Diadema antillarum*.[7] It is thought that the status of the reefs in the 1980s was made less resilient because many herbivorous fish had been heavily targeted by fishermen. The urchin was the last remaining key herbivore, resulting in the phase shift from coral to algal dominance.

Overfishing continues to be a huge threat to parrotfish populations in the Caribbean. Herbivorous fish, especially parrotfish, have been heavily fished

in some locations of the Caribbean for thousands of years.[8,9] The largest species in the Caribbean, including the rainbow parrotfish (*Scarus guacamaia)* and midnight parrotfish (*Scarus coelestinus*), are rare or absent on most Caribbean reefs.[9] Furthermore, these species are most abundant in places with little or no fishing pressure.

The decline in parrotfish populations, particularly in the Caribbean, is a loss not only for the ecosystem but also for the economy. Caribbean coral reefs generate more than $3 billion annually from tourism and fisheries,[6] benefitting 38 different countries. Many people who visit these countries want to swim with large, colorful fish.

Although restoring healthy parrotfish populations will make Caribbean reefs more colorful, it won't solve every problem they face. The good news, as far as parrotfish are concerned, is that overfishing is not a universal problem like ocean acidification or global climate change. Parrotfish populations can be managed locally.

A variety of herbivores is needed to help control algal growth. Herbivorous reef fishes are diverse with specific dietary preferences and assorted feeding techniques, which have different impacts on the reef. For example, parrotfish in genus *Sparisoma* prefer macroalgae, whereas those in genus *Scarus* target turf algae.[9] Parrotfish tend to be "scrapers," while surgeonfish are "grazers." Scrapers, which remove portions of the underlying limestone as they feed, are important in clearing new space for colonization by coral or crustose coralline algae, but scrapers also bioerode the reef. There are many important invertebrate grazers as well, such as the famed *Diadema* urchin. Maintaining a diverse herbivore population is key for reef resilience.

Parrotfish predation may be a source of coral mortality.[10] More research is necessary to determine if the positive effects of herbivory outweigh the negative effects of corallivory. A 2012 study revealed that parrotfish coral predation intensity could increase as coral density declines.[11] Another study found that parrotfish eat polyps with the highest number of gonads and concluded "chronic grazing by parrotfishes has negative fitness consequences for reef-building corals."[12] A contradicting study from the same year, however, stated, "Corallivory may constitute a source of acute mortality in coral recruits, but the available evidence implies that any negative impacts are outweighed by positive effects in removing algal competitors."[3]

Even the evidence that herbivorous fish can promote coral recovery on Caribbean reefs has been inconsistent. While the long-term GCRMN study found a strong correlation between healthy reefs and healthy parrotfish populations, not all studies have come to the same conclusion. Paulina Guarderas and colleagues at Oregon State University studied herbivorous fish within a marine protected area and found that protection of herbivorous fish was not associated with increases in coral cover when compared with a fished location.[13]

The "herbivore/algae/healthy coral" paradigm has many layers and is extremely context dependent. Reefs are unique in structure, species and stressors, and each factor influences a reef's resilience. Coral reefs are complex ecosystems, and the diversity that makes them such exciting places to spend a few hours are also important in keeping them healthy.

Each organism has a niche — a role it plays on the reef. Many of these niches, like that of herbivorous parrotfish, are not yet completely understood, and understanding them better is perhaps more important than ever as we place increasingly more stress on reef habitats.

Save a parrotfish, save a reef? Maybe, maybe not, but these colorful fish certainly play a significant role in the coral reef ecosystem. AD

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RESEARCH EDUCATION MEDICINE

A manatee hovers just beneath the placid surface of Three Sisters Springs in Florida's Crystal River National Wildlife Refuge.

JAMES CARNEHAN/WATERHOUSE MARINE IMAGES

Wrecked In Nova Scotia

By Ron Russell

After a motorcycle crash far from home left Ron Russell and his wife seriously injured, he relied on DAN to transport him back home.

DAN note: In the immediate aftermath of an accident, always contact local EMS first. For DAN to cover the cost of evacuation or medical transportation (subsequent to the initial ambulance ride from the scene of the accident), DAN must make the travel arrangements.

BART SADOWSKI/ISTOCKPHOTO.COM

On July 4, 2012, my wife, Laurie, and I were touring Nova Scotia on motorcycles with my sister, Judy, and brother-in-law, Brad. We had just started our first ride on the Cabot Trail when I hit a patch of antifreeze on the road and lost control of my bike while traveling 50 miles per hour. We entered a ditch and hit a stone retaining wall. Laurie was thrown 30 feet into the road, breaking her pelvis, while I landed with the bike and also broke my pelvis as well as my left arm and three ribs. Additionally, I suffered a punctured lung, intestinal and bladder perforations and a severe concussion.

At the roadside I apparently kept trying to get to Laurie — I was convinced she didn't survive the crash, and I needed to see her to believe she was alive. If not for my sister keeping me under control, I would have done much more damage to myself by trying to get up and walk. I personally don't remember anything about that day.

I was helicoptered to the Queen Elizabeth II Health Sciences Centre in Halifax, Nova Scotia, where I underwent several hours of emergency surgery. Laurie was first transported by ground ambulance to Chéticamp, Nova Scotia. After deciding her injuries were more severe than they could handle, they sent her by air ambulance to the QEII in Halifax as well. Judy and Brad went back to our hotel to gather our belongings and check us all out. They then made the four-hour ride to Halifax to be with us.

As a result of my concussion I was semicomatose for nine days. I remember every minute, just very differently than everyone else. When the doctors finally figured out the combination of meds required to awaken me I somehow knew what had happened but couldn't remember any details. The first fully aware memory I have is of Laurie in a wheelchair visiting me in the intensive care unit (ICU), assuring me she was alive. Obviously this meant a lot to me.

From the ICU, I went to a recovery ward for several days. Judy called to see how I was doing and tell me how glad everyone was that I had finally woken up. She and Brad had stayed with us as long as they could and went home only when they had to, just two days before I came around. Laurie's family had come to Nova Scotia and returned home before I awoke.

Next I was transferred to a general surgical ward, where I was in a room next to Laurie. Eventually a hospital social worker told me that my motorcycle insurance and my health insurance were fighting over who should pay the costs to transport us from the hospital in Nova Scotia to a rehab facility in Salem, N.H. Multiple people spent hours on the phone trying to solve the disagreement. We were facing many weeks in Canada — 18 hours by road from our families — while we healed with no transportation home.

When I heard the commotion about transportation, I told everyone to stop. "I've got this," I said. I told the staff to get my wallet and find the white card that said "DAN" in big red letters. I advised the social worker to call the number on the card and explain what's going on; I assured her that everything would be taken care of. About 20 minutes later the social worker came back into my room and asked me, "Where did you get that insurance? They said they'd arrange everything and call us back with a time and date to be ready." I explained what DAN® was and that I was confident they would step up when called upon.

The hospital wouldn't release us until an orthopedic surgeon near our home would agree take us on as patients when we returned. This took a few days, which turned out to be quite fortunate because in the interim I had a blood clot break loose and lodge in my arm, cutting off all blood flow. Five hours and another surgery later, the blood clot was removed and my arm was saved. Had I been in the air or at a rehab facility, there is no telling if I could have been diagnosed and operated on in time to save my arm.

A few days later the transfer DAN arranged took place: Ambulances took us to an airport in Halifax, where we boarded a customized Gulfstream II jet and flew to Manchester-Boston Regional Airport in New Hampshire. A customs agent met us on the tarmac and cleared us into the U.S., and then we were moved into ambulances and driven to Northeast Rehabilitation Hospital in Salem N.H. I had to sign one piece of paper, and DAN picked up the cost of transportation, which was roughly $23,000 — a very expensive plane ride.

In the spring of 2013 Laurie and I attended the Boston Sea Rovers scuba show so we could talk to DAN representatives there and thank them personally. They were familiar with our case and were glad to see us up and walking. It was very nice to be able to personally shake the hands of the people who provided such great service.

After almost $500,000 in total expenses, negotiations with three insurance companies, three hospital stays and endless rehab, I'm happy to say we are recovered. Laurie still has back problems, but she's working through them. My punctured lung has healed, and I am back in the water with my surgeon's blessing. The easiest part of the entire ordeal was when DAN took care of things for us; the DAN staff were professional, caring and helpful through it all. I implore every diver I meet to join DAN — DAN was certainly there for us. AD

SHARE YOUR STORY

Has DAN been there for you? Tell us about it at *ThereForMe@dan.org.*

The Wreck of the *Lakeland* and the Birth of Mixed-Gas Diving

By Tamara Thomsen and Peter Buzzacott


NATIONAL ARCHIVES AND RECORDS ADMINISTRATION—CHICAGO

Above: Lakeland **sinks as *Cygnus* stands by. This photo was taken from the deck of *Ann Arbor No. 6* by radio operator Elliot Jacobson.**

A piece of *Lakeland*'s final cargo, a Nash automobile, sits upright on the lakebed off the starboard side of the shipwreck. Much of the upper body sheet metal has deteriorated away, exposing the engine.

Below: **This photo mosaic of nearly 320 images shows the *Lakeland* wreck site today. The ship lies on the bottom of Lake Michigan in 200 feet of water.**

On Dec. 1, 1924, the 280-foot steamship *Lakeland* took on a cargo of 1925-model automobiles in Chicago and departed in a storm for its home port of Cleveland. It was the ship's last voyage of the season. The *Chicago Tribune* reported that following *Lakeland*'s departure from Chicago "some of the steel plates [of her hull] buckled," causing a leak. The ship's pumps kept up with the leak, but the captain decided to seek shelter on the evening of Dec. 2 at Sturgeon Bay, Wis., to await calmer weather. According to newspaper reports, after weighing anchor in the early morning of Dec. 3, the leak worsened. The *Lakeland*'s pumps could no longer keep pace with the leak, and one of the holds filled rapidly. Capt. John McNeely turned about and made for shallow water.

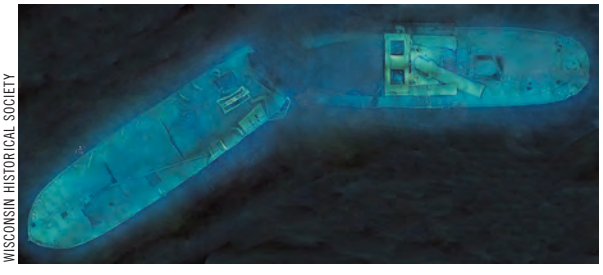
At 10 a.m. a lookout at the Sturgeon Bay Coast Guard station observed *Lakeland* in apparent distress, although no actual distress signal had been given. Initial reports stated that the ship's engine could no longer provide motive power and meet the demands of its pumps when it was approximately nine miles east of the Door Peninsula (this was later corrected to less than five miles). The captain ordered the majority of the crew to escape in the ship's lifeboats, while he and four others remained aboard. Two vessels, *Ann Arbor No. 6* and *Cygnus*, arrived on the scene shortly after the first lifeboats were deployed. A Coast Guard cutter out of Sturgeon Bay reached *Lakeland* at 10:55 a.m. and found one lifeboat in the water carrying Capt. McNeely and the remaining crewmembers. The other 22 crewmembers were already aboard *Ann Arbor No. 6*.

After bringing aboard the last evacuees, Capt. Robert Anderson of the Coast Guard discussed the possibility of towing the foundering vessel to shallow water with Capt. McNeely and the captain of *Cygnus*, who was willing to make the attempt. McNeely felt that the ship was too far gone and advised against it. Fifteen minutes later, at 11:30 a.m., *Lakeland* abruptly went down by the stern. The *Door County Advocate* and Capt. Anderson reported that the hull probably "telescoped" — broke in two. Portions of the cabins and the ship's hatches were blown 40 feet into the air by the force of air trapped in the hull as the ship went down. It was also believed that the ship's boilers exploded during her descent, further splintering the vessel. Remarkably, the radio operator aboard *Ann Arbor No. 6* managed to take a series of photographs of the sinking. The *Lakeland* tragedy was thus one of the earliest Great Lakes losses to be photographed.

The entire crew escaped, but *Lakeland* took her cargo of automobiles to the bottom — a depth of more than 200 feet. A week later, attorney S.D. Foster arrived in Sturgeon Bay to investigate the incident on behalf of the insurance underwriters liable for covering the vessel's loss. Several months later the consortium of insurers decided to investigate the loss, despite the great depth at which the ship lay. Apparently Foster had collected statements from local fishermen who claimed that *Lakeland* had been running in circles immediately before sounding her distress whistle and sank in calm waters. These circumstances raised the insurers' suspicions.

After a local fisherman located the wreck in the summer of 1925, the insurers contracted Overseas Salvors Inc. of New York to conduct underwater operations. The company was joined by several divers who were on leave from the U.S. Navy and had been involved in research and training in deep-sea diving techniques at the Bureau of Mines Experiment Station in Pittsburgh, Pa. Navy diver Clarence L. Tibbals, who had established the Navy's diving school at Newport, R.I., led the dive team, which consisted of three Overseas Salvors employees — Harry "Big Harry" Reinhartsen, H.A. Grove and S.J. Drellishak — and two Navy personnel — G.F. Smith and Joseph Eiven. Drellishak was a former Navy diver who had been involved in the 1915 effort to salvage the Navy's *F-4* submarine from the bottom of Honolulu Harbor, during which members of that dive team reached a record depth of up to 306 feet.

TAMARA THOMSEN



WOODS HOLE OCEANOGRAPHIC INSTITUTION/
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As the ship went down, trapped air from the hull blew hatches and wooden deckhouses more than 40 feet into the air.

Tibbals' team would be the first to field-test a new mixed-gas diving system that used a helium-oxygen mixture. The possibility of using helium as a component of a breathable mixed-gas medium had been proposed as early as 1919, but no dives had yet been conducted with it. Researchers at that time believed that replacing nitrogen, a naturally occurring component of air, with helium would reduce the amount of time divers would be required to spend in decompression after deep dives. It was later discovered that helium prevented nitrogen narcosis during deep dives, but it also introduced new challenges.

Prior to the *Lakeland* dives, decompression tables for helium-oxygen diving had been developed by researchers working at the Bureau of Mines Pittsburgh Experiment Station through a joint program with the U.S. Navy Bureau of Construction and Repair. Decompression tables were critical because they were

used to time divers' ascents from depth to prevent decompression sickness (DCS). The experimental timetable developed by the Navy and Bureau of Mines was based on lab tests using guinea pigs and had not been tested in water with humans. There are brief reports of men diving with helium-oxygen mixtures in 1924, but these were likely chamber dives.

Despite the fact that the Navy divers involved in the project were officially on leave, newspapers claimed that Navy and Bureau of Mines officials saw the *Lakeland* investigation as an opportunity to field-test and perhaps refine the new helium-oxygen diving techniques. The fact that the Bureau of Mines maintained near-monopoly control over the U.S. helium supply, considered a strategic resource at the time, also points to some degree of official sanction of the involvement of Navy divers in the *Lakeland* investigation. The helium used by the divers could have been acquired only by requesting it directly from the Bureau of Mines. Since the three Navy men had been stationed at the Bureau of Mines Pittsburgh Experiment Station, they would have had the necessary contacts to make such a request. The salvage barge *Chittendon* was called in to support the mission, and before leaving the Port of New York it was equipped with a diving platform, as well as a decompression chamber on loan from the Brooklyn Navy Yard. If the untested decompression tables proved inaccurate or other emergencies arose, the chamber could have been a lifesaving device.

The team was equipped with a new, high-intensity, electric underwater light developed by Westinghouse Electric Co. The 1,000-watt light allegedly lit the interior of the wreck "as bright as the average city living room … the men could even read the figures on the [wreck's] small gauges." In mid-August 1925, *Chittendon* arrived from New York City. It took several days to outfit it and anchor it in position at the wreck site. Over the next three weeks the dive team made multiple dives on the wreck to conduct its investigation. As the mission reached the stage of entering the broken hull of *Lakeland*, each descent involved two divers; the first operated as lead diver and the second as a tender. The tender remained outside the wreck and ensured the safety of the lead diver, who penetrated the interior and risked having his supply lines tangled or damaged.

Within the first week, Navy diver Eiven suffered a case of DCS and had to be placed in *Chittendon*'s recompression chamber. By the final week of the investigation all five divers had suffered from at least one bout of DCS. Newspaper reports claimed that none of these cases were serious, but their occurrence suggests there were problems with the decompression tables developed at the Pittsburgh Experiment Station by the joint Navy-Bureau of Mines program. Despite these difficulties, the first effort to investigate a shipwreck at such a great depth was deemed a success, and the salvage crew was treated to a farewell party and dance at Sturgeon Bay's Grasshopper Pavilion. The total cost of the diving operation was estimated to be $60,000.

The consortium of insurers maintained a degree of secrecy regarding the findings until Sept. 11, 1925, when their attorney, William Day, made an official announcement. Day stated that the dive team had found evidence of "barratry" (fraud or gross negligence by a ship's master or crew at the expense of its owners or users), claiming *Lakeland's* crew had intentionally opened valves causing the ship to take on water and sink. Reinhartsen was the first to reach the aft seacock (a through-hull valve) that was allegedly left open. This and other evidence contradicting the initial reports of the ship's sinking was later presented in agonizing detail by the insurance companies' lawyers to support their claim that Thompson Transit Co.'s owners ordered the crew to scuttle the ship and therefore were not covered for the loss.

Lakeland sank with at least 22 1925-model-year Nash, Kissel and Rollin automobiles, 21 of which are known to be on the wreck site today (recreational divers recovered one Rollin car in 1979). Although several vehicles are visible through hatches or cracks in the deck or exposed where overhead decks blew away during sinking, Wisconsin Historical Society archaeologists have penetrated deep inside *Lakeland*'s hull to document each vehicle and gather evidence to list *Lakeland* on the National Register of Historic Places. Experts from the Wisconsin Automobile Museum, Western Reserve Historical Society and Nash Automobile Club of America identified the cars. The Kissel cars aboard *Lakeland* were fitted out as show cars intended for the 1925 Detroit Auto Show.

Visiting the wreck today is challenging due to its location and depth. Wisconsin dive charter operators do not run regular trips to the site, and diving it requires almost perfect conditions. After the wreck of the *Lakeland* gave impetus for the world's first heliox mixed-gas diving nearly a century ago, the legacy of those early divers can be traced through the developments that followed right up to the advanced recreational trimix training that is required today to visit this fascinating shipwreck. AD

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LATTA PICTURES/ISTOCKPHOTO.COM

THC metabolites may persist in the body for days or weeks after marijuana use. The ongoing effects of these metabolites on reflexes and cognition are not well understood.

Marijuana and Diving

By Hillary Viders, Ph.D.

Marijuana (cannabis) is one of the most commonly used recreational drugs in the world. In 2015 a Pew Research Center survey found that almost half of Americans claim to have used marijuana at some point in their lives.[1] According to the 2014 National Survey on Drug Use and Health (NSDUH) prepared for the Substance Abuse and Mental Health Services Administration (SAMHSA), some 22 million Americans ages 12 and older smoked marijuana in a single month that year.[2]

Marijuana, like heroin, is a Schedule I controlled substance in the U.S., a classification reserved for what the government considers to be the most dangerous drugs.[3] The Drug Enforcement Administration (DEA), however, recently revealed that it plans to decide this summer whether marijuana should be removed from that list.[4] Four states — Colorado, Washington, Oregon and Alaska — and the District of Columbia have already passed measures to legalize marijuana for recreational use.

U.S. Surgeon General Vivek Murthy, M.D., told *CBS This Morning* in February 2015 about his stance on marijuana legalization: "We have some preliminary data showing that for certain medical conditions and symptoms, marijuana can be helpful." In a statement issued by the Department of Health and Human Services, he added, "Marijuana policy — and all public health policies — should be driven by science."[5]

Marijuana for medical use is currently legal in 25 states, the District of Columbia and Guam. It is prescribed to treat a variety of severe and debilitating ailments including multiple sclerosis, muscular dystrophy, terminal cancer, AIDS, Crohn's disease, Parkinson's disease, inflammatory bowel disease, severe or chronic pain and glaucoma,[6] and it is currently being studied for use in treating post-traumatic stress disorder (PTSD).[7] In Canada, Prime Minster Justin Trudeau has asked the Minister of Justice and Attorney-General Jody Wilson-Raybould to "create a federal-provincial-territorial process that will lead to the legalization and regulation of marijuana."[8]

As marijuana legalization proceeds in the U.S. and Canada, the number of people, including divers, using marijuana may increase.

Scuba divers are already smoking marijuana in significant numbers and without any guidelines about

smoking and diving practices. In 2011 Marguerite St Leger Dowse and colleagues published a survey of recreational divers in the U.K. who used illicit drugs, including marijuana. Of the 479 divers who responded, 105 (22 percent) reported using illicit drugs since they first learned to dive, and of those 105, 99 (94 percent) had used marijuana.[9]

With this data in mind, there are questions about marijuana and diving that warrant answers. To date, marijuana research in the United States has been very difficult because of marijuana's classification as a Schedule I drug, Those restrictions may change if the government downgrades marijuana to a lower category. In the meantime, we ask the experts.

What are the most immediate concerns with regard to marijuana use and diving?

Paul Auerbach: When considering the effects of marijuana on divers, a number of issues come to mind. There are acute and chronic effects that may influence a diver's mental state, judgment and physical reflexes as well as perhaps relevant cardiovascular, neurological and other physiologies. It is dictum that anything that might impair a diver underwater is detrimental and forbidden, unless there is a benefit that supersedes the negative effects. We know virtually nothing about the effects of marijuana use in divers, but there is scientific literature on the use of marijuana above water from which we can reasonably extrapolate. Common sense dictates that the onus is on the science community to prove that marijuana use in any form or quantity in divers is safe, rather than to take a position that it should be considered safe until proved otherwise.

Tom Neuman: In a laboratory setting, marijuana clearly reduces a number of motor and cognitive skills and thus, if one can extrapolate from the laboratory setting to real-life situations, the use of marijuana prior to diving (i.e., diving while "high") would be problematic.

Are people who are ill enough to warrant medical marijuana fit enough for diving?

Steven Gillon: It depends on why they are taking marijuana and the degree to which they have a specific condition. I prescribe medical marijuana for patients with severe illnesses such as Crohn's disease, irritable bowel syndrome and intractable pain. There are many other indications as well. Some of these illnesses are controlled, while others are not, and of course those situations preclude diving. I would also strictly advise against marijuana use and diving for anyone with cardiovascular or pulmonary disease or compromised vestibular function until they are appropriately assessed for fitness to dive.

Does marijuana have an adverse effect on a diver's lung function, and how does marijuana affect a diver's cardiovascular system?

Ernest Campbell: It is good to answer these two questions together, as lung and cardiovascular functions are closely related. Marijuana smoke, in addition to containing THC and cannabinoids, also has large quantities of tar, foreign bodies and carcinogens (50 percent more than tobacco smoke). The acute effects of smoking marijuana on a diver's lungs include an increase in size of the terminal bronchi, increase in mucus production, cough, inflammation and loss of function of the ciliated bronchial cells (which clean dust and debris and perform an immune function, reducing infection). This process increases the risk of mucus plugs, air trapping and gas embolism. Chronic smoking can lead to chronic obstructive pulmonary disease, with the concomitant risks of air trapping and gas embolism.

Cardiovascular changes that occur with episodic smoking of marijuana include an increase in the heart rate by 30-50 beats per minute, increase in blood pressure and gas changes that can include decreased oxygen and increased carbon monoxide (CO) and carbon dioxide (CO_2) with an elevated risk for heart attack and syncope. Small gas changes at the surface become exaggerated with the effects of depth/pressure and may lead to CO poisoning at depth and hypoxia upon ascent.

To what extent will marijuana exacerbate nitrogen narcosis?

Richard Moon: It is well established that nitrogen under pressure causes cognitive changes and can alter reaction time, judgment and performance in a number of areas. The effects of nitrogen narcosis begin to be most apparent at depths between 80 to 100 feet of seawater, and they become progressively more marked as depth increases. We know that there is interaction between nitrogen and other gasses that can cause cognitive deficits, such as elevated blood CO_2 levels. High levels of oxygen, such as might be experienced with enriched oxygen mixtures such as nitrox, may exacerbate nitrogen narcosis. Marijuana use, which is known to have adverse effects on cognition and

performance, is likely to exacerbate nitrogen narcosis. The effects of marijuana on divers need to be investigated before any definite statements can be made regarding safety. In the meantime, extreme caution is recommended.

Neuman: There are no data that currently exist to suggest whether or not the use of marijuana would exacerbate or possibly ameliorate the effects of nitrogen narcosis. We do know that alcohol and marijuana act additively, and thus it would not be a surprise if the effects of marijuana exacerbated the effects of nitrogen narcosis. In a laboratory setting it would be relatively simple to examine this question, however, validating the results of laboratory testing in an actual diving environment would require separate testing. The first step in further evaluating this question might be conducting chamber dives to depths at which we already know nitrogen narcosis produces measurable effects.

How long after using marijuana should someone wait before diving?

Gillon: Like alcohol, marijuana should be undetectable in a person's system before he dives.

STEPHEN FRINK

Although some divers who use marijuana might believe that diving must be safe as long they wait a day or two (or less) after smoking, these divers may be envisioning calm, clear, shallow water. If they were to consider the possibility of managing an unexpected current, poor visibility or a sudden emergency, they might be more concerned about the potential for lingering performance decrements.

When marijuana is inhaled at sea level, the THC metabolites have an elimination half-life of at least 20 hours and possibly up to three days. Some are stored in body fat, however, and have an elimination half-life of 10 to 13 days. Most researchers agree that urine tests for marijuana can detect the presence of the drug in the body for up to 13 days. But for some individuals it may remain even longer. There is anecdotal evidence that the length of time that marijuana remains in the body is affected by how often the person smokes, how much he smokes and how long he has been smoking. Regular smokers have reported positive drug test results after 45 days since last use, and heavy smokers have reported positive tests up to 15 weeks. So

MEET THE EXPERTS

Paul S. Auerbach, M.D., MS, FACEP, FAWM, FAAEM, is the Redlich Family Professor of Emergency Medicine at Stanford University School of Medicine and medical director of Strategic Projects at Stanford Health Care. He is the world's leading authority on wilderness medicine and one of the world's leading authorities on emergency medicine. He has received numerous science and diving awards.

Ernest S. Campbell, M.D., FACS, a retired surgeon, is a Fellow of the American College of Surgeons and a member of the American College of Physician Executives, among other affiliations. At Brookwood Medical Center in Birmingham, Ala., he served as chairman of the surgery department and president of the medical staff. He is a PADI Rescue Diver and has a U.S. Coast Guard captain's license.

Steven D. Gillon, DO, is a gastroenterologist and owner of the Digestive Health Center of Englewood in Englewood, N.J. He has been practicing gastroenterology and internal medicine for 30 years, and he prescribes marijuana for selected medical cases that meet the legal requirements.

Richard E. Moon, M.D., CM, M.Sc., FRCP(C), FACP, FCCP is a professor of anesthesiology and medicine at Duke University in Durham, N.C. He is also the medical director for the Duke Center for Hyperbaric Medicine and Environmental Physiology. A world-renowned researcher in anesthesiology, pulmonary, undersea, environmental and hyperbaric medicine, he has authored more than 100 peer-reviewed publications.

Tom S. Neuman, M.D., FACP, FACPM, an emergency medicine physician and pulmonologist in La Jolla, Calif., is well known for his work in diving and hyperbaric medicine. He has published numerous books and scientific papers on diving physiology and is the co-editor of the *Physiology and Medicine of Diving*. Neuman is a recipient of the DAN/Rolex Diver of the Year Award for his contributions to dive safety.

without human trials specific to marijuana use and diving, we can only guess at safety parameters, and they would have to be extremely conservative.

Is there currently any way to establish a correlation between the use of marijuana and diving accidents?

Neuman: If one were to use the data from motor-vehicle accidents as a surrogate for dive accidents, the results are not as clear-cut as the laboratory evidence might suggest. Adverse effects of marijuana have not been conclusively demonstrated in experiments involving simulated driving. Furthermore, in epidemiologic studies of motor-vehicle accidents, marijuana has not been shown to be a major problem. Unfortunately, all of the existing studies have major methodologic problems (i.e., are flawed). [*Author's note: Research funded by drug companies may be influenced by the potential profits associated with getting drugs to market as quickly as possible. Maida Taylor, M.D., MPH, who has worked in drug development, notes, "There is a problem in the research that has been done on marijuana by the pharmaceutical companies, even in the most controlled circumstances, because of the strong sociopolitical agenda."*]

Perhaps most important, no way currently exists to determine (with laboratory testing) whether an individual is under the influence of marijuana or has merely been exposed to it sometime in the past hours to days. This problem is related to the way marijuana is metabolized and eliminated from the body; it is not merely a technical issue of detection. Furthermore, the active agent in marijuana is usually not detectable in the bloodstream after two hours from the time of inhalation. Thus, by the time a person arrives at a hyperbaric chamber the likelihood that useful information could be obtained by any currently available blood test is extremely small.

Assuming this technical problem is resolved, there are still extremely large problems that will need to be overcome before any causative relationships between marijuana use and dive accidents can be established. The single greatest issue will be the ability to find an adequate control group for comparison. Given

the relatively small number of diving accidents, the difficulty in establishing a meaningful control group and the technical difficulties in establishing a relationship between laboratory testing and impaired performance in a real-life setting, it may be quite some time before we can clearly delineate the role of marijuana in diving accidents. Until then, prudence would suggest extreme caution in this arena. AD

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I'm Taking this Medication ... Can I Dive?

By Brian Harper

One of the most frequently asked questions to DAN® medics is whether it's safe to dive while taking a particular medication. The answer to this question is rarely straightforward.

Many divers assume DAN has a repository of data on how various medications are affected by the diving environment. Unfortunately, such data do not exist. Ethical concerns preclude formal research trials that would evaluate the influence of drugs on human divers in an underwater environment. Anecdotal reports of dive accidents are of limited value in determining whether it is safe to dive while taking a particular drug; there are generally too many physical and physiological factors involved to allow isolation of a single variable

This is not to say it is impossible to provide sound advice when the question is asked. By considering the medical condition being treated, the physical demands on humans in the diving environment and known facts about a drug from clinical trials conducted on land, recommendations can be made about the suitability of diving while taking certain medications.

GENERAL CONSIDERATIONS

When divers ask DAN about using medications while diving, they are often most concerned about the likelihood of new side effects occurring at depth. It is theoretically possible that certain drugs might potentiate (enhance) or be potentiated by the narcotic effect of nitrogen. A diver should consider this possibility if planning to dive deeper than 80 feet while taking a drug that warns against drinking alcohol or operating heavy machinery. Aside from this theoretical concern, most drugs are not suspected to incur specific biological hazards due to immersion, pressure or breathing-gas mixture. It is understandable for divers to be apprehensive about new side effects occurring during a dive, but the more important issue to medical professionals is whether the underlying medical condition might make diving less safe. The injury or illness being treated is much more likely than the medication to exclude someone from diving.

Diminished physical fitness is not uncommon among people who are being treated for medical conditions. Although diving itself is a relaxing activity for most recreational divers, lifting and wearing heavy equipment as well as entering and exiting the water can be strenuous. Divers should always have sufficient physical capability to fight a current, perform a long surface swim or help a buddy in the event of an emergency. They should not be at increased risk of barotrauma due to congestion, and they should not have symptoms such as numbness, tingling or pain that might be confused with decompression sickness (DCS) after a dive.

STEVE COLE/ISTOCKPHOTO.COM

In addition to the implications of the underlying condition, it is important to consider whether a diver has experienced any side effects from a medication, how long he or she has been taking it and what other drugs the diver is taking. Before diving while taking a particular drug, the person should have experience with it on land. For most prescription medications, 30 days is recommended to ensure the dosage is correct and reveal any side effects the diver is likely to experience. At least one doctor should be aware of all medications an individual is taking to minimize the risk of drug interactions. A diver who experiences any side effects that could cause distraction or decreased awareness underwater should not dive.

In addition to these general considerations, there are some specific questions and points for discussion relevant to particular types of medications. The following questions and considerations should be addressed during the physician's evaluation as well as in the diver's self-assessment.

Orthopedic pain medications and muscle relaxants

- Could pain or impaired mobility cause distraction or physical limitation during a dive?
- Might heavy dive gear exacerbate an injury?
- Could side effects of prescription-strength pain relievers diminish a diver's alertness or awareness?
- Might soreness, numbness or tingling be confused with DCS after a dive?

Neurologic drugs

- Are the diver's physical capabilities diminished?
- Has the diver ever experienced a seizure?
- Could any drugs the diver is taking cause side effects that might be confused with DCS?

Psychiatric medications

- Might symptoms or a drug's side effects impair judgment, behavior, awareness or ability to handle stress?
- Is the patient's condition managed successfully or in remission?

Gastrointestinal drugs

- Is the patient at risk for gas trapping that could cause barotrauma on ascent?
- Is the diver dehydrated due to vomiting or diarrhea?

Cardiovascular drugs

- Does the patient have the cardiovascular health and exercise capacity to safely dive?
- Is a stress electrocardiogram (EKG) needed to confirm good cardiac fitness?

Respiratory medications, including inhaled corticosteroids

- Is there any reason to suspect air trapping or impaired ability to breathe while diving?
- People with asthma should undergo an exercise challenge test, which consists of pulmonary function testing before and after exercise in a clinical setting.

Decongestants, antihistamines and intranasal steroids

- Is the diver congested (and therefore at increased risk of barotrauma)?
- Has he or she been congested recently?
- If the medication wears off at depth, will it cause a problem?
- How might the potential sedative effect of antihistamines affect the diver?

Hormones, insulin and medications used to treat diabetes

- Are the patient's hormone levels stable and close to normal?
- Is the diabetic diver at risk for hypoglycemia with exercise?
- Divers with diabetes must have good health and fitness and be experienced managing blood glucose levels while exercising.

Antibiotics

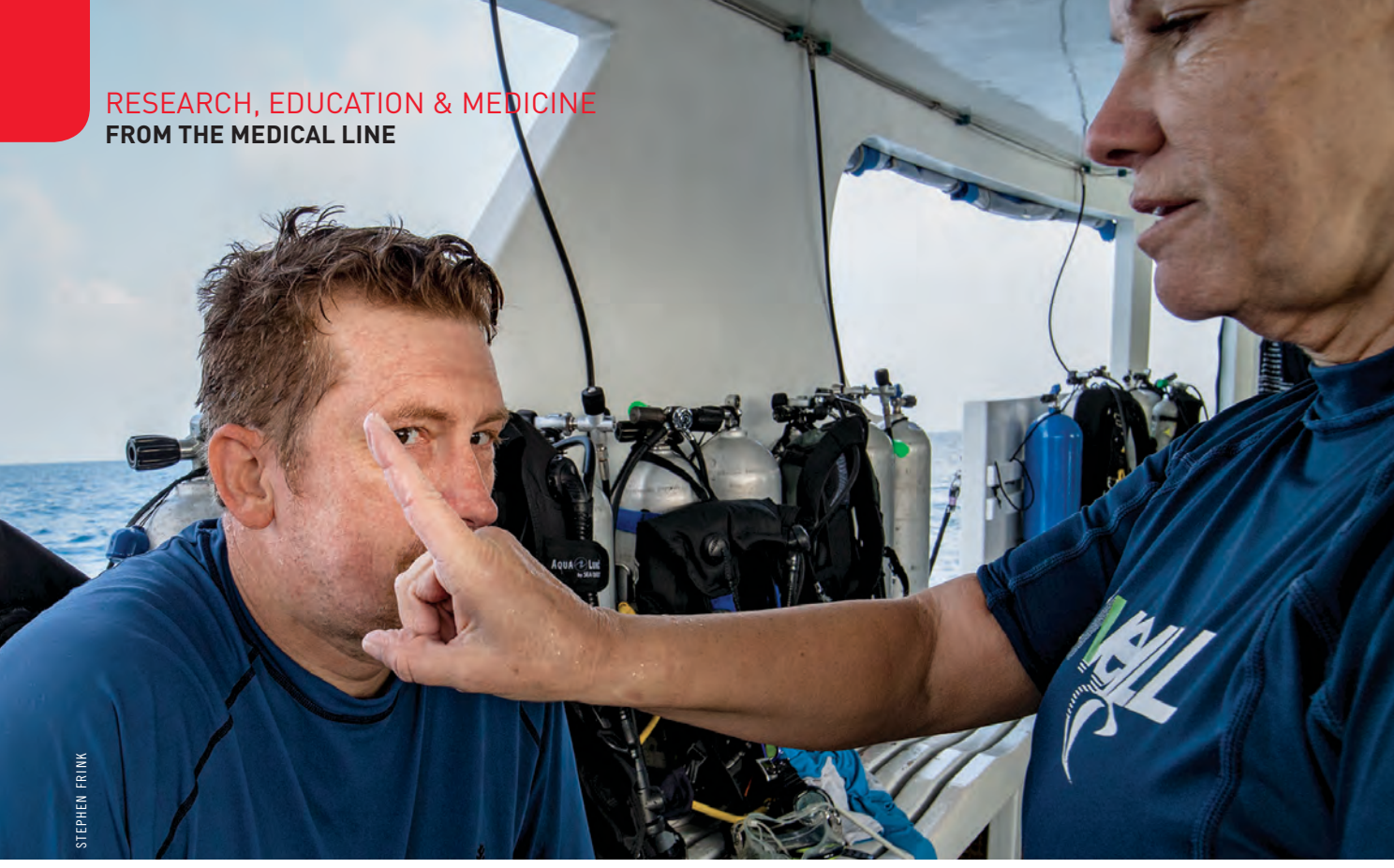
- Does the patient have an illness or infection that might be complicated by diving?

Chemotherapy drugs

- Is the person physically fit to dive?
- Lung cancer warrants particular consideration.
- Medical ports are generally not a problem, but they should be padded well.

These points should be considered in the context of both the symptoms of the medical condition and the side effects of any drugs used to treat it. The focus should be on whether any of these factors might lead to impairment of a diver's physical capabilities, awareness, reaction time or judgment. This list is by no means exhaustive, but it highlights some of the concerns that accompany certain medical conditions and the drugs used to treat them.

Any medical condition or medication should prompt a diver to seek a physician's approval prior to diving. As always, DAN is available to discuss the relevant concerns of injuries, illnesses and the medications used to treat them. If you have questions, call the DAN Medical Information Line at +1-919-684-2948 or email DAN at medic@DAN.org. AD



STEPHEN FRINK

Facial Baroparesis

DAN MEDICS AND RESEARCHERS ANSWER YOUR QUESTIONS ABOUT DIVE MEDICINE.

Q: I understand that arterial gas embolism (AGE) can manifest like a stroke, with facial droop and cognitive problems. It makes sense that bubbles in the brain could cause such serious symptoms, but I have also heard about facial droop occurring with much less severe dive injuries. How could this happen?

A: This phenomenon is illustrated by a recent case involving a 46-year-old male diving in Ambon Island, Indonesia. The diver was doing several days of repetitive diving using 32 percent enriched air nitrox. Recent diving days included 50- to 90-foot dives that lasted 60 to 90 minutes. He typically did two or three dives per day. On his fourth day of diving, he did a dive to 93 feet for a total dive time of 51 minutes and then, following a five-hour surface interval, he did a second dive to 50 feet for 41 minutes.

Ten minutes after surfacing from this second dive, he experienced left facial weakness and a contracture of his left hand. He also described his tongue as feeling "numb" and "thick." Upon further questioning the diver stated that he experienced a significant reverse ear squeeze earlier that day. He was immediately administered oxygen via a mask on the dive boat.

By chance, a neurologist was present on the dive boat and performed a medical evaluation. The physician found that the left facial muscle weakness involved the forehead as well as the lower face. All of the diver's symptoms except for the "thick" tongue sensation resolved within 30 minutes of breathing 100 percent oxygen. Because of his symptoms and multiday diving history, the dive staff were concerned about decompression illness (DCI) and recommended evaluation by a physician trained in dive medicine.

The differential diagnosis in this case encompasses many nondiving- and diving-related diseases. Given the multiday diving history and rapid onset of symptoms, it is certainly prudent to consider DCI. The anatomical distribution and type of symptoms are not typical for decompression sickness (DCS), however, and without a rapid or uncontrolled ascent, AGE is not likely. Possible non-diving-related maladies include a cerebral vascular accident (CVA) and a transient ischemic attack (TIA), commonly referred to as a stroke and mini-stroke, respectively. These conditions, however, would likely

spare the forehead area of weakness and paralysis. Bell's palsy and inner-ear DCS are also possible, yet this diver's history of a significant reverse ear squeeze combined with his pattern of symptoms is highly suspicious for another much less commonly discussed diving illness.

Facial baroparesis, also known as alternobaric facial palsy, is an ischemic neurapraxia (a temporary paralysis) of cranial nerve VII. It is caused by impaired Eustachian tube function that leads to persistent overpressurization of the middle ear following a reduction in ambient pressure — i.e., an ascent. The seventh cranial nerve, or facial nerve, runs through a bony canal as it travels through the middle ear. In most people a small part of the nerve enters the middle-ear cavity unprotected by the bony facial canal. As a result, overpressurization in the middle ear can lead to a localized reduction in blood flow to the exposed portion of the nerve. If the reduction in blood flow is severe or persists, the nerve suffers from ischemia. As a result of this ischemia, the motor and sensory functions of the facial nerve are inhibited. The seventh cranial nerve controls the muscles of facial expression and relays taste sensation from part of the tongue. An appreciation of this anatomy and nerve function along with careful consideration of the symptoms and diving history facilitate diagnosis of this condition.

Facial baroparesis is not DCI. Thus, there is no role for hyperbaric oxygen therapy. In fact, treatment in a hyperbaric chamber might further exacerbate the ischemia and symptoms. Rather, conservative treatment and follow-up with a dive-medicine specialist or otolaryngologist (ear, nose, throat physician) is recommended. If symptoms persist, the treating physician might elect to perform a myringotomy (piercing the eardrum) to decompress the middle ear. To prevent this condition, avoid diving when congested, and equalize early and often. Finally, keep in mind that not all medical problems encountered in diving environments stem from DCI.

— Derek B. Covington, M.D., and Tony Bielawski, M.D.

Q: Could you send me information about hyperbaric chambers in the area where I'll be diving next weekend?

A: In general, DAN® does not provide domestic chamber information to the recreational diving public on a nonemergency basis. There are two major reasons for this. First, chambers frequently change their availability or are offline for periods of time, and it would be impossible to keep divers aware of these changes if we distributed chamber contact information. There have been cases in which divers have gone out of their way to get to a chamber only to find it closed or available only to wound-care patients, not divers. Unfortunately, while there are more than 1,600 hyperbaric facilities in the United States, less than 130 will treat a diver. The rest are primarily nonemergency wound-care facilities.

Second, and perhaps most important, an injured diver should always be routed to the nearest hospital emergency department. For serious cases, this means calling 911. Once in the emergency room, the diver can receive oxygen, fluids as necessary, emergency care, a neurological exam and a thorough evaluation by a doctor to rule out other possible causes of the symptoms. The emergency department staff will often contact DAN to determine appropriate care, including the closest hyperbaric chamber


STEPHEN FRINK

facility available at the time of the call, if necessary. Access to a hyperbaric facility is always through an emergency department, especially after normal working hours. Even 24/7/365 chamber facilities are not staffed after hours until they're notified of an emergency.

A common misconception is that all diving emergencies require hyperbaric treatment. For lung-expansion injuries — including pulmonary barotrauma, pneumothorax (collapsed lung), and mediastinal emphysema (air under the skin) — hyperbaric treatment is contraindicated.

The DAN Emergency Hotline is available 24 hours a day, 365 days a year, to both DAN members and nonmembers. Call us at +1-919-684-9111 at the time of the emergency, and we will provide you with the most current information for the most appropriate chamber near you.

— Frances Smith, MS, EMT-P, DMT

Q: What is the current thinking regarding scuba diving and freediving on the same day?

A: Shallow, low-intensity freediving before scuba diving creates only mild concern. The stress of repeated middle-ear equalization can make subsequent efforts more difficult. Increasingly deep or aggressive freediving requires progressively longer surface intervals before scuba diving. For example, the decompression implications of a few relaxed breath-hold dives in the 40- to 50-foot depth range prior to scuba diving are probably very small with a 15- to 30-minute surface interval before commencing the scuba dive. Deeper or more numerous breath-hold dives should be followed by a longer surface interval that increases along with intensity, but we do not have the data available to make specific recommendations.

Freediving after scuba diving is more of a concern; it requires consideration of the existing inert gas load, the intensity of the exercise during the freediving and the depth of the freediving. The goal is to reduce bubble formation and the potential for migration of bubbles into the systemic circulation.

Even shallow freediving after scuba diving is a problem because of the diver's inert gas load. The primary concern is not the additional gas loads the freediving can produce but the pulmonary shunting that will occur with exercise. Any bubbles present following a scuba dive can be driven across the lung at a much higher rate because of physical activity. (Physical activity may also increase the bubble load.)

It is reasonable to recommend that divers not mix meaningful freediving and compressed-gas diving on the same day. I realize that the word "meaningful" is vague, but it's probably necessary given the wide range of ability and activity possible. I would not worry about casual freediving after a 30-minute scuba dive to a maximum depth of 40 feet because the


STEPHEN FRINK

risk of substantial bubble formation would be low. But maintaining a low level of physical effort during the freediving would still be advisable.

The deeper the freediving and the more intense the exercise, the greater the recommended delay after scuba diving. The primary issue is that bubble formation is more likely after significant decompression stress. As a rough rule of thumb, when a scuba dive approaches half of the U.S. Navy no-decompression limit, the stress of postdive freediving becomes an increasing concern.

If the breath-hold activity is in the "snorkel" zone (that is, with vertical excursions of not much more than two body lengths) and relaxed, I would not be concerned at all. The "relaxed" part is subjective though, so thoughtfulness is needed. The risk for depths beyond 50 feet increases before or after scuba diving — before, because of potential exertion and middle-ear stress issues, and after, because of exertion, shunting and, increasing as a function of depth, direct gas loading from the freediving. Increasingly deeper depths warrant increasingly longer predive surface intervals.

Ultimately there is theoretical risk that should be controlled by conservative surface intervals and the lowest exertion levels possible. There is very little outcome data, but that should not discourage smart practice. Shallow, truly relaxed freediving before scuba diving probably has negligible consequences, given a modest surface interval and provided that equalizing during the subsequent dive is not compromised. But even shallow, relaxed freediving after scuba diving should be delayed if only for an abundance of caution. More aggressive freediving is best left for the next day. The potential negative outcome is simply not worth the risk. AD

— Neal W. Pollock, Ph.D.

BOB HAHN

A Unique Solution

By Bill Simpson

Dutch Springs, a 50-acre lake in Bethlehem, Pa., boasts the largest number of dives logged in the United States every year. More than 30,000 divers visit during the facility's eight-month season, so it's possible for hundreds of divers to be in the water at any given time. For many years the facility used an inflatable rubber rowboat for diver rescues. This seemed to be the best solution for limiting potential contamination of the clear lake water as well as ensuring the safety of divers on the surface. This solution, however, also made for a slow rescue and a tired rescuer.

Many alternatives were proposed over the years, but in 2012 the management and lake safety staff made a concerted effort to improve the efficiency of diver rescue while maintaining the safety of others in the water and the quality of the environment they enjoy. Many hours of brainstorming led to even more hours of experimentation with a variety of vessels. A group of lake safety staff evaluated every type of small boat available, including personal watercraft with sleds, flat-bottom boats with outboard motors and inflatables with cutouts in the floor for diver extraction. The staff and management ultimately decided to use a small, shallow-draft pontoon boat with a shrouded, battery-powered electric drive mounted inboard of the pontoons. This platform would provide the best combination of maneuverability and stability while maintaining a low submerged profile and a nonpolluting drive system.

One persistent problem was the challenge of moving an injured diver in full gear from the water into the boat with a single rescuer. While on vacation one of the lake safety staff, Dave Gregor, observed a ferry boat with a drop-down ramp for cars to drive onto and off of. At that moment a breakthrough in diver recovery occurred. An engineering technologist, Gregor envisioned an elevating ramp located in between the pontoons at the bow of the boat. Additionally there would be a remote control that could be operated by the rescuer while he or she drove the boat. The rescue plan Gregor conceived would allow the operator to single-handedly approach, collect and deliver the injured diver to shore. But no manufacturer offered such a boat.

In 2013 Dutch Springs located and purchased a well-used pontoon boat. With this vessel as a starting point, a construction team of Gregor, Ron Siedlecki and Kevin Scott designed a smaller boat with all of the desired features. Over the course of a year, the team disassembled the original vessel, cut down its pontoons from 20 feet to 12 feet, fabricated a new frame and reassembled the boat. They acquired and installed a drive system with solar panels to charge the batteries, eliminating the need for shore power.

The ramp system features a hinged aluminum frame with a carpeted fiberglass grate deck. The ramp is lowered and raised with a series of cables and pulleys driven by a reversible electric motor that has a battery and charging system separate from the boat's drive system. The operator station is a center console with wheel steering and speed, direction and ramp controls at the operator's fingertips. A grab rope system is attached outboard of each pontoon for assisting tired divers.

After lake safety staff underwent extensive training that included operation, rescue technique and maintenance, the *Daros* was placed in service at the opening of the 2015 dive season. The name represents the names of the builders, Dave and Ron, and Dutch Springs owner Stu Schooley.

There is room on the boat for the rescuer and a staff emergency medical technician (EMT). During busy periods, the boat is moored in the middle of the lake and serves as a central lookout station, manned by one of the lake safety staff. The EMT is posted at one of the lake's three shore-based lookout stations to handle any emergencies that arise at the facility.

In a typical rescue, the operator will make a controlled approach with the ramp lowered to a level just below the injured diver on the surface. The operator will stop the boat and guide the fully geared diver onto the submerged ramp using an extended boat pole. The operator then raises the ramp out of the water while heading back to the dock. The dock is another custom design; it includes an opening that mates to the ramp on the boat. The opening engages the ramp as the boat approaches and provides a secure platform for the waiting lake safety and medical staff to attend to the injured diver.

To date, the *Daros* has been used successfully to assist divers as well as patrons of the adjacent Aqua Park and continues to be one of the many measures Dutch Springs employs to enhance the safety of its guests. AD

BECKY KAGAN SCHOTT

BECKY KAGAN SCHOTT

BOB HAHN

In an effort to improve the facility's diver rescue capabilities, Dutch Springs recently upgraded its rescue vessel to a custom-built pontoon boat with a platform for transporting an injured diver. The platform can be raised and lowered from the helm station.

STEPHEN FRINK

Although arterial gas embolism (AGE) is a concern after any rapid ascent, decompression sickness (DCS) requires a significant exposure to depth and time at depth (i.e., decompression stress).

Thirteen-Foot Dive

By Marty McCafferty, EMT-P, DMT

THE DIVER

The diver was a 19-year-old woman in good physical condition. She denied any history of medical problems and did not take any medications regularly. She completed her confined-water training several weeks before with no problems and was now doing her open-water training dives.

THE DIVES

The dives took place in South Florida. The diver was accompanied by her father, a certified diver with fewer than 100 lifetime dives. On the first day the dives were uneventful, though the diver admitted to some anxiety related to being in open water and diving from a boat. None of the dives were deeper than 30 feet or longer than 40 minutes. She successfully performed all required skills and reported looking forward to completing her certification.

On the second day the dives were at a different location. The boat was anchored over a 13-foot-deep sand bottom. The bottom sloped downward to the reef, which was at a maximum depth of 35 feet. After they entered the water and began heading toward the reef, the diver's father and other witnesses reported that the diver appeared to be having difficulty with her equipment. Exactly what was wrong was never clearly established. Her movements appeared erratic, and she seemed unaware of her buddy or other divers. Within moments she ascended quickly in an uncontrolled manner from 13 feet to the surface. Upon reaching the surface she appeared to struggle and

did not establish positive buoyancy. Her father made a controlled ascent to the surface and was able to establish positive buoyancy for both of them. The diver had already abandoned her mask and regulator and was breathing rapidly. With aid from one of the dive guides, the pair returned to the boat.

THE COMPLICATIONS

Aboard the boat the diver was shaking and continued breathing rapidly. The crew examined her, and she reported tingling in her hands, dizziness, and aches in both arms from the shoulders to the elbows. The crew placed her on oxygen via a demand valve. Since they were only 20 minutes from shore, the dive operator sent a small boat to take her and her father back to the dock. They were met by emergency medical technicians (EMTs), who continued oxygen administration at 12 liters per minute using a nonrebreather mask. The diver's symptoms did not change during the five-minute ride to the hospital.

The attending physician performed a thorough neurological evaluation and did not note any deficits. The diver reported that the tingling in her hands was still present and also complained of a tingling sensation in her face. The aching in her arms had not improved, nor had the dizziness. Normal blood test results ruled out other potential causes for her symptoms, and a chest X-ray did not reveal any lung injuries or other abnormalities. Her breathing rate remained elevated, and she appeared quite distressed.

The dive had been very shallow, and the risk of decompression sickness (DCS) was virtually nonexistent — even considering the rapid ascent. There were, however, few other good explanations for her symptoms. The doctor contacted the local hyperbaric physician for consultation. Although neither doctor believed her symptoms represented DCS, in the absence of another clear diagnosis they believed treating her in the chamber was the safest option. She was transported by ambulance to the hyperbaric facility, which was approximately 30 minutes away. The hyperbaric physician treated her with a U.S. Navy Treatment Table 6. The muscle aches resolved within the first 20 minutes at 60 feet. As she became less stressed and her breathing rate slowed to normal, all the tingling resolved as well. She was discharged approximately six hours later with no residual symptoms. In a phone call the next day she denied any return of symptoms, and no further treatment was deemed necessary.

THE DISCUSSION

The dive profile as reported does not represent a risk of DCS. The dive was shallow, and witnesses stated that it did not last more than 10 minutes. It is highly unlikely that there was sufficient decompression stress to have precipitated DCS at the time of the rapid ascent. Furthermore, there would have been little to no residual nitrogen left from the previous day's dives. Whether the previous day's dives were contributory or not, however, will never be definitively established.

The major concerns with a rapid ascent are a breath-hold leading to a lung-overexpansion injury and, potentially, an arterial gas embolism (AGE). Based on the diver's presentation and subsequent evaluation, her symptoms did not suggest an AGE. (AGE typically presents similar to a stroke.) Tingling sensations and muscle aches are among the many signs and symptoms of DCS, but it is unusual for tingling to be present in both hands with DCS. Aches and pain are also potential symptoms of DCS, but again these are more commonly seen in one arm and occur in major joints more often than in muscles. Although DCS was extremely unlikely, based on these symptoms it could not be completely ruled out.

There is no medical imaging or lab test that can verify DCS. Tests and imaging are still useful, however, because DCS is most often diagnosed by ruling out other possibilities. In this woman's situation there was no clear explanation for her symptoms. Hyperventilation can produce tingling in the hands and face, and the doctor suspected that her struggling, especially at the surface, probably caused muscle fatigue that could explain the aches in her arms. Retrospectively, insufficient exposure, atypical symptoms and no objective findings exclude DCS as diagnosis. Some physicians, however, would rather err on the side of caution, and this doctor consulted with another physician trained in dive medicine. Probably the most compelling factor for considering chamber treatment in this situation was the fact that treatment constitutes a very low risk to the patient. Both physicians expressed the opinion that this was probably not DCS, but they wanted to act in the diver's best interest.

The fact that the muscle aches improved with treatment seems to support the DCS diagnosis, but it does not necessarily do so. Breathing 100 percent oxygen at increased atmospheric pressure produces an anti-inflammatory effect — even aching or pain due to muscle fatigue would improve in the chamber. In this case, time or the placebo effect may have been the factors that most facilitated symptom resolution.

Other physicians or facilities may have opted not to treat this diver in the chamber, which also would have been reasonable. Most physicians try to make decisions that are in the best interest of the patient. As always, DAN® is available to divers and health-care professionals to assist in the decision-making process. AD

DAN
YOUR DIVE SAFETY ASSOCIATION

Be Ready To **Respond**

Every day, divers and emergency-response personnel around the world trust DAN's oxygen units and first-aid kits to perform in an emergency. That's because DAN's products have been developed, tested and refined with input from leading doctors and researchers to meet the discriminating requirements of the diving community. So be ready to respond. Explore **DAN.org/STORE** and make sure you are prepared to effectively handle an emergency situation with the latest safety equipment.

SOFT-SIDED EXTENDED CARE BACKPACK

DAN's lightweight, soft-sided, easy-to-transport oxygen unit holds one Jumbo D cylinder that delivers approximately 45-60* minutes of oxygen. Its large mesh pockets, deep stuff-pocket, and dual external zipper pockets offer ample storage for a range of accessories. This bag is equipped with an adjustable backpack harness system that distributes weights for added comfort over long distances. Includes a brass multifunction regulator, demand valve with hose, nonrebreather mask, oronasal resuscitation mask, and Tru-Fit mask.

601-1080	Soft-Sided Extended Care Backpack	**$660.00**
601-1090	Soft-Sided Extended Care Backpack w/MTV-100	**$810.00**
611-1010	Jumbo D Cylinder (optional)	**$100.00**

International White Cylinder Paks

601-1083	Soft-Sided Extended Care Backpack	**$660.00**
601-1093	Soft-Sided Extended Care Backpack w/MTV-100	**$810.00**
611-1013	Jumbo D Cylinder (optional)	**$100.00**

601-1080


Optional second cylinder shown.

RESCUE PAK

601-4000

DAN's Rescue Pak is a compact oxygen unit featuring a smaller M9 cylinder that delivers approximately 14-20* minutes of oxygen. This unit also comes complete with a brass multifunction regulator, demand valve with hose, nonrebreather mask, oronasal resuscitation mask, Tru-Fit mask, and a waterproof Pelican 1450 case. Ideal for wet environments and locations closer to emergency assistance.

601-4000	Rescue Pak	**$475.00**
601-4100	Rescue Pak w/MTV-100	**$625.00**

International White Cylinder Paks

601-4003	Rescue Pak	**$475.00**
601-4103	Rescue Pak w/MTV-100	**$625.00**

1. Note: Oxygen units may require prescriptions and/or training in administration of oxygen before they can be filled.
2. Note: All cylinders are shipped empty.
* O_2 delivery times listed are approximate and will vary based upon rate of flow and other factors.

COAST GUARD COMPLETE KIT

DAN's Coast Guard Complete Kit has the first-aid supplies needed to meet the U.S. Coast Guard's requirements for small passenger vessels. Ideal for up to 8 persons, this kit includes ammonia inhalants, an oronasal resuscitation mask, trauma pads, and more.

631-3200	Coast Guard Complete Kit	**$120.00**
631-3300	Coast Guard Complete w/Pelican® 1300 Hard Case	**$150.00**

631-3200

FIRST-AID BACKPACK

The First-Aid Backpack is fully stocked with an assortment of first-aid essentials to handle a range of emergencies. Common medications, stop-bleeding wraps, wound-care bandages, fracture/sprain splints, and burn-care supplies are included. It features ample storage compartments for all first-aid components as well as an open storage area for additional supplies. This durable First-Aid Backpack is designed for dive operators and other active individuals.

631-3000	First-Aid Backpack – Complete with Supplies	**$145.00**
501-6300	First-Aid Backpack Only	**$80.00**
631-2000	First-Aid Refill Pack Only	**$38.00**

631-3000

Includes a waterproof cover stored in bottom compartment of pack

DAN OXYGEN TRAINING

Emergency Oxygen For Scuba Diving Injuries Course

This course teaches the techniques of emergency oxygen administration for suspected diving injuries and nonfatal drowning. Students will learn the fundamentals of recognizing dive injuries and how to effectively deliver the primary diving first aid.

Learn more at **DAN.org/TRAINING**

DAN.org/STORE

East of Flores

A NEW HOT SPOT: INDONESIA'S ALOR ARCHIPELAGO

TEXT AND PHOTOS BY BRANDON COLE

I was first lured into the wilds of Indonesia almost 25 years ago. Back then this nation of 17,000 islands was truly out of sight and mind of the average American diver. Times have certainly changed; in the past decade exotic Indonesian destinations such as Lembeh Strait, Komodo and Raja Ampat have become household names for North American divers with wanderlust. But what about East Nusa Tenggara? Killer dive sites between the islands of Flores and Alor are not yet on the tips of divers' tongues. Beangabang, anyone? How about Watu Balu? When I heard through the grapevine that a new frontier had been found, I knew it was time to rekindle the spirit of discovery and dive into the hazy unknown, somewhere East of Flores.

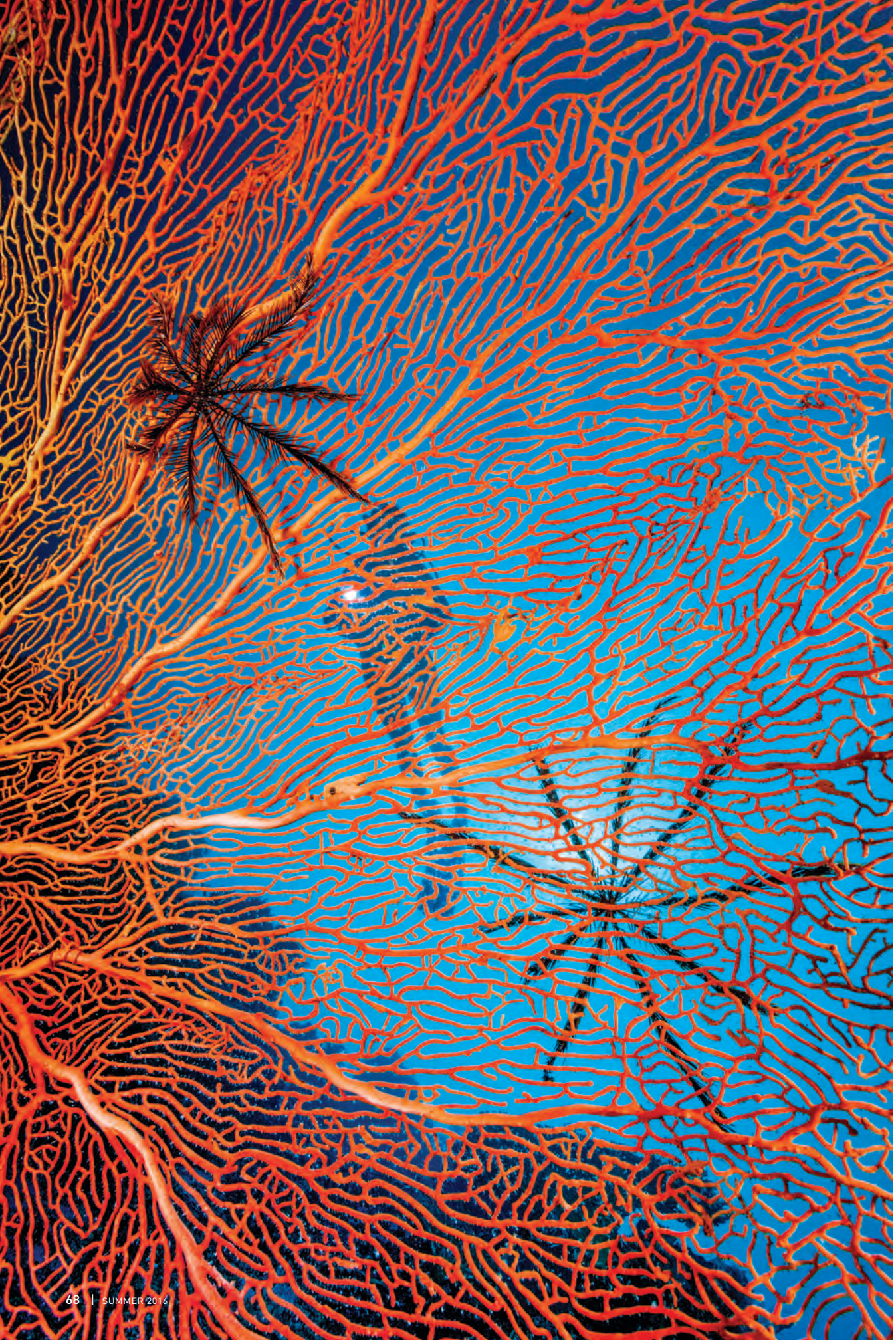
After a very long flight to Bali followed by a thankfully short one to Maumere on Flores' northeastern shore, we climbed onto our liveaboard to a warm welcome by the smiling crew, many of whom we have sailed with before on previous cruises in different parts of Indonesia. We began motoring almost immediately, steaming 80 miles through the night into waters enigmatic and bright with promise.

We awaken in the Ring of Fire surrounded by volcanoes near and far. Their flanks ramping sharply up into the morning blue, they loom over the green folds of eastern Flores, Adonara and Lembata islands. Their presence is greatly appreciated, for we know that beneath us await some of the world's richest coral reefs. The thousands of species of fish and invertebrates thriving here in the heart of the Coral Triangle owe their

existence to the region's volcanic origins. We have come to the epicenter of marine diversity, and we are keen to dive into this cauldron of creation.

Armed with macro lenses, we submerge to taste the waters at **The Brewery.** Poking along this shallow sandy slope off Lembata Island, we find weird and wonderful critters aplenty: a wonderpus showing off, a bright-yellow winged pipefish, psychedelic nudibranchs, leaf fish and a bold peacock mantis shrimp on walkabout. At night the action heats up with squid following us around, creepy devil scorpionfish and stargazers, a variety of crabs and so much more lurking in the shadows. This easy and productive site is one of many excellent muck dives on our 13-day itinerary. During dinner and the first of many slideshows we learn it was discovered by Aussie shark-diving legend Valerie Taylor.

Batu Tara Volcano on the island of Komba in Indonesia's Lesser Sunda Islands sends up a plume of ash. The volcano's summit is almost 2,500 feet above the Flores Sea, but this stratovolcano actually rises nearly 10,000 feet from its base beneath the waves. One of numerous active volcanoes in the area, Batu Tara has been very active since 2006 with regular explosive eruptions of ash and rocks.



Also on Lembata Island is **Tanjung Lusitobo**, which was recently discovered by our boat's team, pioneers who have logged extensive time between Flores and Alor. This wall dive is offshore of a rugged coastline, gorgeous in a *Jurassic Park* sort of way. Palms perch above craggy volcanic rocks. Swirling, surging whitewater crashes against the base. Below the surface we find a multicolored jigsaw puzzle of convoluted leather corals and then a wall that shelves down from 50 to 130 feet. Big trees of green *Tubastrea* cup corals sprout among barrel sponges and sprays of sea fans, crinoids and gorgonians. A jumbled mix of fish swarm the reef and compete for my attention. I cannot decide which to follow with my wide-angle lens — the parade of bannerfish, the cloud of orange anthias or the school of sleek unicornfish. The photo opportunities are almost overwhelming. It's a good problem to have.

While some guests prefer to nap between dives, others choose more active pursuits, which our cruise directors are pleased to provide. On offer are beach walks, kayaking and special cultural tours in which we can meet some of this country's fascinating and friendly people. My special request is a stop at the village of **Lamalera** on Lembata's southern shore, which looks out into the Savu Sea. This community of 2,500 people represents one of the last traditional whaling cultures on earth. The men still hunt sperm whales by hand, leaping overboard from small wooden boats to drive an iron-tipped bamboo harpoon into their prey. They use traditional methods and gear to harvest 15-30 sperm whales annually. Every part of the animal is used, and what meat the villagers do not consume is used to barter with other villages for rice and vegetables. Lamalera has been sustainably hunting sperm whales in this manner for more than 500 years. The people are categorized as aboriginal hunters and are exempt from the International Whaling Commission's moratorium on the killing of whales. Our morning spent visiting Lamalera's people to better understand their unique way of life and appreciate their connection to these rich waters ranks as one of the trip's highlights for me.

We are only a few days into our cruise, and it is already one of the most memorable working holidays I've had in a long, long time. The diversity of marine life and marine habitats as well as the variety of topside activities are remarkable and ensure we will not forget this adventure anytime soon.

How could we, with dives like **Alcatraz**, **Rusa Pinnacle** and **Watu Balu**? We weave through *selats* (straits) that bridge the Indian and Pacific oceans, around *batus* (rocks) and past *pulaus* (islands) in our march eastward to Alor. Pantar, the next major island we encounter, showcases many of East Nusa Tenggara's top scuba sites. Our divemaster guides my wife, Melissa, and me down to a forest of 3-foot-tall burgundy-colored soft-coral trees at Alcatraz. Emerging from the sand at 90 feet, they create an otherworldly landscape, bizarre and beautiful, reminding me of the "upside down" baobab trees in Madagascar.

Rusa Pinnacle, very rarely dived, proves to be one of most challenging submersions of the itinerary. The current gives us a workout, but the reef scenery from the slope at 100 feet all the way up to the pinnacle's peak in 20 feet makes it all worthwhile. Purple hydrocorals and bubblegum-pink cup corals seem to explode off the reef with their brightness. A variety of angelfish species, emperors, damsels, bannerfish and legions of anthias hug the healthy hard corals and sea fans, while the current whooshes us along. Barracuda,

Snowflake moray eels (*Echidna nebulosa*) can grow to about two and half feet long. They're solitary and often seen in the open over sandy bottoms and among coral rubble.

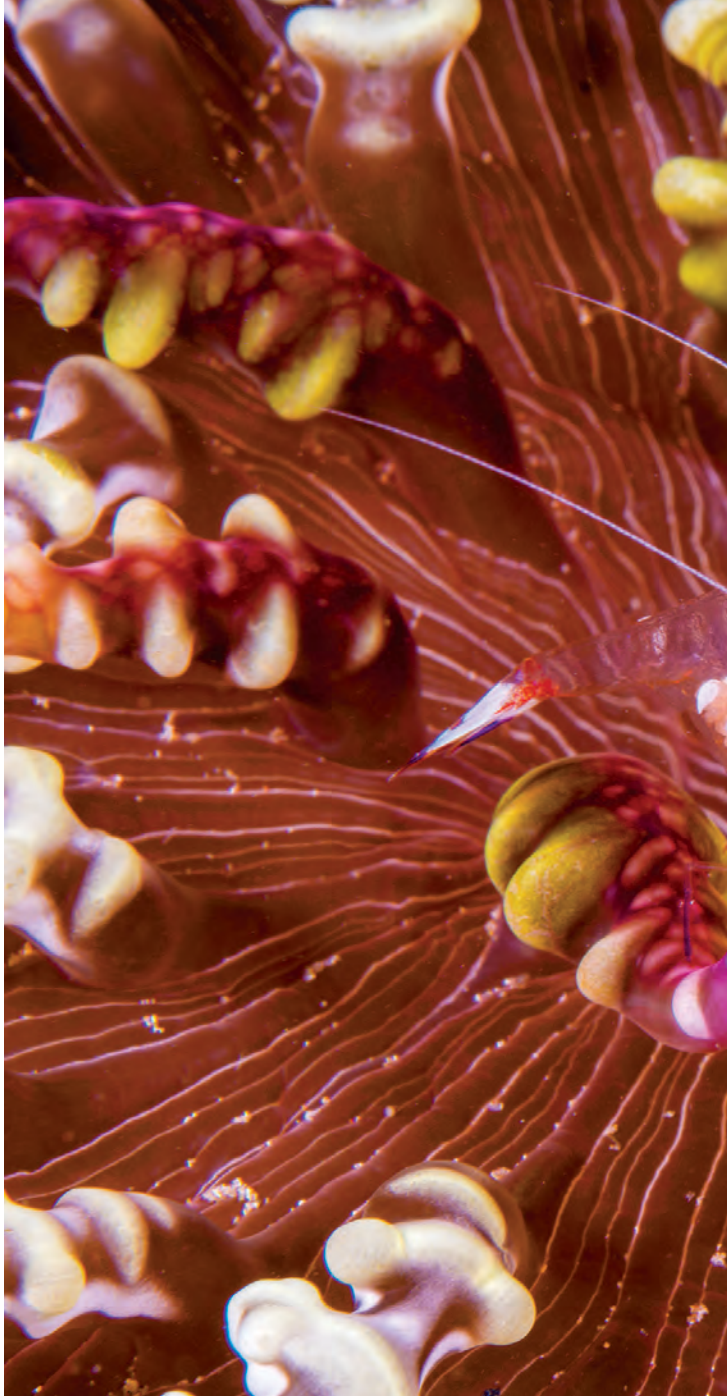
***Opposite:* A diver floats above a sea fan (*Annella mollis*) to which two crinoids cling. This sea fan was formerly named *Subergorgia mollis*.**

sinister sneering dogtooth tuna and even a *Mola mola* tempt us out into the blue, but the current says no.

Another nearby secret spot for advanced divers is Watu Balu, which delivers even more excitement, current, cool upwellings and surge so strong we feel like we are in the world's most colorful washing machine. My logbook reads:

> *Insane dive. And favorite so far! Wild and wooly conditions. Boiling at the surface. Fish soup below. A maelstrom of fish flesh: fusiliers, surgeons, billions of anthias, all feeding in the plankton storm. Current cranking sideways, up, down, spinning us around. Mammoth surge. Tunas and GTs massacring the baitfish. Glorious chaos and mind-boggling color. Terraces of perfect table corals, like Bali's rice terraces. No way photos will do this place justice. Killer site!*

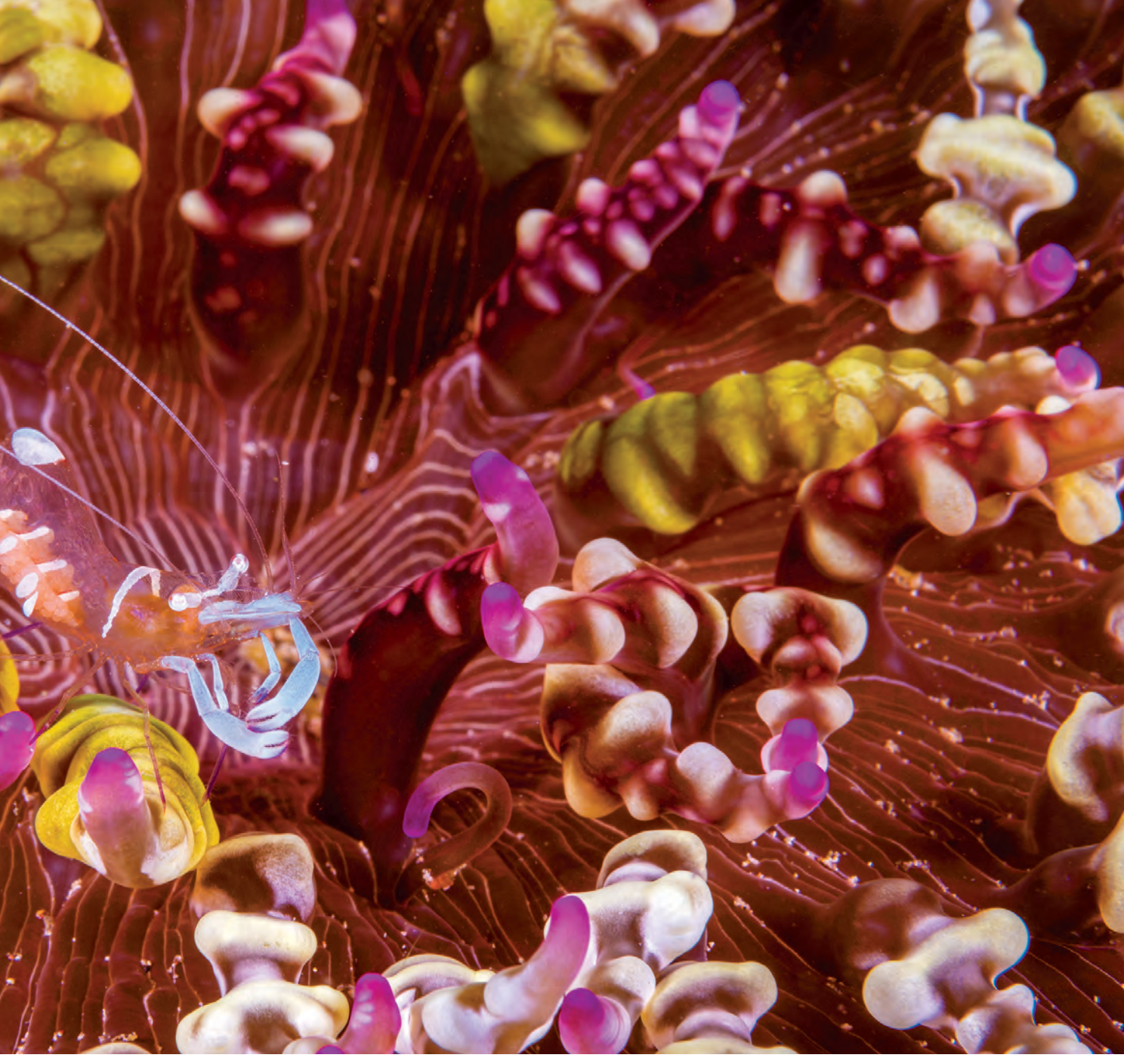
So good is Watu Balu that even with the difficult conditions we beg the crew for a second jump. They agree, commenting that this amazing rock has probably been dived by only a few dozen people, in part because of its remote location and in part because of the tough conditions. The profusion of life, the kaleidoscope of eye-popping colors created by innumerable anthias buzzing over pristine hard and soft corals, and the raw kinetic energy of the waters around us make me wonder whether this is what the primordial seas were like long before man entered the picture.



Magnificent anemone shrimp (*Ancylomenes magnificus*), such as this one with eggs, are cleaner shrimp that grow to about 1 inch and live on anemones.

***Left:* A nudibranch sea slug (*Nembrotha aurea*) raises its head. Previously classified as *Nembrotha purpureolineata*, this animal can be found throughout the tropical Indo-West Pacific region.**

The diving East of Flores is not all hurricane-strength current and stomach-lurching surge. Relaxing, 90-minute submersions by day and night over the black-sand slope off **Beangabang** beach on Pantar's southeast side unveil a wealth of little beasties. We spot



coconut octopus, mating bubble shells, juvenile lionfish and hellfire anemones with harlequin crabs. A spiky cluster of sea urchins provides protection for juvenile bannerfish and cardinals. Ghost pipefish and frogfish hide in plain sight. Surface intervals between our three dives at Beangabang are filled with fun photo shoots of the namesake village's children, who paddle out in dugout canoes to see us.

The Pantar Strait connects two oceans, the Pacific to the north and the Indian to the south. We devote two days to exploring this dynamic waterway above and below Pantar's waterline, starting with a search for cetaceans. Though we do not encounter any of the mighty blue whales or sperm whales that are often sighted migrating through these productive waters, we do luck out with playful pods of both spinner and Fraser's dolphins. We dive Pura Island's **Anemone City**, truly Nemo's kingdom with more carpet anemones and Clark's anemonefish than I've ever encountered before in my life, and **Solong Bali**, where we follow fishlike kids with homemade goggles and rudimentary spearguns as they hunt on their shallow reef. At **Babylon**, adjacent to Reta Island, we drift over a hard-coral garden to see the locals' handcrafted fish traps and then witness thousands of convict blennies emerging from their communal

burrow like liquid mercury to move as one over the reef.

Alor Island marks the turnaround point for our expedition. But before we point the bow westward, our group votes for another surf and turf day, beginning with an early morning visit to the lively fish, fruit and vegetable market in Kalabahi followed by a drive into the highlands to the village of the Aboi hill tribe. Headhunters in the not-so-distant past, the Aboi now welcome guests and are proud to share their culture through traditional song and dance. A few brave souls in our group join them in chewing betel nut.

My excuse for abstaining is that I have to keep taking pictures of the ceremony (and keep a clear head for the afternoon and evening dives at **Mucky Mosque**). My favorite muck dive of the cruise, this site along the northern shore of Kalabahi Bay is aptly named. It is a steep sand/mud/rubble slope directly in front of a mosque. The cast of characters drawn to this mecca is truly impressive. As is always the case, our expert guide deserves most of the credit for "our" discoveries. His superhuman eyes spy blue-ringed and wonderpus octos, iridescent bobtail squid, a rare dottyback species, zebra crabs, frogfish and many spectacular sea slugs — all within a few minutes. My brain cannot process all of the photographic possibilities. But I redeem myself by finding my own paddleflap scorpionfish, splendid in red with its shaggy eyebrows and pectoral fins flared out like frilly Japanese fans.

From top: **Fraser's dolphins (*Lagenodelphis hosei*) leap out of the Savu Sea.**

Schooling bannerfish (*Heniochus diphreutes*) juveniles aggregate around radiant sea urchins (*Astropyga radiata*) on a shallow sand slope. Cardinalfish and juvenile surgeonfish also shelter among the urchins' spines, which provide all of these small fish some degree of protection from larger predators.

Opposite: **Scalefin anthias (*Pseudanthias squammipinnis*), also called fairy basslets, swarm in the thousands as they feed in the current above healthy hard corals 50 feet below the surface.**

At dinner that night, while folks are excitedly reliving the magnificent mucking about, the captain gives us the news that we will now head west and north, way out into the Flores Sea. The weather and the moon, that fickle mistress who pulls the tides to and fro, are finally giving us an

opportunity to sail to Komba. We settle in for a long night's steam.

A thunderous crack and boom shatters the silence, interrupting our 7 a.m. dive briefing. Heads snap around to stare upward at a billowing ash plume mushrooming into the early morning sky. With a smile, our cruise director continues with a deadpan, "Welcome to Komba Island. Maybe we'll hear the next eruption while we're underwater."

It's something for us to contemplate as we gear up, trying to focus on buddy checks and analyzing our nitrox mixes rather than imagining rivers of magma and projectiles of mountainside descending from an ash-clouded sky. The water at **Smokey Point** is warm at 82°F but not as hot as the superheated seawater of my nightmares, in which I'm boiled alive like a neoprene-clad lobster. In no time at all, I've stopped worrying about the eruptions that occur every 15 minutes and am instead contentedly stalking fish — snappers, squarespot anthias, yellow damsels and garden eels — and setting up wide-angle shots of the vibrantly hued sea fans and soft corals. Blue starfish cling to the pretty coral formations that flourish in the shallows. Tuna streak by in the blue. I decide that the submerged shoulders of a grumbling volcano is a lovely place to dive. I'm happy and at peace within the Ring of Fire, deep beneath the waves in the wilds of Indonesia. AD

HOW TO DIVE IT

CONDITIONS: You can dive Flores to Alor year-round. The dry season is May through November; the rainy season is December through April. The air temperature ranges from 80°F to 90°F. Seawater temperature averages 80°F, though there are often cooler upwellings (down to 70°F) at some southern dive sites in the Savu Sea. Underwater visibility varies from 30 feet to more than 100 feet.

SKILL LEVEL: Dive sites range from novice to advanced depending on the depth and current. Surface signaling devices are a great idea. Pay close attention to the briefings, and dive within your limits. Remember that you are exploring a remote area without big cities or advanced medical care. Dive conservatively. The nearest hyperbaric chamber is in Bali.

GETTING THERE: Fly to Bali (airport code DPS) and then to Maumere (MOF). This town of approximately 100,000 people on Flores Island is the port of departure for liveaboard voyages sailing east to Alor and back through the Indian and Pacific oceans. A 10- to 15-night cruise is highly recommended to provide enough time to zig and zag between the islands and pause for topside treks as well. There are also a few land-based diving resorts in the Alor Archipelago.

Curaçao

AN ISLAND TO OURSELVES

TEXT AND PHOTOS
BY ANDY AND ALLISON SALLMON

We're in a bright-orange rigid-hulled inflatable boat, and we are racing (as much as one can race in 7-foot swell) into the wind. My knuckles are white from gripping the center console — and it's a good thing I'm holding on tightly, because the boat has just caught air. Come to think of it, it's also a good thing that I pulled on my wetsuit back at the dock, because I'm so drenched that this boat ride could just about be classified as a dive.

We've only seen one other vessel since we left the harbor — a large fishing boat that was headed in the opposite direction. The absence of boat traffic strikes me as odd, and I lean toward the captain, a quiet Dutch expatriate, and bellow, "So, do a lot of divers go to this site?" The captain looks at me evenly, one lip raised in a not-quite-smile, and replies, "No."

What does his "no" mean? Of course, it could be a simple reply. And there's always the possibility that it means "I can't really hear your questions over the engines. Please don't bother me while I'm driving." The tipoff here, however, is in the half smile, which on the face of the stoic Dutchman transforms "no" into something more along the lines of "No, and it's their loss, because you're about to have your world rocked."

That smile pretty much says it all about the island of Curaçao: It may seem like your everyday Caribbean dive destination, but there is nothing everyday about Curaçao's spectacular — and spectacularly uncrowded — dive sites. We get our first hint of this before we even board our flight, while we are still entrenched in the ever-popular airport game of "spot the diver." Boisterous, dive-flag-marked groups are everywhere, headed to Grand Cayman, Bonaire, Honduras and Mexico. No such group is gathered at the gate to Curaçao, which instead contains a busy mix of families, businessmen and young couples comparing shiny wedding rings. I had the distinct feeling we were onto something.

My suspicion is confirmed with a vengeance during our very first dive at Eastpunt. There isn't another boat in sight as we roll in and descend to a coral-lined cavern at 95 feet called the **Love Cave** (named for a nurse shark tryst once witnessed by a lucky diver). Although there is no romance on view today, the large spiny lobsters dispersed among the cracks in the cave's ceiling are a nice consolation. There is no time to loiter,

A diver explores the wheelhouse of Curaçao's signature wreck, *Superior Producer*.

however, as a mild current pushes us along a sloping reef, passing hawksbill turtles, moray eels and large tube sponges in a gradual ascent to 60 feet.

We arrive with time to explore one of Curaçao's most fantastic sites: **Tarpon Arch**. It almost goes without saying that sites named for a particular creature can be unreliable for delivering interactions with the marine life in question (I'm looking at you, Love Cave), but in this case the name is completely accurate. More than a dozen tarpon circle lazily under the large coral arch, joined by a large African pompano suffering an identity crisis. We admire the unafraid tarpon, distracted only momentarily by a bold octopus busily hunting among the sponges.

We break the surface, where there are still no other boats in sight, and head back around the point of the island to take a look at a south-facing site called **Guliauw** (our crew has named it "Best Reef"). We drop in and poke around a shallow lagoon for a bit in search of nurse sharks, finally giving in to the lure of the adjacent wall and dropping over the edge. We pass sponge after sponge — red barrel, yellow vase and purple tube — and finally pass around a corner to discover a dense garden of black coral so extensive that the entire wall takes on a fluffy, dreamlike appearance. We surface and head back toward the harbor. We have not seen another diver all day.

The trend continues as we head to Klein Curaçao, an uninhabited island eight miles southeast of Curaçao

One of the most-photographed waterfront views in Curaçao, the Handelskade features colorful examples of colonial Dutch architecture.

Opposite: **Green turtles sometimes gather in the shallows near fishing piers, hoping to get an easy snack.**

proper. When we approach, I figure that solitude has gone out the window. It is a weekend, and the lee of Klein looks like a mild traffic jam, with several other dive boats weaving between moored speedboats and large snorkeling charters. The aqua hue of the shallow water and cerulean tint of the cloudless sky are interrupted only by a strip of powder-white sand upon which a pair of swimsuit models cavort for a photo shoot (no, I'm not kidding). Given the scene, I feel fortunate that anyone's attention can be swayed by scuba at all.

We leave the crowds behind, and by the time we have pulled up to the northernmost point of the island, diving is all anyone can think of. This site, **Shark Cave**, is accessible only on the calmest days, and it seems that we have hit the jackpot. Green and spotted morays gape from a soft-coral- and sponge-covered wall as we descend 120 feet to the (shark-bereft but tarpon-filled) cave. The adjacent reef is dotted with anemones and large purple tube sponges, and a glance into deeper water reveals the nurse sharks, watching us smugly from under a rock.

We swim into the shallows for our safety stop, passing narrow ledges caked with cup corals and sea fans, as a cluster of reef squid observe us from just beyond camera range. For our next dive, we head toward **South Point** on the opposite tip of Klein for a completely different experience. We descend to 110 feet, where we are followed by several large barracuda as we admire a sloping wall thick with vase sponges and black coral trees.

The next day we head toward Westpunt to dive two of Curaçao's most famous sites, and although most of the island's dive operations run regular trips here, we seem to have the area all to ourselves. **Watamula** looks nothing like what we've seen at either Eastpunt or Klein. The seascape here is composed primarily of hard corals, with so much pillar coral that some areas resemble towers of melting ice cream. A variety of moray eels peer from the reef as schools of grunts and squirrelfish weave past.

We surface, and our captain asks, "Want to see something interesting during your surface interval?" We know better than to turn down an offer like that, and the boat motors toward a nearby pier where several small fishing boats are moored. In one, a fisherman cleans a pile of feathery lumps. "What the heck are those?" I ask. "Lionfish," the captain replies. A moment later, we watch in confusion as a gaggle of snorkelers passes us, shouting excitedly to one another. I am all for limiting the spread of this invasive species, but it seems odd that tourists would be so gleeful about seeing fish carcasses. I look at the captain questioningly, and he laughs and says, "Look down." We peer into the clear water just as four green turtles swim past. The smallest turtle is lugging around a chunk of fish gill as big as its own head.

You've never seen two people enter the water faster. An hour (or possibly two) later, after we've shot our fill of turtle photos and heartily debated whether we should bother with another dive or stay put, we clamber back into the boat.

We're still hooting with delight over the turtle bonanza when we gear up to dive at **Mushroom Forest**. This shallow site, like many others near Westpunt, is dominated by hard coral, but with an unusual twist: The bases of the coral heads have been so eroded that they resemble outsized versions of their namesake fungus. Add in some encrusting sponge for a bit of color, and a dive here has an otherworldly *Alice in Wonderland* feel. This is likely why it is considered Curaçao's signature dive. But once again we seem to be the only ones in on the secret.

We thank our captain profusely and bid him farewell; the next morning we'll begin exploring one or two of Curaçao's numerous shore dives. At this point we have yet to encounter a single other diver underwater, but we fully expect that to change when we pull up at the beach adjacent to the ***Superior Producer***, hailed as one of the best wreck dives in the Caribbean. The ship sank just outside of the harbor in December 1977 when her cargo shifted, and since that cargo included quite a bit of liquor, the event kicked off a party that — according to locals — lasted for two glorious days. The *Producer* has long since

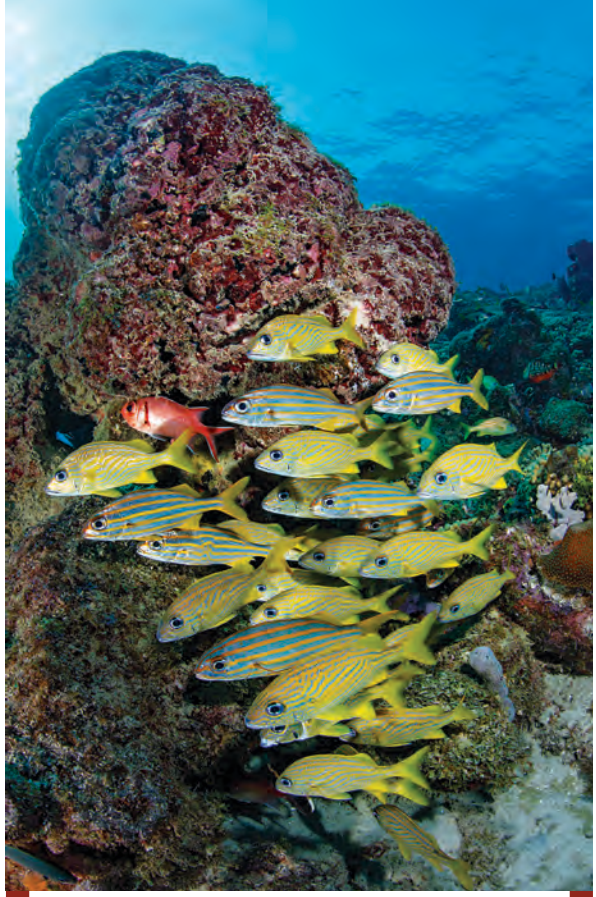
been relieved of her booze, but divers still flock here to admire this upright, intact behemoth in 110 feet of water. The building of a cruise-ship pier adjacent to the site about a decade ago created a bit of an obstacle: Divers are not permitted at the site when a cruise or military ship is present, and this can limit access quite a bit. Our research has revealed only a single day during our weeklong visit when we can dive the site, so we head there early in anticipation of a crowded wreck. We are shocked to discover that we are the only visitors on the beach, but we don't spend time discussing matters. Instead, we gear up and enter the water before we can say "sleeping in."

We approach the majestic ship from the stern, noting incredible visibility, several dozen large tarpon overhead, sponge and coral covering the superstructure, and a watchful spotted moray peering from the engine block. The adjacent reef is equally gorgeous, so when it's time to turn around, we swim in slowly, admiring cowry-decorated sea fans and anemones hosting colorful shrimp in the shallow water. We emerge to discover a significantly more congested beach, and several people approach to ask us about visibility and current (factors that can occasionally make this a challenging dive). By the time our surface interval is complete, however, nearly all the others have returned from their dives, so our second exploration is as private as our first.

On our final dive day, we're drawn to dive a site that we know we'll be sharing with others: the **Tugboat**. This small wreck is situated in 20 feet of water next to a sloping reef, so it's visited regularly by classes and novice divers, and it is also a common destination for groups of snorkelers. Sure enough, despite an obscenely early arrival, the beach is packed with people donning gear. A bit of speed on our part gets us a blissful 10 minutes of alone time on the pretty site, and we are able to appreciate the glassy sweepers crowding the wheelhouse, the grunts schooling next to the propeller, and an octopus hunting before a large group of snorkelers materializes above us. We begin swimming back toward the beach, but when we spot the structure of the **Baya Beach pier**, we can't resist a closer look. Our impulse is a good one: We are rewarded with beautiful sunrays filtering past pilings laden with sponges and feather duster worms, and we have the small area all to ourselves.

We can't bring ourselves to pack a minute before it's obligatory, and the lure of our resort's house reef becomes too much to take. **Snake Bay** harbors an incredible array of small marine life including frogfish, a seahorse or two, a snake eel, arrow crabs and shrimp. During the swim in, we are distracted by the fleeting sight of a tight baitball swirling past with a couple of ravenous jacks giving eager chase.

We're rinsing our gear when a couple approaches. They are divers from Arizona, and they want to know all about our visit. Which was our favorite site, they ask, and was it amazing? We rave about Eastpunt and Westpunt, Klein Curaçao, and the incredible shore diving. One of the pair looks at me, his voice lowered, and he stage-whispers, "So give it to me straight — are there going to be crowds of divers everywhere we go?" I can't help but channel my inner Dutch expat as I half smile and reply very simply, "No." AD



Clockwise from above: **The only underwater crowd in Curaçao, a school of grunt, gathers next to a sponge at Klein Curaçao. A hunting octopus steals attention from the tarpon at Tarpon Bridge. The sponge-covered pilings of Baya Beach pier are well worth a closer look.**

Opposite: **Playa Kenepa Grandi (Knip Beach), located on the western side of the island, provides a glimpse of this idyllic, uncrowded paradise.**

HOW TO DIVE IT

GETTING THERE AND GETTING AROUND: Many airlines fly into Curaçao, and a number of car-rental agencies are at the airport.

WATER TEMPERATURES AND EXPOSURE GEAR: Water temperatures range from the high 70s°F in the winter to the mid-80s°F in the summer. A shorty or 3 mm wetsuit is adequate for most divers. For shore diving, thick-soled booties are a good idea.

SHORE OR BOAT: Curaçao boasts a fringing reef, which means that a staggering number of fantastic dive sites are just a short swim from the beach. The shore diving here is phenomenal and should not be missed, but several popular sites, such as Mushroom Forest and Klein Curaçao, can be reached only by boat. Many dive operations offer packages that include a combination of shore and boat diving.

SURFACE INTERVAL: The city center of Willemstad, Curaçao's capital, has been recognized as a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage site. A stroll along the waterfront to view the colorful Dutch colonial architecture is a must.

"WE MAKE OUR DIVERS SAFER, SO THEY CAN STAY LONGER AND GO DEEPER."
— Master Diver (Retired) Samuel Huss

DEEP IN THE SCIENCE OF DIVING

THE NAVY EXPERIMENTAL DIVING UNIT

TEXT BY MICHAEL MENDUNO | PHOTOS BY STEPHEN FRINK

Four muscular Navy divers, all volunteers, file carefully through the first two interlocking pressure chambers on their way to "Charlie" chamber. From there they will climb down into a cylindrical, water-filled chamber — large enough to house a school bus — that constitutes the base of the U.S. Navy Experimental Diving Unit's (NEDU) Ocean Simulation Facility.

The divers, each designated by a number for the purpose of the experiment, wear Navy Mark 16 (MK-16) closed-circuit rebreathers equipped with full-face masks. The rebreathers are charged with either trimix 12/44 (12 percent oxygen, 44 percent helium, 44 percent nitrogen) or heliox 12/88 (12 percent oxygen, 88 percent helium) — the divers haven't been told which mixture they have.

Once they're submerged in the wet pot, the dive watch supervisor in the control room will press the divers to 200 feet, where they'll complete a 40-minute dive while pedaling cycle ergometers (stationary bikes). They will then decompress for nearly two hours according to the MK-16 trimix table, which is 15 minutes shorter than the corresponding decompression schedule for heliox and allows initial ascent to the first decompression stop at 70 feet (the first deco stop in the heliox schedule is at 90 feet). After surfacing, the divers will be monitored for signs and symptoms of decompression sickness (DCS).

Because helium, which is nonnarcotic (unlike nitrogen), is believed to have faster tissue uptake and elimination than nitrogen, existing decompression models (including Albert Bühlmann's algorithm, popular with technical divers) assign deeper stops and correspondingly longer decompressions the greater the fraction of helium in the breathing mix. This is sometimes referred to as the helium penalty.

If the models are correct (that is, if decompression with trimix is more efficient than heliox for bounce dives), NEDU scientists would expect to see a higher incidence of DCS in the heliox dives in the study than in the trimix dives. But lead researcher David Doolette, Ph.D., who is also an underwater cave explorer, is not convinced that's what they will find.

NEDU researchers developed heliox diving in the 1930s as part of the command's initial mission. Their goal was to find a way to limit the debilitating effects of nitrogen narcosis to make it possible to rescue crews from downed Navy submarines. They hypothesized that helium would require less decompression than nitrogen, but their early tests concluded otherwise. With the successful rescue of USS *Squalus* survivors in 1939, heliox became the Navy's standard breathing mix for deep diving.

In recent years the Royal Canadian Navy and others began trimix research programs, in part due to high helium costs, and invited the U.S. to participate. Doolette and colleagues Wayne Gerth, Ph.D., the head of NEDU's decompression team, and Keith Gault, however, convinced their sponsor that the program would make sense only if trimix offered significantly reduced decompression times over heliox, a claim that had never been tested. They designed the experiment accordingly.

The results? The four Navy test divers successfully completed their dives. Over the next nine weeks a total of 32 volunteers conducted 50 heliox dives without incident and 46 trimix dives with two diagnosed cases of DCS. Statistically that means that the researchers must

A diver wearing a tubesuit calorimeter undergoes cold-water testing to determine where the body gains or loses heat in different water temperatures. The project will show how much heat is required and where it is required to safely and effectively maintain diver thermal balance.

retain their null hypothesis: Trimix decompression is not more efficient than heliox; existing models require revision. It's not the first time that an NEDU experiment has refuted legacy diving practices or beliefs.

BRAIN TRUST MEETS GEEK SQUAD

Experimentation is at the heart of the enterprise that is NEDU (pronounced N-E-D-U), which traces its scientific heritage back to the Navy's first experimental dives, conducted by Chief Gunner George D. Stillson in 1912, to test John Scott Haldane's decompression theory. Located at the Naval Support Activity Panama City military base in Panama City Beach, Fla., the NEDU's mission is to develop solutions to support and improve the fleet's diving and other manned undersea operations through research, development and independent testing and evaluation of equipment and procedures. Think of it as the brain trust meets geek squad of U.S. Navy diving.

Since its inception in 1927, NEDU, along with the diving biomedical research and development division of the now defunct Naval Medical Research Institute (which NEDU absorbed in the late 1990s), has been responsible for a disproportionate share of advances in decompression procedures, mixed-gas diving, underwater breathing apparatus (UBA) engineering, saturation (SAT) diving and our knowledge of diving physiology.

In terms of quantity and significance, no other institution can claim a more distinguished record of contributions. NEDU's collected works, which include more than 1,000 technical reports and innumerable scientific papers, most unclassified, embody the intellectual and technology infrastructure used by practically every diving community today.

For much of its history NEDU's research focused on issues facing tethered divers conducting surface-supplied and SAT diving, which was of critical importance during the Cold War. Over the past decade and a half, however, the growth of special operations has caused the diver-driven command to turn its attention to the problems encountered by free-swimming divers, which represent half of the fleet's 5,000 divers.

"We're pushing the envelope on gases, depth and gas switches, mostly with closed-circuit rebreathers," explained Lt. Cmdr. Steve Duba, an Explosive Ordnance Disposal (EOD) diver, who serves as NEDU's Executive Officer (XO). "It's special mission support. One of our priorities is keeping divers warm in free-swimming situations. There's also a push to go deeper, and we're looking at developing the tables and gear to support that." Surface-based dives on the MK-16 are currently limited to 300 feet (open-circuit dives are limited to 190 feet).

If you're wondering what the future holds for U.S. Navy diving and, by extension, diving as a whole, consider this: It's being invented right now at NEDU.

FOR DIVERS BY DIVERS

Walking down the long beige cinder-block hallway with brown-flecked linoleum flooring and black-and-white pictures of famed alumni, passing clean-cut young men in khaki short shorts and blue NEDU T-shirts, it's easy to imagine you've entered a 1950s parochial school rather than dive geek heaven. Diving is, in fact, regarded with near religious fervor here.

You could say NEDU was created by divers, for divers. Its 120 employees, including nearly 35 civilians, comprise a unique team of military divers, diving medical officers (DMOs), scientists and engineers. In addition to the leadership drawn from officers in the fleet's 20-some diving communities — including Sea-Air-Land (SEAL) Teams, Fleet Divers and EOD — there are six DMOs, nearly 25 scientists and engineers and 50 First Class Navy divers, who serve as test subjects and maintain the facility and equipment under the supervision of a Navy Master Diver.

The depth of knowledge is palpable. "I've been in the Navy for 29 years, and this is the best command I've served in," said Project Officer Capt. Edward "Andy" Woods, M.D., a former SEAL Team medical officer. "There are so many exceptional individuals — the best of the best. People come here because they're passionate about diving; they couldn't do this anywhere else."

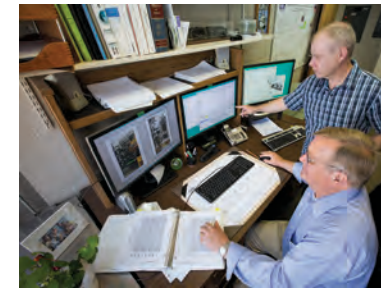
NEDU focuses on improving diving safety and performance. About 30-40 percent of its $10 million annual budget is reimbursable for the work conducted on behalf of its sponsors, which include the Office of Naval Research, Naval Special Warfare Command, and Submarine Escape and Rescue (part of the Naval Submarine Medical Research Laboratory), as well as other branches of service such as the Air Force. Its investigations range from basic and applied biomedical research to addressing the specific operational needs of warfighters. Sometimes that involves Einstein-meets-MacGyver solutions.

NEDU also tests and certifies all of the equipment used or being considered for use by the Navy diving community; its unique unmanned test facility is capable of subjecting gear to depths of 730 feet in cold, hot, fresh or salt water. In addition, it conducts all diving accident investigations involving federal

Above: **A Navy diver in the NEDU test pool performs an exercise during a physiology study.**

From left: **Navy Diver 1st Class Greg Early hoists a KM-37 helmet after an unmanned freezing-water performance evaluation dive inside the Experimental Diving Facility Bravo Chamber.**

Gerth (foreground) and Doolette evaluate an experimental decompression schedule.



employees, which have numbered close to 100 in the past decade.

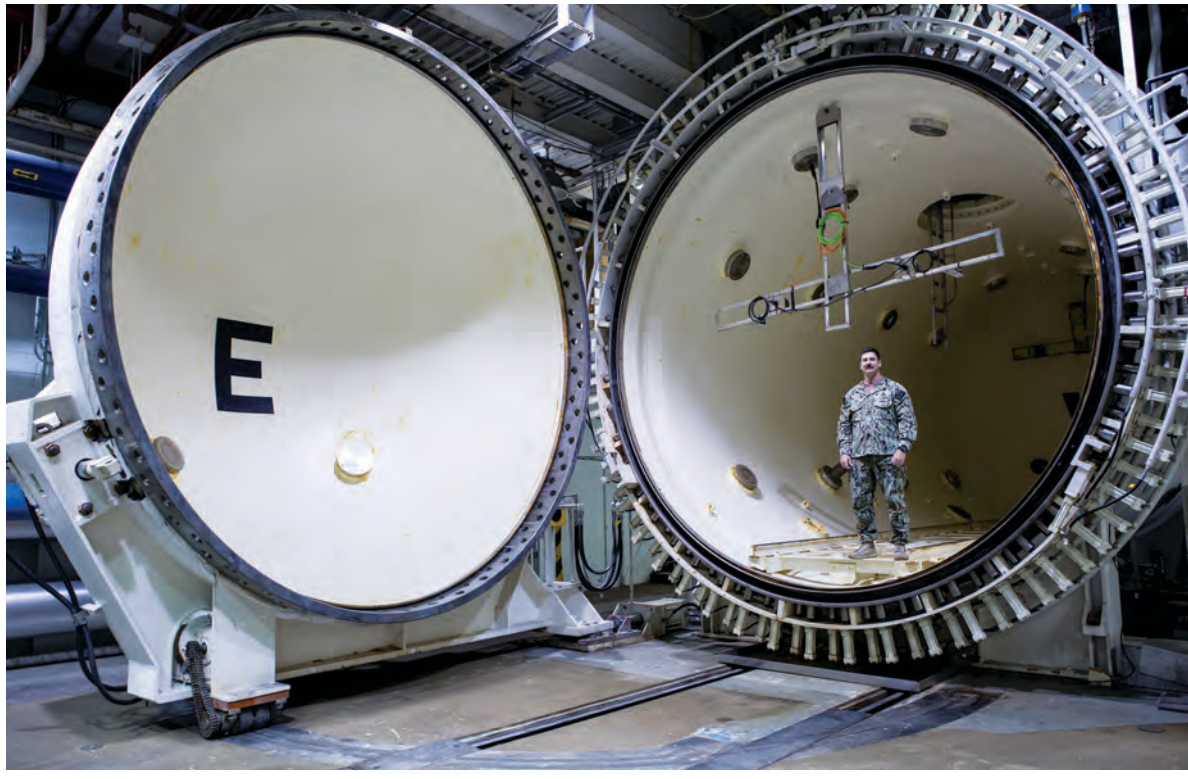
NEDU's work relies heavily on the Ocean Simulation Facility (OSF), which is the largest and most sophisticated hyperbaric facility in the world. Built in 1971, the chamber complex consists of a wet chamber and five interconnected dry living/working chambers that can simulate ocean conditions to depths equivalent to 2,250 feet of seawater and altitudes up to 150,000 feet. The complex also accommodates complex man-machine testing. NEDU conducts two to three SAT dives a year in the OSF as part of its mission to maintain the Navy's SAT diving capability. The dives can last up to 30 days and cost as much as $750,000.

Scientists such as Doolette say NEDU's diving culture enables them to do research that other institutions can't. "We're one of the few facilities in the world that can take an experiment all the way to DCS," Doolette said. "Almost everyone else looks at VGE [venous gas emboli] as an outcome measure."

Although most research organizations find it increasingly unacceptable to bend people, the hard endpoint makes decompression studies more valuable. "Divers here say, 'Yes, I'll do it,' because their buddies are out there at the tip of the spear," Doolette said.

NEDU divers must give their informed consent to participate in a given experiment, each of which is carefully reviewed by a federally mandated institutional review board to ensure it meets ethical standards for human subject research. There is no coercion. The unit's 50 enlisted divers aren't the only ones to man up; every diver participates.

"I volunteer, and so does the CO [Commanding Officer] and the XO," said Command Master Chief Louis Deflice, a Master Diver who is third in command and completing his second tour of duty at NEDU. He originally came in



Above: **NEDU's Executive Officer LCDR Steve Duba stands in the open wet pot of the Ocean Simulation Facility.**

From left: **Divers in Alpha and Bravo chambers of the Ocean Simulation Facility prepare to leave the surface.**

Researchers conduct human performance testing following repeated long-duration dives.

1997 as an enlisted SAT diver. "We believe in our divers and wouldn't ask them to do dives that we wouldn't do. It's an opportunity to give something back."

No doubt this democratization of science contributes to NEDU's compelling sense of team. Many individuals say that they consider it a family.

BACK TO THE FUTURE

"Suppose you were performing a SAT dive and locked out of a warm subsea platform on a rebreather at 1,000 feet in near-freezing water," said Vince Ferris, a department head who oversees NEDU's unmanned test facility. He is testing the variability of temperature compensation circuits in oxygen sensors, which determine how much oxygen (O_2) is added to a rebreather's breathing loop. A 1 percent overshoot at 200 feet is no big deal, but at 1,000 feet it would be deadly. His team is also investigating a promising new carbon dioxide (CO_2) sensor that uses a polymer sensing film to detect CO_2, which unlike existing infrared sensors is impervious to water vapor. The device could greatly improve the safety of rebreather diving.

Their latest project is to determine the efficacy of using Micropore Inc.'s CO_2 absorbent cartridges for the MK-16 as well as the fleet's Dräger LAR V oxygen rebreather. Though cartridges haven't caught on with tech divers due to their expense, Ferris, who is a veteran cave and rebreather diver, thinks they offer potential advantages over manually packed scrubbers to military divers. The lab is also in the process of

retesting all Navy regulators and helmets to see how they perform in near-freezing fresh water. As a result of two diving fatalities, they recently discovered that a regulator that performs in 29°F salt water can freeze up in 34°F fresh water. Ferris' list goes on.

Respiratory physiologists Dan Warkander, Ph.D., and Barbara Shykoff, Ph.D., both sport divers, have spent the past five to six years examining how humans interact with underwater breathing apparatuses, measuring what combinations of breathing resistance and CO_2 can be tolerated. "Our goal has been to get insight into the physiology: what's safe, what's not, what you can do and why," Shykoff said. "The Navy is interested in safety."

Warkander has performed critical work designing and testing CO_2 scrubber gauge systems, while Shykoff is regarded as the resident expert on whole-body or pulmonary oxygen toxicity. Late last year Shykoff published a new descriptive risk model for rebreather diving meant to replace the familiar but outdated oxygen tolerance unit (OTU) model taught in nitrox and tech classes. The problem? "We've been trying to describe oxygen toxicity as a single phenomenon, but it represents different phenomena depending on the PO_2 [partial pressure of oxygen]," she explained. "The OTU model also includes no provision for recovery" (resuming diving after metabolizing the excess oxygen).

John Florian, Ph.D., another researcher who specializes in warfighter performance, discovered a new form of whole-body oxygen toxicity shortly after his arrival at NEDU in 2008. Special Operations Forces (SOF) were anecdotally reporting excessive fatigue following six-hour hyperoxic swims on oxygen rebreathers. Florian conducted experiments and found that divers were suffering from a severe decrement in performance in their muscular and cardiovascular systems.

Florian's team is now working to understand the underlying physiological mechanisms and come up with prescriptive solutions. "Warfighters can be sick and cold and will gut it out. That's the SOF culture, but they don't have to do that," he said. "We want to give them an advantage so they can arrive with a 0 percent decrement and focus on their task instead of gutting it out."

They are also investigating the body's thermal protection system in hopes of better understanding underwater thermal physiology. He is looking at the basic mechanism of heat exchange, where the body gains or loses heat in different water temperatures, how much heat is required and where it is required. For example, Florian said that applying heat in the wrong places can actually lower a diver's core temperature. Their goal is to keep free-swimming divers warm with minimum bulk and/or power consumption. NEDU has tested several active thermal protective systems that are in development.

Gerth and his team continue to refine our understanding of decompression management. In addition to the recent trimix experiment, in a 2011 study involving hundreds of dives they debunked the notion that deep stops, generated by bubble models, are effective. They also discovered that a diver's thermal status (e.g., being warm on the bottom and/or cold during decompression) is a risk factor in DCS. Their clue: North Sea data linked the use of hot-water suits with a slight increase in DCS. "We thought it wouldn't make any difference but found that it did," said Gerth, who's considered one of the world's foremost decompression modelers.

They are currently examining the efficacy of air breaks — the practice of breathing air for five minutes after every 30 minutes of breathing pure O_2 during decompression and in hyperbaric treatment. The practice has never been tested, and it's not known if the pattern of air breaks is optimal or even necessary.

The team's main priority, however, is to enable Navy divers to tailor their dive profiles with risk levels appropriate to the operation — i.e., to dial in a specific risk of DCS using probabilistic algorithms. A training dive could be conducted with low risk, while the risk could be increased in a combat situation, enabling divers to get out of the water faster. Eventually they hope to incorporate this capability into dive computers. The MK-16 tables, which are "iso-risk" tables — i.e., every dive has the same 2.3 percent probability of DCS — are the only probabilistic tables currently in use. While a 2.3 percent probability of DCS might seem high, this measurement assumes that the dive profile is pushed to the limit (a square-profile dive) and represents the average risk on a typical Navy table profile.

Is what we now know about diving greater, the same or less than what we don't know? John Clarke, Ph.D., NEDU's Scientific Director since 1991, science-fiction author and authority on the human-UBA interface, smiled and answered: "There's a never-ending depth of questions about diving. We're constantly learning and finding out that many of the things we believe are simply not correct." AD

LEARN MORE

Visit *AlertDiver.com/NEDU_milestones* for a timeline of important NEDU milestones. See a video about the NEDU at *AlertDiver.com/NEDU*.

THE PHYSIOLOGY OF COMPRESSED-GAS DIVING

BY SIMON MITCHELL, MB, CHB, PH.D.

STEPHEN FRINK

The breathing of compressed gas while submerged and exposed to increased ambient pressure imposes significant homeostatic challenges on the body (i.e., challenges maintaining physiological equilibrium). This article discusses the important mechanisms of these challenges, with particular attention to the respiratory system.

I. THE RESPIRATORY SYSTEM

COMPRESSED-GAS BREATHING EQUIPMENT

Scuba equipment is the most commonly used recreational compressed-gas system, and it provides examples of important features and functions relevant to diving physiology. Basic scuba equipment consists of a cylinder of air at high pressure, a demand-valve regulator and a device for holding this equipment on the diver's back, typically a buoyancy control device (BCD). Together with a wetsuit (necessary for temperate-water diving) and a weight belt, this apparatus may constitute a significantly restrictive force over the diver's chest and abdomen.

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The regulator reduces the high-pressure air in the cylinder to ambient pressure and supplies air on demand. Thus, at a depth of 100 feet, where the absolute pressure is 4 atmospheres, the regulator supplies air at 4 atmospheres, and the air is four times as dense as air at sea level (1 atmosphere). The ambient pressure is measured by the regulator's second stage (attached to the mouthpiece), which in an upright diver is approximately 8 inches above the center of the chest. The water pressure acting on the chest will therefore be approximately 8

inches of water depth greater than that of the inspired gas, creating negative transmural pressure (pressure difference across the chest wall) that's greatest at the base of the lungs.

The breathing resistance of a regulator is inversely related to the quality of manufacture and standard of maintenance. Furthermore, breathing resistance tends to increase with depth as denser air flows through the regulator mechanism.

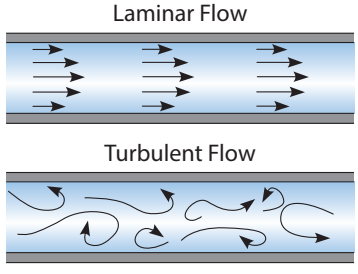
Finally, it should be noted that the internal volume of a portion of the regulator second stage is effectively an extension of anatomical respiratory dead space.

MECHANICS OF BREATHING

Changes in compliance: Changes in compliance are seen in the lungs and chest wall. The negative transmural pressure across the chest wall of the upright scuba diver causes some pulmonary capillary engorgement. This effect is enhanced by the relative centralization of blood volume that occurs with immersion, especially in cold water. This engorgement of the pulmonary capillaries causes reduced compliance in the lung tissue. This reduces the vital capacity of the lung by 10-15 percent.

Scuba equipment, wetsuits and weight belts exert a restrictive force on the chest wall and abdomen. This effect is potentially significant if equipment is excessively tight fitting. The compliance of the chest wall is reduced, and diaphragmatic breathing is impeded.

Changes in airways resistance: Airways resistance is affected by changes in gas density. Resistance is defined as the pressure decrease across a tube divided by flow. In laminar flow, flow is largely independent of the density of the gas. In turbulent flow, however, flow is inversely related to gas density. Therefore, in turbulent flow, for a given pressure decrease, flow will be decreased if gas density is increased, and by definition resistance to flow will be greater.

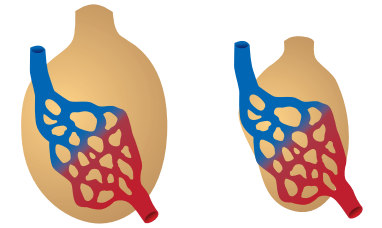


According to Reynolds number predictions (a method of predicting flow), flow within the lungs and airways is largely laminar; this assumption, however, is likely to be invalid because of the vortices that occur in inspired air at each division of the bronchial tree. Indeed, it is likely that turbulent flow occurs widely in the large airways, particularly during rapid breathing when flow rates are much higher.

Changes in the work of breathing: Work of breathing in diving is consequently increased. Work is performed by the respiratory muscles in stretching the elastic tissues of the lungs and chest wall, moving inelastic tissues and moving air through the respiratory passages. The preceding discussion demonstrates that in the immersed scuba diver there is an increase in elastic work (due to decreased compliance in the lungs and chest wall), work of moving inelastic tissues (due to constrictive equipment) and work of moving air through airways (due to increased air density). The airways-resistance component of this increase in work of breathing is dependent upon depth.

VENTILATION/PERFUSION MATCHING IN DIVING

The single most important determinant of efficient gas exchange is the matching of alveolar ventilation to the perfusion of the alveolar capillaries. The optimum ratio of these two factors is unity. Underventilated and overperfused lung units represent a right-to-left shunt. The mixture of hypoxic blood from underventilated and/or overperfused units into systemic arterial blood is an important cause of a significant alveolar-arterial oxygen gradient.



The lungs of a scuba diver are subjected to changes in both perfusion and ventilation. There is an increase in perfusion of lung units due to capillary engorgement (particularly at the bases of the lungs) and the relative centralization of blood volume that occurs with immersion. There is a decrease in ventilation due to reduced lung- and chest-wall compliance, abdominal constriction and increased airways resistance. The net effect is toward an increase in underventilated and/or overperfused units and thus the shunting of blood from right to left.

CHANGES IN GAS TRANSPORT

Oxygen: Oxygen is transported in the blood either bound to hemoglobin (Hb) or dissolved in plasma. The solubility of oxygen in plasma is low, and in normobaric conditions the greatest proportion of oxygen by far is transported bound to Hb.

Hb is normally 97 percent saturated when breathing air at 1 atmosphere of pressure, so there is little potential for increasing oxygen transport on Hb by increasing the partial pressure of oxygen. In contrast, dissolved oxygen increases linearly with the partial pressure of oxygen, although it is only in hyperbaric conditions with a high fraction of inspired oxygen that the dissolved fraction becomes significant.

At 3 atmospheres and breathing air, there is still only a relatively small amount of dissolved oxygen. Breathing 100 percent oxygen at 3 atmospheres, however, results in a dissolved fraction sufficient to meet the body's needs at rest in the absence of Hb, hence the value of receiving hyperbaric oxygen in conditions in which oxygen delivery is compromised (such as anemia and carbon-monoxide poisoning).

Carbon dioxide: Unlike oxygen, which is supplied at increasing partial pressures at depth, the number of molecules of carbon dioxide that are produced remains constant for a given workload, irrespective of depth. Transport of the carbon-dioxide load from tissues to lungs, however, may be less efficient in the hyperbaric environment, where an increased partial pressure of oxygen causes a fall in Hb in venous blood. Reduced Hb forms carbamino compounds with carbon dioxide and buffers the hydrogen ion resulting from the hydration of carbon dioxide in red blood cells. These are two of the quantitatively less important mechanisms of carbon-dioxide transport, however, and the significance of this disturbance is questionable.

CHANGES IN CONTROL OF RESPIRATION

The precise anatomy and physiology of the control of breathing are still unknown, but there is little doubt that carbon-dioxide and oxygen levels in cerebrospinal fluid and arterial blood, monitored by central and peripheral chemoreceptors, are important determinants of the rate and depth of respiration. A rise in the partial pressure of carbon dioxide or a fall in the partial pressure of oxygen of arterial blood increases the level of brain-stem respiratory center activity, and changes in the opposite direction have an inhibitory effect. In the hyperbaric environment, the increased partial pressure of oxygen is thought to produce a slight depression of the respiratory drive. Further, many divers, especially older career divers, show a reduced response to raised carbon-dioxide levels. The mechanism of this reduced response is unknown, but it has been suggested, without good supportive data, that it is a learned response in some divers.

At a cortical level, some divers deliberately override their insensible control mechanisms in an attempt to extend their underwater duration by conserving air supply. This unsafe practice in which ventilation is intentionally slowed or punctuated with short periods of apnea is called "skip breathing."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NET EFFECTS OF RESPIRATORY ALTERATIONS

Sustained work output by tissues is largely limited by their oxygen supply. In normal exercise, tissue oxygen supply is limited by cardiac output rather than ventilation or gas exchange. In a healthy person ventilation can be dramatically increased to 200 liters per minute or more, and a rapid transit of blood through alveolar capillaries (normally about 0.35 seconds) in high-output situations does not prevent equilibration of gases across the respiratory barrier. In addition, the ventilation/perfusion profile of the lung usually improves during exercise.

Underwater, even at the relatively modest depth of 100 feet commonly attained by sport divers, air density/airway resistance factors mediate a reduction in maximum voluntary ventilation to approximately half the surface value. This reduction in ventilatory capacity, the concomitant increase in the work and oxygen cost of breathing, the increase in underventilated and/or overperfused lung units and dead-space effects determine that underwater work may be ventilation-limited rather than perfusion-limited. It can be readily appreciated that a diver at a modest depth swimming into a 1-knot current (oxygen consumption for fin swimming at 1 knot is roughly 2 liters per minute), wearing ill-fitting equipment, using a poorly maintained regulator and being subject to the above physiologic compromise might fail to sustain the required work to make progress.

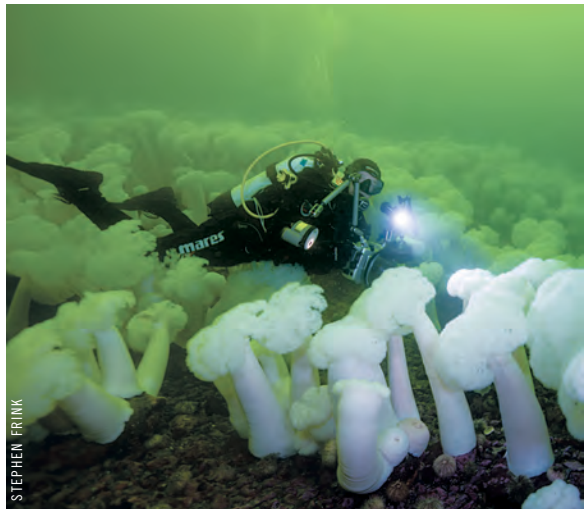
Another important consequence of these respiratory alterations is the diver's predisposition to retain carbon dioxide. Factors contributing to this situation include increased work of breathing (which increases carbon-dioxide production and limits ventilation), decreased

respiratory drive, decreased carbon-dioxide sensitivity in some divers, skip breathing and dead-space effects. The consequences of hypercapnia in divers include unpleasant and dangerous symptoms such as dyspnea, headache, nausea and unconsciousness as well as potentiation of nitrogen narcosis, oxygen toxicity and decompression illness.

II. THE CARDIOVASCULAR SYSTEM

CHANGES IN BLOOD VOLUME DISTRIBUTION

When a diver is immersed, the hemodynamic effect of gravity is abolished, and there is a consequent redistribution of peripheral blood into the central circulation. This effect is enhanced in cold water when peripheral vasoconstriction further promotes this redistribution. The relative central hypervolemia increases the activity of stretch receptors in the walls of the great veins and right atrium, with receptors in the carotid sinus and aortic arch also involved if the blood shift is sufficient to increase mean arterial pressure. The increased stretch receptor activity mediates a decrease in production of antidiuretic hormone from the hypothalamus/posterior pituitary. This results in an increased permeability to water in renal distal tubule cells and, therefore, increased urinary loss of water. The net result is an undesirable tendency toward dehydration, which may be exacerbated by lack of adequate drinking water and/or seasickness.



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CARDIAC EFFECTS

Immersion has been shown to increase cardiac output by up to 32 percent in thermoneutral water (approximately 91°F-94°F). The mechanism is an increase in venous return due to the centralization of blood volume. The increased preload, manifest as increased stretching of the heart muscle fibers during diastole, invokes the Frank-Starling mechanism in which the force of contraction is raised to cope with the extra volume. Stroke volume is therefore increased. In colder water the increase in cardiac output is less due to a concomitant bradycardia (decreased heart rate).

A bradycardia is associated with immersion. The "mammalian dive reflex" provoked by cold water contacting the face includes a bradycardia. In predisposed individuals the vagal outflow can be intense enough to produce asystole (cessation of heart beat) or arrhythmias (abnormal heart rhythms), which may lead to unexplained drowning after leaping into cold water. A bradycardia is produced even in a dry chamber at elevated ambient pressure, however, and researchers have sought other explanations for the immersion bradycardia in divers.

It has been demonstrated that an increase in the partial pressure of oxygen and the narcotic effect of inert gasses can produce a fall in heart rate on average of 10 beats per minute in divers, independent of the dive reflex. The degree of bradycardia is increased in colder water, and concomitantly so is the risk of arrhythmias in predisposed individuals. The role of these factors in diving fatalities, however, is largely unknown.


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Another mechanism of bradycardia of questionable significance in divers, but one that is often mentioned in the diver training literature, is the carotid sinus reflex. There is a theoretical possibility that a wetsuit hood that fits too tightly around the neck may stimulate a carotid sinus reflex and therefore bradycardia.

Views differ on the net effect of these mechanisms on mean arterial blood pressure. It is likely that blood pressure remains within healthy parameters in the hyperbaric environment.

In conclusion, a better understanding of the physiological processes involved in breathing underwater can lead to enhanced comfort and safety during dives as well as an improved ability to assist a diver in trouble. AD

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Edmonds C, Lowry C, Pennefather J, Walker R, eds. Diving and Subaquatic Medicine, 4th edition. London: Hodder Arnold, 2002.

Cave divers at Devil's Eye in Ginnie Springs, Fla., in 1989 (Nikon F3, Sea & Sea housing)

KURT AMSLER

SHOOTER: KURT AMSLER

PHOTOS BY KURT AMSLER
TEXT BY STEPHEN FRINK

Kurt Amsler may have inherited the photographer's gene from his father, an alpine and outdoor photographer, but the inspiration for his eventual career as a marine photographer came from famed Austrian photographer and cinematographer Hans Hass. The year was 1958, and young Amsler was a child in landlocked Switzerland. By chance he picked up a copy of *Among the Corals and the Sharks*. The words and especially the photos that Hass took for this, his second book (published in Austria in 1941), were transformational for the young boy.

While on location in Bonaire, Hass had no rebreather, and the Aqua-Lung had not yet been invented. So he went underwater as William Beebe had described in his 1932 article "A Wonderer Under the Sea" for *National Geographic* magazine: with a homemade diving helmet. Amsler did much the same for his first underwater adventures in Lake Zurich. With a helmet cobbled together from wood and metal fittings and the help of a friend pumping air to him from above, Amsler could go as deep as 20 feet and stay for as long as he could stand the cold or his friend had the stamina to pump air to him. He could breathe underwater, he could see the fish, and, most important, he could dream of a life of ocean exploration.

When Amsler was in high school, his father bought him his first real gear for diving: a pair of fins and a mask. Now that he could see properly, the next step was to try to take photos underwater. After all, he had learned photography from his dad and had been helping him in their home darkroom since he was 10 years old. With a Leica camera housed in the bladder of a soccer ball and a bit of Plexiglas for a port, Amsler took his first underwater photo in 1959, thus embarking on a path he would follow for the next 57 years and beyond.

Maldivian sunset at Ari Atoll, Maldives, in 2003 (Nikon D1X, Seacam housing)

STEPHEN FRINK: You seemed to know at a very young age that underwater photography would be your life's passion, but it must have been clear to you that you would have to travel beyond Lake Zurich. When did you venture out from home and begin to see the wider world of scuba diving?

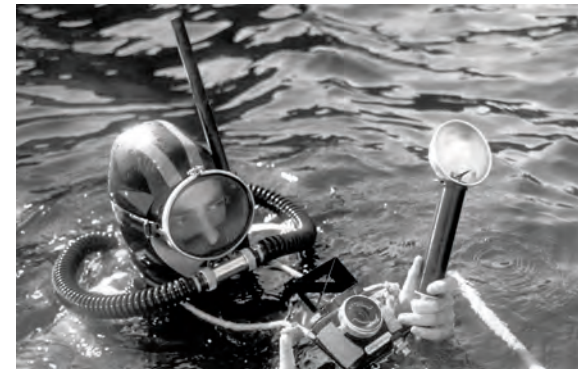
KURT AMSLER: Some underwater photographers come to their careers by being scuba divers who learn to shoot. Then there are those like me who are photographers first and then learn to shoot underwater. After I finished high school I enrolled in the School of Art and Photography in Zurich. I was just 16 then and attended for four years, graduating with skills in studio photography, darkroom techniques, outdoor photography and portraiture. But the thought of doing more and better underwater photography was never far from my mind.

I bought my first Calypso PHOT camera with a bulb flash attachment in 1963, and finally I had quality gear I could use for underwater photography. Around the same time I bought my first Aqua-Lung tank and regulator from France, so I could actually dive and take pictures underwater without having to hold my breath or be tethered to the crude diving helmet we used in those early days.

SF: I saw a picture of you online recently. You were just a teenager, sitting in front of what seemed to be a caravan on a beach on the Red Sea. You were born in 1946, and in this picture you couldn't have been more than 19. So that would put you diving the Red Sea in about 1965. That had to be a magical time in your life. Tell me how that came to be.

KA: Inspired by Hans Hass and his 1952 film *Under the Red Sea*, I wanted an underwater adventure of my own in the Red Sea. For me, that meant hitchhiking from Zurich to Greece with one of my friends. We hopped a freighter that got us to Haifa, and from there we made our way to Eilat, Israel. We met some Israeli navy divers who let us stay in that caravan you saw in the photo. We were there for eight months, diving every day.

It was a glorious time to see the Red Sea; the water was so clear, and the reefs were magic. There was lots of soft coral and amazing tropical fish — many sharks, too! This was the height of adventure for a couple of kids. I had my cameras — the Calypso PHOT and my Rolleimarin with the flash bulbs — but we had no money. I could play the drums, so I got jobs at night playing in a jazz band at the End of the World nightclub in Eilat. My friend was hired to yodel at weddings. That was quite a sight: a Swiss guy yodeling at an Israeli wedding. But somehow we managed to scrape together enough to stay. There were very few tourists there at the time. In eight months we saw maybe



Amsler dives in 1963 in Le Drammont, South of France, with the Calypso PHOT, which was made by La Spirotechnique. It was the first amphibious camera with a flash bulb attachment.

Opposite: **Coral grouper in the Red Sea, Ras Mohammad, Egypt, 1993 (Nikonos RS)**

100 tourists, and of those only 25 were divers. We had those reefs totally to ourselves — in places where the fish and turtles had never seen a diver before.

SF: I'm surprised that having been trained as a commercial photographer you didn't want to move to London and be a fashion photographer like David Hemmings in the 1966 film *Blow-Up*. At that time there had to be a lot of work in many different fields for a skilled photographer with a portfolio from art school.

KA: I must admit there are parts of the *Blow-Up* lifestyle that would have appealed to me at that point in my life, but I remember very vividly standing on a beach in the Red Sea and having an epiphany. I knew for damn sure this was what I wanted to do with my life: underwater photography. I didn't want to end up in a studio somewhere. The ocean would be my studio.

Yet it wasn't that easy to make it happen. I was derailed for a short time to do my military service in the special forces of the Swiss Army. Then I started doing the travel circuit, showing the 16mm underwater films I'd shot to local dive clubs. I also began to get some of my underwater photos published in magazines. There weren't any dive magazines in Europe at this time. You had *Skin Diver* in the USA, but my first published photos were in larger circulation, general-interest magazines, and their readers hadn't really seen the underwater world before. My photos were a revelation to many who didn't know such beauty and color existed beneath the sea.

My plan was to have one foot in the dive industry and one foot in photography. I became a dive instructor so I could easily get a job and support myself in places I might want to dive and take pictures.

In 1968 I met a pretty American girl who was on holiday in Switzerland and who also had a job as

a secretary at the Holiday Inn in Freeport, Grand Bahama. She said I should come visit, and as I had never dived the Bahamas, a few months later I did just that. Coincidentally, a couple of years earlier the Underwater Explorers Society (UNEXSO) had opened up in Freeport with an innovative 18-foot-deep scuba training tank and a fleet of boats for diving their nearby reefs. This was the state-of-the-art in destination diving, and celebrities from all over the world came to train and dive there. Walter Cronkite did a story about it, and glamorous starlets such as Kim Hunter went there to learn scuba. Lloyd Bridges, who I had the pleasure to meet there, traveled there with his sons, Beau and Jeff, so they could learn to dive.

I had my portfolio with me, and I showed it to UNEXSO manager Dave Woodward. Few people were shooting serious underwater photos at the time, and Woodward was amazed. He said, "You must dive with us … maybe I can find you a job." And he did. For the next two years I drove the dive boat when they needed me, and visitors gave tips to underwater photographers when they came around. The famous naturalist and dive guide Ben Rose became my best friend. And the diving was amazing. The shallow reef was solid with elkhorn coral, and we saw sharks and grouper on almost every dive. I learned a lot and made some great connections. While at UNEXSO I entered my first photo competition, in Santa Monica, Calif. I did very well and began to think I should compete in more contests.

SF: I read an interview with you written by our colleague Alex Mustard, and he said of your success in European photo competitions, "It is impossible to summarize the multitude of highlights in Kurt's career here. Suffice to say that he has shot thousands of stories for magazines, written many books and photographed high-profile advertising campaigns. His competition record is also a full house. He won the 2nd CMAS [Confédération Mondiale des Activités Subaquatiques, or World Underwater Federation] **World Championship in 1987, he was named Grand Master at the 1987 Brighton Festival that included the prize of a Rolex watch, his book *Maldives* won the best book of underwater photographs at the Antibes Festival in 1994, and he has won awards in just about every other competition, including the BBC Wildlife Photographer of the Year." Very impressive, Kurt!**

KA: It is true I won almost every photo contest there was in those days. Contests were very popular in the 1970s and '80s, typically organized by the Italians or the French and held all over the world. Usually they consisted of a three- to six-day shoot at some dive destination. I'd arrive with a model, shoot a lot and, mostly, win.

But it wasn't about ego gratification; I wanted to have influence, and I needed to be famous for people to

pay attention to what I was saying. By then I had been diving long enough to see changes in the ocean, and I wanted to make people aware of the need for marine conservation. I've always believed one-third of my time and one-third of my money should be spent giving back to the sea. My biggest campaign over the years has been to protect sea turtles, and now for 30 years we have been combating the harvesting of turtles for food and souvenirs. I was involved in closing dolphinariums and protecting sharks. More and more I have been fighting for animals on land as well. Recently I have become an ambassador for Sea Shepherd Global. They have power, and with power comes awareness. Together we can do great things to protect marine life.

SF: You have been active in commercial and advertising photography in the dive industry. I remember your early product ads for dive computers, which combined studio photo techniques in the underwater environment for product illustration.

KA: I met Dick Bonin, the founder of Scubapro, while at UNEXSO, and I used to shoot some of the very early lifestyle photos for their catalogs. I also enjoyed sponsorship from Nikon and Rolex. The composite images you now see coming out of computers, I used to do in real life, in the water. Many of these were big campaigns, paying $2,000 a day, and the shoots could go on for two or three weeks. That was really big money then, and not so bad even now!

You and I, we had the good times. We got to be underwater photographers when the scuba equipment became good enough to trust, the cameras and housings were good enough to capture quality photos, the dive infrastructure was maturing, and the reefs were unimaginably beautiful. Ours was the sweet spot in time.

When I was talking to topside commercial and editorial photographers at agencies such as Black Star, they always told me it was important to become a photojournalist. I had to be as good at writing as I was at photography, maybe better. This helped me when it came to doing books. I've published 14 books — five coffee-table books, five dive guides and assorted underwater photo guides and such.

SF: I know you as a photo equipment innovator, and you have a close and visible relationship with Seacam these days. How did you evolve from your Rolleimarin to the digital cameras you use today?

KA: When I think back to the various cameras I used over the decades, I note the good reasons I had to move from one to the next. Actually, I am very loyal to my gear. I have dived with Scubapro equipment for 45 years, and I've used only Nikon cameras since 1975.

Amsler was the overall winner of the 2nd CMAS World Championship of Underwater Photography, held in Cadaqués, Spain, in 1987.

Opposite: **School of bannerfish in Rangiroa, French Polynesia, in 1994 (Nikonos RS, 13mm fisheye lens)**

My first self-made housing was pretty easy to move up from. I know what I like in an underwater housing, but I am not a brilliant machinist or housing manufacturer. Even the Calypso PHOT was a huge improvement over the crude housing I began with. But I knew to get the fish portraits I wanted that I needed greater compositional accuracy than cameras of the Nikonos design could provide. I needed the precision of reflex viewing. I will say that throughout my career, however, as long as I was shooting film, the Nikonos and 15mm lens would be with me on most every dive for wide-angle shots. Some of my favorite underwater photos were taken with that unique and venerable optic.

As a student I'd play drums in jazz bands to earn enough to satisfy my lust for camera gear. This took me (chronologically) from the Calypso PHOT to the Rollei twin-lens reflex camera in the Rolleimarin housing (coincidentally a Hans Hass design) to a Hasselblad in a Hugyfot housing and then a Bronica 2 ¼ square (also in a Hugyfot) during my medium-format era. In 1975 I headed in a different, more modern direction with 35mm film and a housed Nikon F2 with an action finder. I had the Oceanic Hydro 35 housing and Oceanic 2001 strobes.

Chandelier Cave, Palau, in 2014 (Nikon D800, Seacam housing, 2000-watt HMI lights as back lighting)

This was very good equipment, designed in the USA by Bob Hollis. When the Nikon F3 came out I went to Sea and Sea for the housing and strobes and then went back to Hugyfot when the F4 came out. I worked with them on the design of that housing, and it turned out beautifully.

When the Nikon F5 came out there was a reason to think differently about the housing design, because now there was autofocus. The idea of two hands always on the grips so one could continuously tweak focus was now obsolete. I wanted to free my left hand to hold the strobe as necessary, and Subal was more accommodating of my design ideas for that housing.

With my migration to digital in 2002, I made the transition to Seacam. They had a very nice housing for the Nikon D1X, and I knew I was never going back to shooting film. I wasn't one of those guys who'd shoot half a job on film and half on digital, deciding later which I liked better. I waited to make the transition until the technology was already better than film, and I've never looked back. I've gone through many iterations of Nikon digital cameras, always with the corresponding Seacam housings, ports and strobes. At the moment I shoot the Nikon D3 and the D800. Right now we're talking about manufacturing a Seacam housing for the new Leica cameras. If that happens, I will have come full circle, back to the brand of camera I shot for the first time in Lake Zurich so many years ago.

SF: You have always been a very active and fit person. Do you find it necessary for your job as an underwater photographer?

KA: Maybe it's not necessary, but it's certainly helpful — several times in my career I was awarded jobs over other shooters because they were 65 pounds overweight. How can you swim with whales if you can't keep up, at least for a while? My dad was a very skilled athlete; in fact, he won the silver medal in gymnastics at the 1936 Olympics in Berlin. He was very good at the rings and parallel bars and remained active in mountaineering photography in his career. I was a black belt in judo, I've freedived to 115 feet, and for six years I was on the Swiss national windsurfing

team. I still mountain bike, but my nondiving passion these days is solo-sailing my 28-foot boat.

At age 74 my father climbed the Matterhorn (one of the highest peaks in the Swiss Alps at 14,692 feet), and as I near my 70th birthday there is no question I'd like to be like my father. For him it was sport, sport, sport all the time, and he told me if your body is OK, your mind is OK, too.

Many of the things that have happened in my life have been significant events that shaped my future direction. I see turning 70 as one of those. I have taught underwater photography for 30 years (in fact, I have operated a school for underwater photography near my home on the French Riviera since 1995). But now I'm retiring from that part of my life. I still have my Seacam online academy (*seacam-store.com/en/academy/the-equipment*), but I'm moving on from hosting students. That particular chapter is done, but I look forward to the next ones.

• • •

While Amsler has enjoyed many triumphs in life, he experienced what he considers to be the apex of his career in 1984, when he served as cameraman and actor for a film called *The Maldives: Paradise Transformed*. His co-star was none other than Hans Hass, the man who first inspired him to peer beneath the sea to find his way in life. AD

From left: **Spinner dolphins at Fernando de Noronha, Brazil, in 2007 (Nikon D2X, Seacam housing); wreck of a German Messerschmitt fighter plane from World War II in Marseille, France, in 1978 (Hasselblad, 40mm lens, black-and-white film, no strobe)**

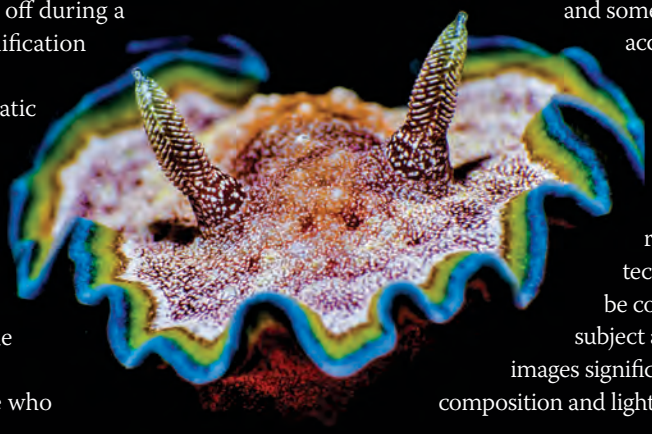
Above: **Film production with Hans Hass for *The Maldives: Paradise Transformed* in 1984**

THE BIG LITTLE

GOING BEYOND 1:1

Text and photos by Mike Bartick

In the past, taking macro photography beyond 1:1 — greater than life size — was difficult. Magnifying lenses (known as diopters) could be threaded to the front of a macro lens inside a housing, but then the whole dive would have to be dedicated to shooting small creatures because the diopter could not be removed underwater. Wet macro lenses, which attach to the outside of the housing, could be put on and taken off during a dive, but the level of magnification was marginal. With the introduction of apochromatic wet lenses in the past few years, however, diopters of varying strengths have managed to achieve effective magnification for high-quality images. These new tools have made supermacro photography readily available to anyone who wishes to go beyond 1:1.



A wet diopter increases magnification while decreasing the lens' working distance. This makes a longer lens (such as a 100mm or 105mm lens) the best choice. Magnification beyond 1:1 can also be achieved with a 60mm macro lens, but this can make the working distance between the port and the subject so short that it becomes difficult to illuminate the subject with a strobe light and skittish creatures are more likely to be frightened. Using a longer macro lens will allow you to maintain a respectful distance from marine life and provide the space for a more creative approach to lighting. The most popular setup involves an external wet lens attached with a flip adapter. This configuration allows the photographer to shoot without additional magnification for larger or more nervous critters or to flip down the diopter and zero in on really small subjects.

To paraphrase David Doublet, "If you can't shoot exotic subjects, then shoot the common subjects in an exotic way." Supermacro photography will relentlessly challenge your skills as a photographer and a diver. Even spotting supermacro subjects is challenging. Shooting supermacro will certainly deliver visual diversity and can add exotic flavor to a plain vanilla portfolio.

Ideally, the objective is to capture the images in-camera — not through creative cropping in postprocessing. This ensures the highest-resolution images and, thus, the greatest enlargement possibility for decorator prints or publication. Newer high-resolution cameras such as the Canon EOS 5DS and Nikon D810 offer huge files, and some cropping is certainly acceptable. But purity of the discipline obliges composing and capturing as close as possible to the end result.

Once you're within the realm of supermacro, certain technical considerations must be considered. Magnifying your subject and creating supermacro images significantly affects depth of field, composition and lighting.

DEPTH OF FIELD (DOF)

To increase DOF, most photographers begin by adjusting the aperture, or f-stop. The higher the number, the less light enters through the camera's iris and the greater the DOF. Yet this comes at a price: Ambient light is decreased, and the background may go black. This is a nice effect at times, but not every supermacro shot benefits from a black background. The creative photographer will know how to bring more ambient light into the image via aperture or shutter speed and can thereby control how light or dark a background will appear. An aperture that's too small can soften the image detail due to diffraction. An image may actually be sharper at f/11 than at f/32, but the DOF won't be as great. Imagine, for example, a small moray eel. You might be able to get the sharpest detail of its eye at f/11, but if your intended composition requires both the eye and the nose to be sharp you might wish to shoot at f/32. A slight increase in ISO will also help you shoot at a higher f-stop by amplifying the incoming light. Knowledge of the science of optics will help translate the vision in your mind's eye to the pixels in your digital camera.

A colorful pygmy squid (*Idiosepius pygmaeus*) rests on a cobalt-blue tunicate. Colorful details of supermacro subjects may go unseen without the use of a diopter. Lighting also plays a significant role in creating a glow effect in translucent subjects.

Opposite: Supermacro isn't just for the tiniest things — larger subjects, such as this *Glossodoris cincta* nudibranch, shot with a diopter can completely fill the frame to create a dramatic image. Pay close attention to the camber of your subject relative to the lens to ensure the best plane of focus and desired depth of field.

COMPOSITION

Consider the fact that all lenses have a sweet spot, which is generally at the center of the lens. Not all wet diopter lenses are equal in this regard; some offer a greater area of sharp rendition. Yet no matter what lens is being used there is a way to get around a "bullseye" shot. Some compositions will benefit from the subject being centered, but others will favor the primary subject elsewhere in the frame. When autofocusing, the photographer will need to shift the autofocus indicator zone to the portion of the frame that needs the greatest sharpness. Many supermacro aficionados prefer to focus manually, perhaps taking the lens to its greatest magnification and then moving closer to the subject until the desired portion of the composition pops into clarity.

LIGHTING

When shooting macro and supermacro, lighting is critical to both exposure and composition. Due to the close working distances, some technical issues such as backscatter (particles suspended in the water column illuminated by the strobe) are happily minimized. This is fortunate because many supermacro subjects are found in muck or in places with poor or variable water clarity. I like to keep things simple, so in most cases I use the fastest shutter speed possible. This minimizes ambient light, but the composition is usually so tight that everything in the frame is typically strobe lit anyway. This allows me to concentrate on f-stop, strobe positioning and composition.

My strobes are usually angled so they're not aimed directly at my subject. A modeling light separate from the strobe is extremely important for this setup. Often I use a single strobe over the subject and aim it slightly back toward my housing so most of the light is actually shadowed by my housing and port. Just a small curtain of light illuminates the subject. This strobe angle can help eliminate background light even on a shallow reef. In some cases I use a light-shaping device such as a snoot (see *alertdiver.com/Unique_Techniques*) to eliminate a distracting background.

Sometimes I want big and bright macro images and need a flood of light. In these cases I aim a primary strobe and use a second strobe (usually set to low power) for fill light. Backlighting with a third light can give the subject an additional layer that will set your photo apart from the pack.

Before your next dive, get to know your system a little bit. Identify and learn how to work with your camera's weak points. Learning how to squeeze a little more horsepower out of your existing system can be as simple as experimenting. Here are a few ways I have revved up the power of my camera system through logic and experimentation.

Learn the camera's focus-locking functions. This can be a powerful tool for split-second shooting. Once you achieve correct focus you can stop the lens and adjust the critical focus with subtle camera movement (or the subject's movements).

Practice focusing, locking, adjusting and firing while paying close attention to critical focus. Remember that what we see through the lens and diopter is equivalent to a maximum aperture of the lens, usually f/2.8 for a macro lens on a digital single-lens reflex camera. With practice you will become accustomed to the difference between what you see through your viewfinder and what your lens and settings capture.

Any lens appears darker as the aperture decreases, for the obvious reason that less light reaches the viewfinder. To eliminate the handicap of focusing through a dark lens, modern cameras have automatic diaphragms and only step down to the preset aperture at the moment of exposure. The image's DOF will no doubt be better than what is seen through the ground glass for the simple reason that rarely would a macro shooter expose at wide-open apertures. The precise DOF will not be revealed until later in the image review.

Visualize your sensor plane as a three-dimensional rectangular space in which your subject will be

A pink ladybug (isopod) takes center stage under the canopy of a hydroid. Hydroids are a great place to seek smaller supermacro subjects. Strobe angle and high shutter speeds are an essential combination in creating a black background, eliminating distracting backgrounds.

Opposite, from far left: **Mushroom-coral pipefish (*Siokunicthys nigrolineatus*) are elongated subjects with interesting facial features. Shooting subjects from front to back can yield dramatic drop-off in depth of field. Using your focus lock button (AE/AF) and waiting for your subject to bring itself into the frame can help you capture subjects with unpredictable movements. Once the eyes are sharp and in the desired focal plane, release the shutter.**

These supersized clownfish embryos were shot with stacked diopters, magnifying the image (i.e., going beyond 1:1). Using off-camera lighting to illuminate your subject from behind creates bright macro images and reveals even more detail.

photographed. Left to right is the plane of field, and front to back is the depth of field. After locking your focus you can recompose in this space to get away from the standard bullseye composition. Getting low is also important for exposing the little critter's habitat and getting a more intimate look into its world. Shooting anything from front to back will always create a greater fall off of acceptable sharpness in your DOF. Shooting the subject on a plane parallel to the camera's sensor will maximize the areas of the image in sharp focus.

Good buoyancy control and sensitivity to fragile coral is of course very important with supermacro photography. It usually takes time to gradually approach cryptic and skittish creatures, and it may be tempting to kneel on the bottom when doing so. It is almost always best to dive without being in contact with the substrate and to also make sure gauges or fins don't inadvertently come in contact with fragile coral.

Going beyond 1:1 isn't as difficult as you might think; all it takes is a little practice, determination and a good eye for finding subjects. Remember to be patient with yourself, have some fun, and try to apply a few of these techniques to help you along. AD


STEPHEN FRINK

Palau's famed Rock Islands give a sense of the interconnectivity of the land and the sea.

Below: President Remengesau walks on the beach in front of the Palau Pacific Resort.

Opposite: Remengesau confers with U.S. Secretary of State John Kerry during the Our Ocean conference at the State Department in Washington, D.C., in June 2014.

CONTINUING A TRADITION OF OCEAN STEWARDSHIP

AN INTERVIEW WITH PALAU PRESIDENT TOMMY REMENGESAU JR.

By David Helvarg

After helping to establish the world's first shark sanctuary in his nation's waters in 2009, President Tommy Remengesau Jr. of the Republic of Palau signed legislation last year that set aside 80 percent of his small west Pacific island nation's ocean as a fully protected marine sanctuary. The world's sixth-largest reserve, the Palau sanctuary covers an area larger than California and has the greatest percentage of any nation's waters off limits to fishing.

"Creating this sanctuary is a bold move that the people of Palau recognize as essential to our survival," Remengesau explained. To protect this vast tract he also signed an international treaty targeting illegal, unreported and unregulated (IUU) fishing. "Palau will not tolerate poachers in our ocean," he warned. His administration followed up on that warning by confiscating and burning vessels from Vietnam and the Philippines caught illegally fishing in Palau's waters.

In May 2016 Remengesau was awarded the Peter Benchley Ocean Award for Excellence in National Stewardship. In June, David Helvarg visited Palau and interviewed Remengesau for *Alert Diver*.


DAVID HELVARG

***Alert Diver*: What led Palau to become a world leader in ocean conservation?**

Tommy Remengesau Jr.: Ocean conservation is very much a part of our tradition and livelihood, and we know to sustain our future existence as island people we must balance nature and development.

AD: What in your own life brought you to the idea of ocean stewardship?

TR: As a young Palauan you're taught from early on not to take more than you need for today, to think about your children and their children and to live in harmony with nature. This is an integral part of growing up in Palau, so it's natural for me to lead by rallying the people to do what we've been taught from a young age.

AD: What is a bul?

TR: Bul is part of our traditional practices. It literally translates as prohibition — it means conservation and thinking about the future. When the chief of a village and the fishermen notice the fish population of a certain area of the reef declining, the chief would institute a bul, telling the local villagers to stop fishing that particular location. People would comply with a bul because the whole community policed it. We noticed over generations that fish populations in those prohibited areas would eventually rebound, so the leaders would open up the bul and allow fishing again.

So now we have a bul for the ocean. When you talk about an 80 percent marine sanctuary, it's not just for that 80 percent; this will repopulate and reenergize the 20 percent that we are opening up for domestic fishing and other activities. We have proven that the benefits of a bul extend outside of the protected area. With 80 percent of our waters protected, the spillover effect is not small. This will benefit not only us but the Philippines, Indonesia and FSM (Federated States of Micronesia) as well. This is our contribution to the Pacific and to the world.

AD: You've often said that your environment is your economy. Could you expand on that?

TR: We believe you cannot separate the two. Our economy is based on tourism — people coming to experience our natural resources. Our livelihood as Palauans therefore is based on how we protect our resources for our visitors and for ourselves in terms of our food security. We have a long history of looking to the ocean to provide us with fish.

AD: Fishermen often say sharks are taking their fish or that sharks should be targeted for their fins, but in 2009 you created the world's first nationwide shark sanctuary.

TR: We believe every living thing on this earth is here for a reason — the shark is a part of the reef ecosystem. Besides that, we've done research and found that a live shark is worth $1.9 million over its 60- to 70-year lifespan. A dead shark's fins, in contrast, are worth about $45 per kilo just once. It's been a good partnership with the sharks, so to speak.

EPA/JIM LO SCALZO

AD: When you signed the Palau National Marine Sanctuary Act into law, what impacts did you expect?

TR: Eighty percent is the culmination of the Micronesia Challenge we embarked on 10 years ago. This initiative targeted 20 percent of our reef and 30 percent of our terrestrial areas for protection. At 20 percent we said, "Why not go to 80 percent?" — and that's where we are now. Again, the benefits of a marine protected area are not confined to that area: It is very effective at repopulating other areas. Imagine the benefits if every country had a sizable marine protected area

AD: Another big challenge you face is climate change.

TR: It's on! Sea-level rise is a challenge we are already dealing with. We have agricultural lands that have been flooded by salt water, and low-lying atoll communities threatened by the sea. Global warming is contributing to unpredictable storms, severe typhoons and more. We're seeing all of this here, and the only way to address it is for the world community to begin to stop contributing to the problem. Here in Palau we do have some high areas, but the Marshall Islands, for example, are all sandy atolls, and the people there have no high ground to go to.

AD: I hear you're a fisherman. What are your other favorite ocean activities?

TR: Anything that has to do with the ocean is a favorite activity of Palauans. Did you know the most eligible bachelor in Palau is the good fisherman? If you're a good fisherman, you'll likely find a wife.

As an island boy, freediving and fishing, I thought I knew what the ocean was all about. But when you get into scuba, you really begin to understand the world beneath the waves and how the organisms depend on one another to survive. I strongly encourage people to learn how to scuba dive. When you really spend some time down there you can enjoy the underwater beauty and learn how everything is connected.

Also, did you know nobody has been killed by a shark in Palau? Not in our entire history. That's a fact we're very proud of. Crocodiles — yes, there have been some unfortunate incidents with crocodiles, but never with sharks. AD

THANKS TO SCUBA, THE WORLD REALLY IS MY OYSTER

By Cody Unser

On Feb. 5, 1999, at the age of 12, I found myself learning how to do everything with a paralyzed body. I was diagnosed with transverse myelitis, an autoimmune condition in which my immune system attacked my spinal cord. Growing up in an auto-racing family came with the expectation that by age five all of us kids would know how to ride four-wheelers, go-karts, jet skis and snowmobiles — basically anything with a motor, a throttle and brakes. Figuring out how I was going to live life in a wheelchair with a paralyzed body was an enormous and emotional challenge.

After spending months in rehabilitation where therapists taught me how to dress myself, catheterize myself and transfer into and out of my wheelchair, I went home struggling with my new identity but waking up each day wanting to use my voice to make a difference. With the help of my mother, Shelley, I created the Cody Unser First Step Foundation (CUFSF) to raise awareness about transverse myelitis and to advocate and improve the quality of life for people with disabilities.

After I became paralyzed, all my thoughts and actions involved my broken body. The next year my older brother, Al, encouraged me to get scuba certified. Scuba diving erased my doubts about whether I was going to succeed at anything in life. On my certification trip I realized, *if I can do this, I can do anything.* The world above went silent, and I found myself underwater with my family — doing the exact same thing they were doing. Suddenly life had a lot to offer. I wanted to share these new feelings of confidence and independence with other people with disabilities who might feel like giving up.

PROMOTING ACCESS

Adaptive sports can help people with disabilities improve their physical, mental and emotional health. Through CUFSF we developed a quality-of-life program called Cody's Great Scuba Adventures, which brings together medical and dive professionals at the same table, or rather, in the same pool.

MARLA BROSE/ALBUQUERQUE JOURNAL

Raising awareness and promoting inclusion are at the core of CUFSF's adaptive scuba diving program. In an ideal world, anyone with a disability would be able to go to any dive shop or dive site and be welcomed by at least one instructor familiar with his or her disability and capable of effectively adapting the sport for him or her.

Teaching someone with a disability how to scuba dive is no small endeavor. In 17 years of advocating for adaptive diving and witnessing the dedication of my dive instructors, I have learned a lot about facilitating the diving experience for people with disabilities. One such lesson is that many people with spinal cord injuries manage autonomic dysreflexia, an involuntary response to an injury or stimulus to a part of the body that lacks sensation. When I surface from a dive, a full bladder or a brush with fire coral on my lower body might trigger a headache or even make my blood pressure rise, which must be dealt with immediately.

It is so meaningful to work with an instructor who knows the basics of managing such secondary conditions (post-injury issues). Other secondary conditions

The Cody Unser First Step Foundation organizes dive trips for injured veterans and other disabled divers in destinations such as the Cayman Islands and the Florida Keys.

Opposite: **Cody Unser became paralyzed at age 12. When she began diving a few years later she became a passionate advocate for the sport and for the benefits it can offer people with disabilities.**

PHOTOS THIS PAGE COURTESY CODY UNSER FIRST STEP FOUNDATION

include bladder and kidney infections, pressure sores, osteoporosis, scoliosis, bowel maintenance, heart problems due to poor blood circulation, depression and anxiety, fatigue, pain and loss of muscle mass. These conditions can often seem to be the dominant forces in the life of a person with a disability. Even simple awareness of these issues by dive staff can really make a difference.

Jacques Cousteau once said, "From birth, man carries the weight of gravity on his shoulders. He is bolted to Earth. But man has only to sink beneath the surface and he is free." For the paralyzed person, this feeling of freedom is greatly enhanced, because diving releases not only the bolts to earth but also the bolts that lock the body to the wheelchair.

In 2011 CUFSF teamed with Paralyzed Veterans of America, researchers from Johns Hopkins University and our dive instructors to certify nine paralyzed veterans and to study the neurological and psychological effects of scuba diving on paralyzed people. It took 10 years to convince my neurologist and neuropsychiatrist that the sensations I was feeling at depth warranted medical investigation. The study seemed to document the improvements I felt underwater in other divers, too. Most participants with PTSD symptoms reported some relief, and the researchers believe it is worth continuing the study.

LOOKING AHEAD

CUFSF's adaptive scuba program will continue to bring together the dive industry and medical professionals for a future in which dive professionals around the world will understand all kinds of disabilities. Each person with a disability has specific needs, and adaptive diving requires instructors who will be patient and able to think outside the box to make the experience possible. Divers with spinal cord injuries, for example, may need a certain weighting strategy to improve their trim, while divers with visual impairments may require sensory training.

Through scuba diving, not only can I achieve freedom from gravity, I can also share an experience with my family that requires relatively little adaptation. Historically, people with disabilities have faced limitations to physical activity not only because of physical barriers but also because of inadequate resources and knowledge among professional facilitators. This is why it is so crucial for the dive industry to see the impact it can have in evolving the sport to not simply include people with disabilities on dive boats and underwater with everyone else, but to do so with a deep understanding of what a person with a disability experiences on a daily basis.

According to the Centers for Disease Control and Prevention, 53 million Americans have some form of disability. Scuba diving provides an opportunity to enhance self-worth, independence and confidence; it can be a catalyst that makes formerly impossible things in life possible. CUFSF will continue conducting dive research studies, training dive and medical professionals and bridging the gap between the dive industry and the disability community. I have enjoyed seeing the dive industry embrace this community; it's not always easy, and sometimes it gets political, but those of us living with a disability are not going away anytime soon. AD

SHARE YOUR STORY

Do you have tips, advice, travel strategies, dive techniques, lessons learned or other words of wisdom to share with your fellow divers? Alert Diver wants your story! Email it to M2M@dan.org, or mail it to "Member to Member," c/o *Alert Diver*, 6 W. Colony Place, Durham, NC 27705.

ACCESSORIZE YOUR DIVE

By Reilly Fogarty
Photos by Stephen Frink

Quality dive accessories exist to make diving not only safer but also simpler and more enjoyable. Whether it's an easy-to-use signaling device to get your buddy's attention, a rugged cutting tool to get you out of a sticky situation or a bright light to illuminate a dark place, an effective accessory might be just what your gear bag is missing.

LESS IS MORE

While a few handy accessories can enhance your dives, carrying too many may do the opposite. Looking like a Christmas tree underwater with countless shiny gadgets hanging from your BCD might make you a hit around the holiday season, but it will also make you work harder while swimming and limit how quickly you can reach what you need. More dangling gear also increases your risk of being entangled in loose line, nearby buddies or innocent marine life. Thoughtfully consider what tools or gadgets you'd like to take with you on each dive.

CUTTING DEVICES

Few problems in diving can be as stressful and dangerous as underwater entanglement. Even when you're not in immediate danger, having a cutting device — or better yet, more than one — within easy reach will put your mind at ease and let you focus on having fun. Whether you use it to trim a few inches off your weight belt before you gear up or to free your buddy from some fishing line he swam through during the dive, a cutting device is one of the most important accessories you can have on hand. Trauma shears and fully serrated knives can make quick work of thick lines and wire, while hook-shaped cutting devices are most useful for cutting thin lines with one hand. Corrosion resistance is an important factor when choosing a cutting tool, and devices made of titanium or high-quality stainless steel will generally last the longest. Any device that is simple, robust and easily accessed can be useful in an entanglement and will make dealing with problems that arise underwater minor annoyances rather than emergencies.

ATTENTION-GETTING DEVICES

Whether you need to let your buddy know you're running low on gas or you want to show her the elusive albino frogfish you just found, attention-getting devices such as tank bangers and underwater maracas can be incredibly useful. These accessories come in a variety of forms, from elastic bands with hard rubber balls you use to strike your tank, to waterproof containers filled with metal beads that you shake. Other types of noisemakers can be attached to your regulator's low-pressure inflator hose; these use gas from your cylinder to make duck calls or whistling noises that are hard to miss. These accessories are particularly useful in good visibility when your buddy can see you but needs to be reminded to look in your direction. In areas of limited visibility, noisemakers can still be helpful, but their usefulness is limited by the visibility. This underscores the importance of maintaining viz-appropriate proximity to your buddy.

LIGHTS

Essential on night dives but often overlooked for deeper dives, wreck dives and dives on certain reefs,

Among the most useful dive accessories are tools that can help you get your buddy's attention, free yourself from an entanglement and illuminate dark places. A few thoughtfully selected accessories can make dives more enjoyable and safer.

dive lights make for excellent signaling devices and bring color back to the depths of the ocean. The water column filters out many of the brilliant hues of the ocean's flora and fauna — even on sunny days in clear water — but by providing your own light you can see the creatures of the deep in their full glory.

Dive lights can vary greatly in power, burn time and cost. The majority of recreational divers are best served with a compact handheld dive light. John Brigham, vice president of Ikelite, contends that a good dive light should be "small, simple and easily accessible," adding that advances in LED technology have made LED lights almost universally more powerful while also having longer burn times. Because they draw less power than halogen bulbs at a similar light output, LED-powered dive lights also burn less hot, so they can generally be used on the surface as well. That low power draw also means that LED lights can be brighter than similarly sized halogen lights. The increased performance of LED lights comes at a cost, however, both literally and in the fact that owners often cannot replace the LED themselves like they would with a halogen bulb.

Other considerations for light choice include travel concerns, ease of operation and whether the light is user serviceable. Some lights come with batteries that are too large to fly with or are made of materials that aren't allowed on commercial aircraft. Features such as beam width, rechargeable batteries and multiple power settings are available, although Brigham notes that "a light is a light" — it's best to keep lights simple and easy to use.

It is important to realize that accessories are just that: accessory to the dive. Even the best tool can be a hindrance if it takes up time or mental bandwidth that a diver could be using elsewhere. Accessories can make your dive easier, safer and more fun, but they should never be used to compensate for skill or equipment inadequacy. But whether it's the convenience of easily getting your buddy's attention, the comfort of knowing that you can cut your way out of an accidental entanglement or the knowledge that you will have a bright and reliable light source for an exciting night dive, accessories provide valuable utility that can brighten days as well as dives. AD

ALERTDIVER

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PARTING SHOT

By Imran Ahmad

Among Wakatobi's spectacular reef walls are some of the world's best subjects for macro photography. Instead of shooting this skeleton shrimp with a conventional macro setup, I decided to go with a reverse-ring macro lens-mounting technique. I also used florescent lighting to bring out detail in the subject and to create a mood. It was challenging to focus and compose this shot since the subject was very active, but patience paid off, and I was able to create a psychedelic image of this little guy. AD

EQUIPMENT: Nikon D4, 105mm and 50mm (reverse ring macro) lenses, AOI RGBlue System 02 with snoot kit, custom blue and yellow filters, Seacam housing
SETTINGS: 1/125 sec @ f/3.5, ISO 1000
LOCATION: Wakatobi, Indonesia

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