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THE MAGAZINE OF DIVERS ALERT NETWORK
FALL 2016

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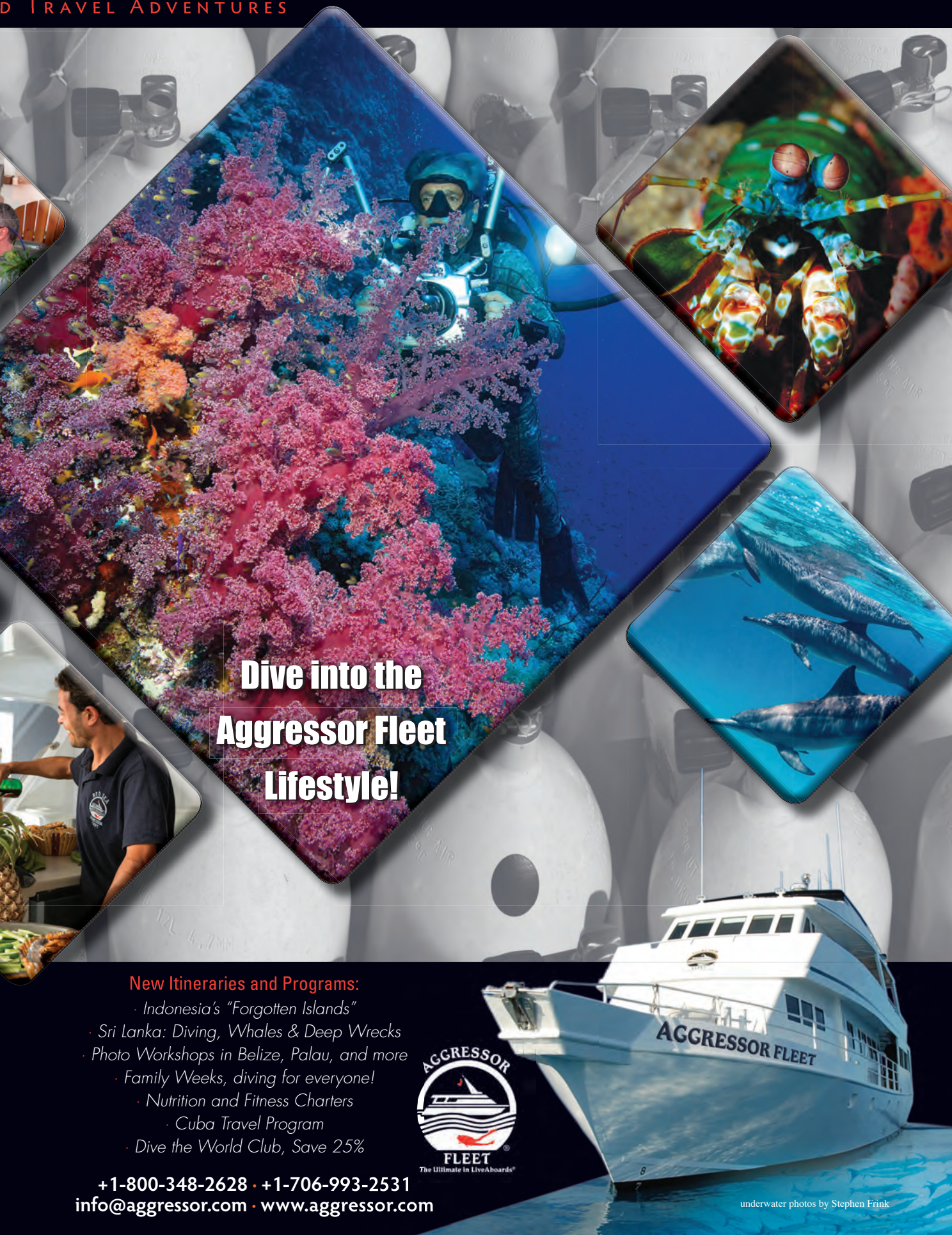

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underwater photos by Stephen Frink

ALERT DIVER

THE MAGAZINE OF DIVERS ALERT NETWORK FALL 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.

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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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FEATURES

ON THE COVER: Caribbean reef sharks (*Carcharhinus perezii*) are commonly encountered along the shallow coral reefs of Cuba's Jardines de la Reina. Stephen Frink took this photo of a pair of sharks with his daughter, Alexa Frink, using a Canon 5Ds with a Canon 16-35 mm f/2.8 II lens (at 16 mm) in a Seacam housing with two Seacam Seaflash 150 strobes and an exposure of 1/50th sec @ f/10, ISO 320.

THIS PAGE: Pinnate batfish and sponge. Photo by Douglas Seifert


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DEPARTMENTS

Freediver and light rays.
Photo by Jason Bradley

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NEW INITIATIVES FOR DIVE SAFETY

By Bill Ziefle

This has been a rewarding and very productive year at DAN®, and we are excited to announce several new programs, products and services that will directly support our dive safety mission. We developed a program to educate new divers about safe diving practices, expanded our professional membership to include all dive industry professionals, enhanced our insurance coverage for entry-level students and launched DAN Risk Retention Group to provide liability protection for dive leaders. While many of these initiatives directly address the safety and security concerns facing dive professionals, their businesses and their students, the full impact will be felt by the entire dive community in the form of increased awareness and an enhanced culture of knowledge and safety.

First, we developed a program for students and new divers based on extensive analysis of our medical and insurance-claims data, which showed that the majority of dive-related incidents have a root cause in one of a few fundamental concepts in diving. The Prepared Diver program addresses these common accident catalysts with a series of informative and engaging videos that review the science behind safety guidelines and provide techniques, tips and best practices related to each issue. Complementing all entry-level certification and refresher courses, this program can be used by instructors to help convey the knowledge divers need to avoid the most common dive injuries.

To better align our professional memberships with DAN's mission, we've completely revamped and expanded the existing programs to include all dive and aquatic industry professionals — leaders, instructors, store owners, managers and operators. The new DAN Professional Membership has been broadened to offer access to general and professional liability insurance as well as all DAN first aid and Prepared Diver programs for individual professionals, students and staff. We believe it is crucial to provide our members with access to relevant and valuable educational materials and the best possible liability coverage to support them as they continue to educate the dive community and work to reduce the occurrence of dive accidents.

We significantly enhanced the medical expense protection available to students of dive professionals who participate in the DAN Professional Membership program. During training, all eligible students will benefit from up to $25,000 in medical expense coverage for injuries occurring during entry-level open-water training. This program is a key benefit available to DAN Professional Members and is provided at no charge to instructors or students.

In addition, we understand the importance of thorough and comprehensive coverage for the professionals who take on the risk of teaching and supervising water-based activities. Therefore, earlier this year DAN Risk Retention Group began offering general and individual/group professional liability insurance to a select group of dive professionals. We recently extended these programs beyond the initial group and hope to soon be able to offer this coverage to all dive industry professionals. Backed by reinsurance provided by various Lloyd's syndicates and Gen Re, this new DAN program is structured to provide sustainable and reliable cost-effective solutions for the dive industry's liability insurance needs. As with other DAN subsidiaries, DAN Risk Retention Group is 100 percent owned by DAN, and all profits will be used to support other DAN dive safety programs.

It is our hope that these initiatives will allow DAN to take data from our exhaustive analyses of dive accidents to minimize and prevent future accidents, thus making diving safer for all.

To learn more about DAN membership, insurance and dive safety programs, visit *DAN.org*. AD

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- *Health & Diving* Reference Library
- Online Incident Reporting and Case Summaries
- Medical FAQs and Information Line
- Social Media Channels
- Webinars, Safety Quizzes and Online Seminars

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These two photos were taken nearly simultaneously, both with full-frame fisheye lenses. For the photo on the left, the camera's dome port was within 4 inches of the crocodile's teeth. For the photo on the right, the shooter was 4 feet away from the action, which significantly altered the perspective.

STEPHEN FRINK

DENA MINTZ

PERSPECTIVE DISTORTION

FEAR AND LOATHING IN SOCIAL MEDIA

By Stephen Frink

I was recently in Cuba (see "Jardines de la Reina: Cuba's pristine paradise" on Page 68) leading a photo tour on a liveaboard. Since it was summer and school was not in session, my daughter, Alexa, was able to join me. It was a great opportunity for us to spend some quality time together doing what we love: scuba diving and being around interesting marine animals.

One of the things I looked forward to was an encounter with crocodiles in the mangroves that I'd seen photographed by others. Dive operators have been conducting such encounters for two decades, and they have learned that divers can interact safely and reliably with some of the subadult American crocodiles (*Crocodylus acutus*).

The whole process was pretty interesting. We would travel to a spot commonly visited by crocs, and the guide would call out, "Niño, Niño!" The crocodile he had in mind was obviously habituated to encounters with snorkelers and rewarded with raw chicken for good behavior. This is not to say the interaction is guaranteed though — one day we got skunked. But the second morning was quite productive. Niño came swimming out to us, and we got in the water with snorkels. I had a large housed camera and strobe that I could put between the croc and me. My daughter had her GoPro on a selfie stick that she could use to fend off any approaches that were too close for comfort.

Throughout the 40-minute encounter we were never alarmed; in fact, we were excited about our good fortune to have been there at high tide (for optimal water clarity) and about the crocodile's willingness to get close. The fact that this all happened in a gorgeous mangrove and seagrass environment made it all the more special — such places are typically far more turbid. No one should extrapolate from our good luck with this particular crocodile that the more aggressive species in Australia or Africa are approachable. While this particular encounter was mellow and benign, snorkelers in Raja Ampat, for instance, have been killed by crocodiles inhabiting the blue water mangroves.

Photographer Dena Mintz captured the photo above of me at work with my camera; because both the croc and I were on roughly the same plane, the size reference is pretty authentic. But as I maneuvered around the front of the croc and got closer to its open mouth with my extreme wide-angle lens, an optical phenomenon called "perspective distortion" occurred. The object in the foreground (the open mouth of the crocodile) appeared unnaturally massive and intimidating relative to Alexa swimming in the background. Shooters with experience in wide-angle photography know about this and can recognize it in photos, but the image provoked strong reactions from some members of the public.

I distribute my images through a variety of stock photography agents, and one works with mass media in the UK and Australia. The crocodile shots went viral. I'd like to think it's because they turned out so well, but in reading the comments I could see it was mostly because so many people thought it was very irresponsible for a father to expose his daughter to such danger. Here are some examples of the comments (from *grindtv.com/wildlife/daughter-swims-dangerously-close-crocodile-father-takes-photos-video*):

"It doesn't matter that the daughter is an adult. For the father to encourage her to swim with a croc was a stupid, stupid thing to do. You can show that the croc's environment is shrinking without endangering a human. What an idiot!"

"Personally, I think the photographer/dad is a bit daft, myself. Go figure ... crocodiles eat people for goodness' sake!"

"The risks people will take — even putting their own family in harm's way — just for a moment of attention. Hope he doesn't make a habit of it. Seems a very foolish thing to do."

"Very irresponsible and selfish behavior. I am a father of a girl, too (same age as this one), and I would never think of risking her safety like this. Amazing what people do for five minutes of fame!"

One comment was less inflammatory: *"I'm sick and tired of armchair people using photos and social media as the sole means of assessing an event. Quite frankly, it's no one else's business but Stephen's and his daughter's. Unless you have an equal amount of experience with diving and sea creatures, you have no basis to be critical."*

The whole experience was enlightening. For a moment I felt a little of what Jennifer Anniston must feel every time she goes to the grocery store and sees tabloid headlines speculating that she might be pregnant. I didn't engage with any of the commenters. Clearly their experiences were different from mine, and my words weren't going to bridge the experiential divide.

This also gave me some insight into the vast gulf in understanding between a general public who will never see the world though our face masks and those of us who know the ocean, its creatures and the realities of life underwater. They may never understand the importance of sharks to our oceans and therefore not comprehend what a massive problem shark finning is. They may never see coral bleaching and thus never understand the implications of climate change. And they may not be able to differentiate marine life that is safe to approach from marine life that's hazardous.

I wish we could help them understand. But most people will never commit to learning about the ocean firsthand as scuba divers and seeing what we see, so consensus will continue to be difficult. AD

WHAT'S NEW ON ALERTDIVER.COM

STEPHEN FRINK

BACK IN THE GARDEN

Read about Stephen Frink's trip to Cuba (Page 68), then watch his daughter's video of the experience and view a bonus photo gallery.

SEEING LIKE SEIFERT

Learn how Douglas David Seifert mastered photography (Page 92), then see more of his excellent imagery in a bonus photo gallery.

DOUGLAS SEIFERT

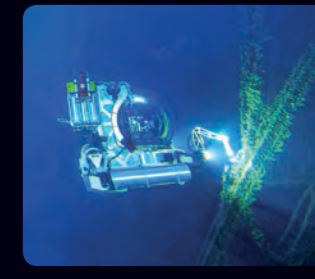
JIM GARBER

LOVING LOOE KEY

After reading about Florida's Looe Key (Page 36), check out the online photo gallery to discover more of what awaits divers there.

CARE AND COLLABORATION

Leigh Bishop explains how to prepare for a deep wreck expedition on Page 46. Go online to watch a trailer for the film made during his expedition to the *Britannic* in 2016.



LEIGH BISHOP

ALL THIS AND MUCH MORE AWAITS AT ALERTDIVER.COM

COURAGE

I loved reading Cody Unser's article in the summer edition of *Alert Diver* (Member to Member). As a volunteer diver at the Aquarium of the Pacific in Long Beach, Calif., it has been my privilege to dive with Cody on several occasions. Each year the aquarium presents the Festival of Human Abilities, which brings together at the aquarium individuals with all sorts of challenges, and Cody and her team have participated in the event. When you consider the courage it takes to dive in deep water without the total use of every physical attribute, Cody's achievements are even more impressive. The opportunity to dive with Cody has been humbling and rewarding. Thank you for helping tell her story.

— Andy Marias, via email


MARLA BROSE/ALBUQUERQUE JOURNAL

FOND MEMORIES

Typically, everything stops for me when *Alert Diver* arrives, and the Summer 2016 edition was no exception. I particularly enjoyed the piece on Kurt Amsler, which brought back many good memories.

When he arrived at UNEXSO, in Freeport, Bahamas, I had been on staff there for a year or so, after a decade in the British navy. As it was soon apparent that he was just as broke as me, l let him share my living quarters: the dive club's broom and wash bucket closet. There was just enough room for another cot. It was a great couple of years diving and socializing with this talented guy, and, as your interview records, he had a wonderfully developed underwater eye.

Thank you for introducing this remarkable underwater photographic pioneer to today's diving community.

— Dick Clarke, Columbia, S.C.

OUR MARINE ENVIRONMENT

Kudos to Stephen Frink for advancing the idea that divers need to be doing more to promote ocean conservation. Mentioning David Doubilet's concept that every day is World Oceans Day is right on point. Raising awareness and encouraging divers to examine how everyday choices affect the oceans should be a part of the diving curriculum. After all, the dive industry would not exist if it weren't for the wondrous resources found beneath the sea.

Every diver today should be familiar with how plastics, overfishing, bycatch, land-based pollutants and fossil fuels affect our marine ecosystems. Stephen, David and other longtime observers of the marine environment are well suited to describe the changes and trends they have seen over the years.

— Steve Mussman, Lawrenceville, Ga.

I appreciated Stephen Frink's comments about plastic straws and cups in the recent *Alert Diver*. It is a shame that it's cheaper for bars to give out one plastic cup after another than to wash and reuse glassware. I actually have my

own "islandy still glass" that I take out in its own little carrier pouch to try to fight this plastic plague confronting our world.

A few nights ago I saw a documentary called *Plastic in Paradise* — shameful and shocking. Several years ago there was a big movement in the Key West bar scene to shift to a corn-based biodegradable drink cup identified by a green stripe. Apparently it raised the price of drinks a few pennies and was soon abandoned. Sad!

— Jim Hoefling, Key Largo, Fla.

BRANDON COILE

PRETTY PICTURES, WISE WORDS

Alert Diver has risen to a level above all the other magazines that were ever published for this industry. The outstanding photography by a diverse group of professionals is my primary interest, but the articles by DAN staff certainly have great appeal to both the professional diver as well as the novice. We educate our students about all the benefits of being a DAN member. As we say, "Don't go diving without it!" Just keep this fantastic magazine coming with the quality and information we have grown to enjoy.

— Chaz Kafer, via Facebook

REMEMBERING *THE DORIA*

I so enjoyed your article on the *Andrea Doria*. I sailed on it the trip before it sank, and my family knew a family on the voyage when it sank; all were well. I was five at the time of my sailing, so I do not remember it, but I have two memorabilia from the ship. My parents bought me an *Andrea Doria* doll in a sailor suit, and my father won the skeet-shooting contest, garnering a trophy.

— Michele Cribley, via email

As always, I enjoyed the latest issue of *Alert Diver*. I wanted to mention a couple of things related to Michael Menduno's article, "Remembering the *Andrea Doria*." First, there were casualties when the ship sank; 46 people lost their lives, including San Francisco publishing magnate Ferdinand Thieriot and his wife, Frances.

Next, one of the photos in the article was taken in the early 1970s during Chris DeLucchi and Don Rodocker's weeklong saturation dive on the wreck with dive industry icons Jack McKenney of *Skin Diver* magazine and Bob Hollis of Oceanic. The chamber that they dubbed "Mother" was purchased after their expedition by Dacor Corporation and used at its Chicago location for testing regulators and other equipment for more than 25 years. AD

— Ron Pavelka, via email

WRITE US

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

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

DIVE SLATE

KELP PADDIES

ISLANDS OF LIFE ADRIFT IN THE OPEN SEA

Text and photos by Richard Herrmann

I was in a small boat about 30 miles offshore of San Diego, Calif., looking for life. We were running hard at 20 knots when out of the corner of my eye I caught a glimpse of a tiny patch of brown against the vast blue background. It was a bit of kelp about the size of a trashcan lid. I turned toward it and immediately saw a huge splash and a distressed yellowfin tuna doing tight circles around the kelp. Here was a picture I had wanted for years: a tuna on a kelp paddy.

When I got into the water I saw what had made that big splash as the form of a massive 400- to 500-pound blue marlin materialized out of the blue. The lightbulb went off immediately, and I knew why the big marlin was there — the more commonly seen striped marlin does not prey on 20- to 30-pound tuna.

That day I got images of the blue marlin and the tuna (see Parting Shot, *Alert Diver*, Winter 2015). These were likely the first-ever underwater photos of a blue marlin taken in California waters. It was among the two or three best days I have ever had in 35 years of diving kelp paddies.

That happened in the fall of 2014, which was the beginning of a series of warming years that included the very powerful 2015 El Niño. The warming events of 2014, 2015 and 2016 have brought to the California coast warm-water species from the south that had rarely been seen over the years, and all of them were observed around kelp paddies.

WHAT IS A KELP PADDY?

Searching for photographic subjects in the big blue void of the open sea can be frustrating. Signs of life are fleeting. The subtle splash of a marine mammal or working birds are among the few signs that indicate the possibility of life.

Much like the Atlantic coast, which has its own drifting algae habitat (*Sargassum*), the Pacific coast of North America has drifting kelp. Giant kelp (*Macrocystis*) grows from Alaska to central Baja California. Kelp paddies form when the anchoring kelp holdfast weakens and breaks free after storms, warming events or grazing by sea urchins. As the 80-foot-tall plants drift away, they become entangled with other kelp plants. Buoyed to the surface by gas-filled bladders, these floating masses are then swept out to sea by wind and currents. An average-sized kelp paddy might be the size of a bathtub, but they can be more than 50 feet across with holdfasts dangling down 40 feet. Kelp paddies can be found any time of the year with locations varying from just a mile or so off the coast to hundreds of miles out to sea. Most kelp paddies drifting off the California coast originate from the beds of giant kelp in the Channel Islands or elsewhere along the West Coast.

Best described as "drifting islands of life," kelp paddies provide a refuge for planktonic fishes and invertebrates that initially settle in the ready-made habitat. Small fishes and invertebrates attract schooling baitfish such as sardines and mackerel. Larger predators such as tuna, marlin, sharks and marine mammals complete the food chain as they come to feed on the baitfish. The entire range of large pelagic predators found on the Pacific coast can be seen near kelp paddies. When the larger predators appear, juvenile fishes can retreat within the protection of the tangled plant mass.

The assemblage of animals found in association with kelp drifting off the Pacific coast cannot be found anywhere else in the world. For example, the juvenile stage of the splitnose rockfish (*Sebastes diploproa*) has only been observed under drifting

A Pacific white-sided dolphin checks out a kelp paddy at the "nine-mile bank," 10 miles off the coast of San Diego, Calif.

kelp. The adult form of this rockfish is found in very deep water from 700 to 1,500 feet. Drifting kelp may also be an important habitat for the juvenile stage of the California yellowtail, halfmoon and other species of fishes. Marine scientists sampling kelp paddies have found more than 25 different species of fishes amid kelp paddies, with most of the species consisting entirely of juveniles.

You never know what you are going to see under the kelp; populations vary from year to year and area to area. An area of 65°F water may have a completely different set of animals than an area of 72°F water just five miles away. That's what makes kelp paddies so interesting.

The recent warm years have brought smooth hammerhead sharks, blue marlin, bluefin tuna, false orcas and many other species that were rare in previous years. Until the summer of 2014, for example, wahoo had never been documented in California waters, but in the strong 2015 El Niño event, more than 1,000 wahoo were caught in California waters by sport fishermen.

MOLA MOLA

Kelp paddies are absolutely the best place to find *Mola mola*. Molas, which come to the drifting kelp to be cleaned by the halfmoon fish, are loaded with parasites, both externally and internally. We saw one mola that was particularly undisturbed by diver presence and were able to pull out parasitic copepods deeply embedded in its skin. The fish actually seemed to enjoy the encounter.

It is not unusual to see up to three molas on a drifting kelp. My personal record from a few years ago was 50 adult molas on a single kelp paddy. They are generally wary of photographers approaching them at the surface or from underwater. A diver in a black wetsuit looks like a sea lion to the mola. I have seen sea lions tear apart molas, so it is important to approach slowly and not aggressively. Some molas may not care much about an approaching diver, but it is more common for them to swim away.

Seagulls perch on a drifting kelp paddy off Santa Barbara Island during the 2015 El Niño.

Below left: Kelp paddies are great places to find ocean sunfish (*Mola mola*).

Below right: Diving kelp paddies can be very rewarding; you never know what you'll see.

DIVING KELP PADDIES

Kelp paddies are best dived by live boating, with a driver staying aboard. Tying up to the kelp usually pulls it apart, and anchoring or mooring is impossible because of the water depth (typically 1,000 to 3,000 feet). Stay aware because fishermen looking for pelagic gamefish also target kelp paddies. On a few occasions I've seen fishermen cast jigs at the drifting kelp with divers in the water.

For this reason the vessel should fly a dive flag, and the boat driver should carefully monitor the location of the kelp and the divers at all times. It is also best to live boat upwind of the divers. Weather can change quickly, and a vessel that gets downwind and loses power could become a liability for a diver who has to swim and catch up to the rapidly disappearing vessel. With only a speck of brown for reference against a vast blue background, it is easy for the boat driver to lose visual on a

kelp paddy. Taking this into account, divers should carry a surface marker buoy, whistle, strobe and a diver's emergency position indicating radiobeacon (EPIRB) of some sort.

In recent years crews have filmed the kelp paddy story for IMAX, BBC, National Geographic and Silverback Films. My most memorable filming project of a kelp paddy was one in which Howard Hall coordinated our five-man crew underwater to position a 1,400-pound IMAX 3-D camera with cable lights to successfully film multiple *Mola mola* at a cleaning station. Finding and exploring kelp paddies takes some time and effort, but it's worth it to see what lies beneath them. AD

The DAN board of directors. *From left:* Lee Selisky, Joe Poe, Sylvia Earle, Wayne Massey, Kathy Weydig, Michael Lang, Harry Rodgers, Bill Anlyan and Doug Stracener

THE DAN BOARD OF DIRECTORS

COMMITTED TO SAFE DIVING

By Brian Harper

The members of DAN's board of directors are a passionate and motivated group. All volunteers, most of them have been involved with DAN® for more than 10 years, and they've been diving for an average of almost 40. Their breadth of experience is impressive, and their dedication to scuba diving and safety is abundantly clear.

Lee Selisky has been diving deep wrecks — from Lake Superior to Truk Lagoon — since 1967.

Tell me about your involvement with DAN®.

I have been involved with dive safety initiatives for a long time, including early promotion of nitrox back when the industry was against it. If I'm going to spend my time and energy on something, I want to be able to see a positive impact, otherwise I'll do something else. I've been involved with DAN since its inception, first as a corporate sponsor and for the past 12 years as a board member, and I've never been as excited about the future of DAN as I am now.

Joe Poe, J.D., was a member of the first civilian team to dive the USS *Monitor*. He has done more than 40 dives on the wreck and has documented it and many other shipwrecks through articles and photography.

What brought you to the DAN board of directors?

In our lives we don't often have opportunities to make a difference, but diving is an activity that I and the other members of this board want to protect. We try to make certain that everything we do furthers DAN's mission, and I think we've been able to run this organization in a way that ensures DAN will always be here for divers.

Sylvia Earle, Ph.D., an ocean advocate and National Geographic Explorer in Residence, has led more than 100 scientific expeditions and spent more than 7,000 hours underwater.

Why do you dedicate your time to DAN?

The existence of DAN is a reflection of caring by people who have taken it upon themselves to create a self-sufficient organization that provides a vital service to the diving community and helps give a voice to the blue part of Earth. It is a privilege to work with people who are making aquatic

exploration safe and to be able to have input on policies that affect the future of diving. DAN has served divers well — myself included — for many years.

Wayne Massey, M.D., gained significant experience treating divers with serious decompression illness as a doctor in the U.S. Navy and later as a doctor and professor of neurology at Duke University Medical Center.

What are the most important things DAN does?

I've seen how people's lives can be affected by dive accidents, and I think DAN's focus on prevention is crucial. It's important for divers to learn to perform field neurological assessments and recognize the signs of a heart attack and other cardiovascular emergencies. Most of us have certain things in our lives that we believe are worthwhile and want to put effort into, and for me DAN is one of those things.

Kathy Weydig is a tech diver, former dive shop owner and cofounder of the Women Divers Hall of Fame.

What drew you to the dive industry and to DAN?

I became a dive professional because I wanted to train people to a level of competence I'd want in a dive buddy. I later became an emergency medical technician (EMT) to improve my understanding of the medical aspects of diving to better teach them to my students. I also became a dive medical technician (DMT) and a certified hyperbaric technician (CHT) and ran a hyperbaric chamber for a while. I appreciate that at DAN, the revenue funds research, outreach and educational materials.

Michael Lang, Ph.D., directed the Smithsonian Scientific Diving Program for 21 years and the U.S. Antarctic Diving Program for 10 years.

How is DAN reaching various sectors of the diving industry?

DAN's educational programs have really made an impact in recreational diving, and it's great to see DAN being more involved in scientific diving, public safety diving and other types of diving. For example, there has been significant adoption of DAN training courses among the more than 130 member organizations of the American Academy of Underwater Sciences. Our materials are getting better and

more user friendly. DAN's impact and influence in recreational diving and beyond is stronger than ever before.

Harry Rodgers is a "fish head" — he's been an avid angler, aquarist and diver since he was a kid. He's also an expert in insurance.

What goals do you have for DAN, and what initiatives are you most excited about?

Beyond seeing DAN be the leader in dive safety and the No. 1 service provider for divers who encounter problems, I want to see DAN's efforts promote a renewed interest in diving, particularly among young people. If we can keep the sport safe and take care of divers, that helps diving grow. I'm really enthusiastic about the new professional liability program — it's a natural extension of our safety and risk-management efforts.

Bill Anlyan, former vice chancellor of the University of North Carolina at Wilmington (UNCW), was very involved in the school's marine science program.

What are some highlights from your time in diving and at DAN?

Many of my best underwater experiences involve *Aquarius Reef Base.* UNCW ran *Aquarius*, and we would host researchers from around the world. Learning from them and seeing what they were working on are experiences I wouldn't trade for anything.

My time at DAN has likewise been inspirational. The subject matter — diving, safety, science, the marine environment — is inherently interesting, and everyone at DAN is so committed to the mission. During meetings we are always asking ourselves, "How do we make diving safer?"

Doug Stracener, J.D., is a solo private attorney and scuba instructor who also teaches motorcycle safety classes for the Louisiana Department of Public Safety. He works with law enforcement and public safety dive teams and has been accused of being a collector of instructor certifications.

What is DAN's role in the dive industry?

My predecessor on the board, Dick Long, told me to constantly ask myself, "What have we done today to save divers' lives?" In the dive industry there are multiple agencies with competing interests, but DAN is like the United Nations — we try to stay out of the politics and be a resource for everybody. DAN exists to save divers' lives; everything we do is geared toward that. AD

A surgeon prepares to place an occluder in the heart of a patient with a patent foramen ovale (PFO).

BSIP/OTO/CHU BORDEAUX/SCIENCE PHOTO LIBRARY

PATENT FORAMEN OVALE AND FITNESS TO DIVE

By Petar J. Denoble, M.D., D.Sc.

The Patent Foramen Ovale and Fitness to Dive Consensus Workshop was held June 17, 2015, in Montreal, Canada. The Undersea and Hyperbaric Medical Society (UHMS) and DAN® invited experts to review the current state of knowledge about diagnosis of patent foramen ovale (PFO), evaluation and mitigation of individual risk, and how PFOs affect divers' safety. DAN published the proceedings of the workshop, including the consensus statement, which are available online at *DAN.org/research/workshops*.

A PFO is a passage in the wall between the right and left atria of the heart that can be found in about 25 percent of adults. Its size and the degree of blood flow through it vary. In a small percentage of people, a PFO allows for a continuous passage of blood from the right atrium to the left atrium — a spontaneous right-to-left shunt (RLS). In some people, the RLS occurs when pressure in the right atrium exceeds pressure in the left atrium. This may happen after relieving a temporary obstruction to blood flow to the heart such as with a Valsalva maneuver or straining while lifting, sniffing, coughing or defecating. Spontaneous or provoked RLS may be seen in 10-15 percent of adults.

A PFO with RLS has long been suspected for paradoxical embolism, wherein particles carried

by venous blood bypass the pulmonary filter, enter arterial circulation and block blood flow in terminal vessels (embolism), which results in ischemic injury of tissue downstream of the obstruction. The most common form of embolism is caused by blood clots from peripheral veins passing through the PFO and causing a stroke. Paradoxical embolism may occur in divers with a PFO if the RLS occurs postdive when a lot of venous gas emboli (VGE) are present. Paradoxical embolism caused by VGE may manifest with symptoms of neurological (spinal, cerebral and vestibular) or cutaneous decompression sickness (DCS).

The overall incidence of DCS in recreational divers is two to four per 10,000 dives, and the incidence of neurological DCS is less than one per 10,000 dives. In the presence of a PFO, however, the incidence of neurological DCS increases fourfold. While the average DCS risk for divers with a PFO seems low, for some individuals the risk may be greater than overall statistics predict. The main question regarding PFOs and diving is how to identify individuals who are likely at an increased risk of DCS and how to mitigate that risk. The workshop's consensus guidelines provide some answers.

WHO SHOULD BE TESTED FOR A PFO?

The consensus maintains that no routine screening for PFOs in all divers is necessary. It recommends, however, that divers with a history of more than one episode of DCS with cerebral, spinal, vestibulocochlear or cutaneous manifestations should be tested for a PFO. On the other hand, divers with mild (other than cutaneous) DCS need not be tested.

HOW TO TEST FOR A PFO

Experts well practiced in the procedures should conduct the test. The most appropriate testing method is transthoracic echocardiogram (TTE) with

"Divers should always remember that the main factor causing DCS is the dive exposure itself — the depth, time and ascent rate. With a significant exposure, anybody is at risk of DCS. Most people who get DCS do not have a PFO."

bubble contrast and a provocative maneuver such as a Valsalva or sniffing. Other methods are suboptimal.

INTERPRETATION OF FINDINGS

A spontaneous shunt is a passage of contrast bubbles from the right atrium to the left atrium without a provocative maneuver. This is considered to very likely represent an increased risk for DCS in cases when dives result in a lot of VGE.

A large provoked shunt means that a lot of VGE are passing through after a Valsalva maneuver or sniffing. It is likely to open with any kind of straining and is recognized as a risk factor for the previously listed forms of DCS.

The presence of smaller shunts is associated with lower risk that should be evaluated on a case-by-case basis. It is important to note that the detection of a PFO in divers who suffered an episode of DCS is not proof that the PFO caused that specific episode of DCS.

RISK MITIGATION

Divers with a diagnosed PFO that's likely to be associated with increased risk of DCS should consult a dive physician and consider options that best suit their needs and diving styles with a solid understanding of the risks and benefits of each option. The options are as follows:

1. Stop diving.
2. Dive more conservatively to reduce occurrence of VGE, and do not strain after diving to avoid opening the PFO and provoking RLS.
3. Close the PFO.

Conservative diving includes strategies to reduce the risk of significant venous bubbles postdive and of shunting bubbles through the PFO. Since there is significant variability in VGE occurrence among divers and in the same diver over time, discuss options with a dive medicine expert before making any decision. For more details about conservative diving, see *AlertDiver.com/Conservative_Diving.*

The closure of a PFO may reduce the risk of DCS, but it is not a guarantee that DCS will not occur in the future.

Deep and long dives may cause DCS without VGE passing to the arterial side. Even in the absence of a PFO, VGE may pass to the arterial side through shunts within the lungs that tend to open with exercise, hypoxia and beta adrenergic stimulation and close with hyperemia.

RETURN TO DIVING AFTER A PFO CLOSURE

Diving should not be resumed before full closure is confirmed with another contrast echocardiogram at least three months after the closure. Divers should not return to diving as long as there is a need to take potent antiplatelet medications. If the test at three months or more after closure shows complete closure and the diver is prescribed only aspirin or nothing for clotting prevention, diving can be resumed.

Divers should always remember that the main factor causing DCS is the dive exposure itself — the depth, time and ascent rate. With a significant exposure, anybody is at risk of DCS. Most people who get DCS do not have a PFO. Divers with a complete closure of PFO may avoid DCS episodes that they may have had in the past, but if they engage in extreme diving, their risk of DCS will be commensurate. AD

DAN
YOUR DIVE SAFETY ASSOCIATION

GEORGIENNE BRADLEY

By Terry Ward

Hometown: Croydon, Pa.
Years Diving: 32
Favorite Dive Destination: Cocos Island, Costa Rica
Why I'm a DAN Member: I can focus on my work knowing that DAN experts are available at any time and that I have access to premier evacuation coverage and medical treatment.

Georgienne Bradley, founder/director of Sea Save Foundation (*seasave.org*) and a producer at Bradley Ireland Productions, is an enthusiastic scientist, writer and activist who has spearheaded conservation efforts for most of her life.

Among Bradley's many accomplishments are being the Latin American Representative for the Cousteau Society, the cochair/cofounder of the American Society of Media Photographers underwater specialty group, an inductee in the Women Divers Hall of Fame, an SSI Platinum Pro Award winner and the founder of Earth Images and Bradley Ireland Productions. She has written three books, hundreds of magazine articles and multiple scientific papers and has produced work for Paramount, Disney, National Geographic and others. Her first published documentation of shark finning was in 1989. One of Bradley's most noteworthy achievements was having worked closely with the Costa Rican government for more than 26 years on projects protecting Cocos Island and its shark population, culminating in Cocos Island becoming a United Nations Educational, Scientific, and Cultural Organization (UNESCO) World Heritage Site.

How did a girl from Pennsylvania discover diving?
Both my parents and grandparents owned marinas, so I was on the water from a young age, moving the boats around. In high school, a friend of mine was a diver. I knew you weren't supposed to dive if you didn't have the certification, but I was a strong swimmer and young and stupid. In Monterey, Calif., I convinced my friend to rent some gear, and I walked off the pier and laid on my back in the water and watched a sea lion bark at me. I thought, "This is the coolest thing ever."

JAY IRELAND

My friend then realized I'd never dived before, and I had to 'fess up. She then told me the area we'd just seen was rubbish, but even so I had been thrilled by it.

What made you decide on a career in diving?
There's a twofold answer to this. The first part I can summarize with a name: Jacques Cousteau. What Cousteau was doing was all new. I was a kid watching with my family, and he would use his camera to bring us along on his adventure.

Subconsciously, I think, I saw how you could inspire with imagery. It's a very strong tool. At Sea Save the lengths to which we have to go to get people to take advocacy steps is crazy. People want to see the oceans protected but are not always willing to take time to engage, even in the smallest actions. Cousteau showed people the personalities of whales and the beauty of the oceans, and from there it was an easy sell to get people to say, "Let's protect them."

The second thing that moved me toward a career in diving was a project I spearheaded: the Costa Rica Marine Imaging Project (CRMIP). I recognized that there was a strong need for marine-related educational programs in Costa Rica; with some creative solutions, Jay Ireland, my partner at Bradley Ireland Productions, and I were able to execute several national educational programs with little funding. The projects included the creation of a series of national postage stamps and educational and PR campaigns that increased awareness

and cultivated local stewardship. At CRMIP I worked closely with Costa Rica's president, José María Figueres Olsen, and Cocos Island director, Joaquin Alvarado, documenting the national park and creating a visual presentation that helped gain Cocos Island a place in the list of UNESCO World Heritage Sites.

Cocos Island has had a special place in your heart since then — tell us more about Cocos.

Cocos is a remote island where time has stood still. When I first went there, it changed my life. After working in ocean conservation, I decided not to finish medical school and instead went in a different direction.

When we are talking about the oceans and protecting them, we can liken our passion for the ocean to passion for poetry and art — things that are important to the soul. We might have food — the sustenance we require to live — but we need things that fill our souls, that make us *want* to survive. From Robert Louis Stevenson to Michael Crichton, many writers and artists have gone to Cocos; I am just one of many that this place has changed.

I am always happy when I go back to a place and see that it hasn't been harmed very much. But I go back to Cocos, and it's better. Now we see whitetip sharks hunting, resident tiger sharks and orcas coming in consistently.

Speaking of sharks, Sea Save's "Give 'em the Fin" campaign to stop shark finning is wrapping up after three years, and you're focusing on something new. What's next?

Next year one of our major campaigns will target Cocos Island. It is so remote, and that's what has protected it. But as megafauna begin to diminish throughout the oceans, people are casting an eye on Cocos and similar places as the last spots to catch sharks.

We are planning a 2017 expedition to go there and reestablish our communication program. We will be speaking with leadership on the island. We only hear about Cocos when there is trouble, but our idea is to develop "The Voice of Cocos Island," a program to educate people about what's going on there.

Can the public get involved?

Yes! We still have a few spots on our Cocos Island liveaboard expedition (Feb. 15-25, 2017), with a portion of the payment funding conservation. We will have a submarine on board and a top-notch crew. There will be talks about the history of Cocos Island and why it's a world heritage site and, of course, lots of diving. Visit *SeaSave.org* to see what it's all about. AD

BRADLEY IRELAND PRODUCTIONS

JAY IRELAND

JAY IRELAND

JAY IRELAND

Clockwise from top: **Bradley shoots for the *Wall Street Journal* in the Bahamas.**

The UNESCO team at Cocos Island works to achieve World Heritage status.

Bradley photographs evidence of turtle poaching in Limon, Costa Rica.

Bradley attends the 2016 CITES conference to fight for protection for sharks and rays.

Opposite: **Bradley models for the cover of the Delphinus housing manual.**

DAN
YOUR DIVE SAFETY ASSOCIATION

PUBLIC SAFETY ANNOUNCEMENT

BREATHING-GAS CONTAMINATION


STEPHEN FRINK

Although DAN® occasionally receives reports of divers who breathed contaminated gas, such incidents are rare. The health effects of breathing contaminated gas vary depending on the contaminant, but even trace amounts of contaminants can cause symptoms. The most severe symptoms associated with breathing-gas contamination are impaired judgment and loss of consciousness, both of which can be deadly underwater. Here's what you should know.

RECOGNIZING SYMPTOMS

Sources of contamination vary, but they are generally related to impurities from the environment (engine exhaust, carbon dioxide, dust particles) or byproducts of the compression process (carbon monoxide or hydrocarbons from compressor lubricants). Each contaminant is associated with particular symptoms.

carbon monoxide: headache, dizziness, weakness, nausea, vomiting, shortness of breath, impaired judgment, confusion, unconsciousness
carbon dioxide: hyperventilation, dizziness, confusion, unconsciousness
volatile hydrocarbons: fatigue, headache, confusion, impaired judgment, numbness, cardiac arrhythmias, unconsciousness
oil (condensed): headache, nausea, lung injury (pneumonitis), impaired respiratory function
dust particles: impaired respiratory function

While some contaminants cause direct harm to divers, others may cause equipment damage that increases divers' risk of incidents. For example, excessive moisture can cause regulators to freeze or malfunction, corrosion and oxidation of scuba tanks, or reduced efficiency of compressor filtration.

PREVENTING CONTAMINATION

Prevent incidents related to breathing-gas contamination by getting your air fills from reputable dive shops. Take personal responsibility by conducting predive gas checks, and refrain from diving if your breathing gas has an unusual odor or taste. You can check your cylinder for carbon monoxide (CO), which is odorless, tasteless and colorless, by using electronic CO detectors or color-indicating devices. If you own a compressor, keep track of its maintenance schedules, and comply with proper fill procedures.

CONFIRMING CONTAMINATION

To receive timely and appropriate medical treatment, it is important to confirm contamination, which may be difficult based on symptoms alone. If you suspect exposure to contaminated breathing gas, stop diving, seek immediate medical evaluation, and contact DAN. Notify others who were exposed to the same source of breathing gas. Breathing pure oxygen may be advisable, especially if CO contamination is suspected.

DAN offers free gas analysis assistance. If you were involved in an incident possibly related to breathing contaminated gas and have lawful control of the tank, keep it closed, and contact DAN Research at +1 (919) 684-2948 or *DAN.org/DivingIncidents*. For immediate assistance, call the DAN Emergency Hotline at +1 (919) 684-9111.

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

EDUCATION SPOTLIGHT

PREPARED DIVER

Although certification and refresher courses expose divers to the information they need to safely enjoy the sport, incidents still occur every year. To identify and address the root causes of these incidents, DAN® has created a new, engaging and informative program: Prepared Diver.

DAN examined multiple sources of data within our emergency, medical and insurance-claims networks to develop the program's content. Analyzing information gathered from calls received, incidents reviewed and claims made, DAN identified the following five key *preventable* contributing factors that commonly lead to diver injury or death:

- disregarding limits
- improperly managing air
- overlooking proper equalization or ear issues
- failing to manage buoyancy
- lacking control during ascent

The Prepared Diver program offers insights into the science behind fundamental diving skills and highlights practices necessary for safe diving. The video series is divided into sections that address the root causes of dive incidents. Each segment includes an overview of the issue, a scientific explanation, a set of tips and techniques and a quiz.

Although the program was designed to complement entry-level and refresher training courses, Prepared Diver includes information that will be of interest and applicable to divers of all levels of experience and training and who believe we have a responsibility to keep everyone safe.

Administered by dive professionals, the Prepared Diver program will be available via DAN's online eLearning platform. For more information, visit *DAN.org*.

STOCK YOUR FIRST-AID KIT

As outdoor enthusiasts, adventurers and globetrotters, divers participate in activities that can potentially cause injuries. Even diving itself involves its fair share of bumps, bruises, stings and scrapes. Remembering to stock and carry your first-aid kit is an important step in being prepared. Customizing and maintaining your kit will protect you further. Make sure you're ready for just about anything.

STEPHEN FRINK

Start with the Essentials

Commercially available first-aid kits for divers will provide you with a reasonable array of supplies that can be upgraded or augmented according to your circumstances (see *DAN.org/store*). These kits are typically well organized and easy to use.

If you choose to put together your own kit, start with the following essentials:

Basics	Dressings and Bandages	Accessories	Medications
hypoallergenic gloves	adhesive bandages	vinegar	aspirin
CPR barrier	gauze pads and rolls	sterile saline solution	acetaminophen
tweezers	triangular bandages	irrigation syringe	ibuprofen
safety pins	elastic bandages	hot and cold packs	diphenhydramine
scissors	medical tape		hydrocortisone cream
soap			antibiotic ointment
first-aid guide			dimenhydrinate
			loperamide
			antacid

Customize for Your Needs

The list above is only a foundation. If you know you'll be hiking or walking somewhere with uneven terrain, include one or two lightweight, reusable splints. If you will be traveling with someone who has a history of severe allergic reactions, ask your physician about getting a prescription for an EpiPen. You might also ask your doctor to prescribe other prescription medications he or she thinks you may need. Consider the circumstances and conditions of your upcoming activities, keep track of items you wished you had packed on previous trips, and stock up. If you have questions, call DAN's medical services staff at +1-919-684-2948.

Maintain Your Kit

Remember that the contents of your kit may be perishable and must be replaced periodically. Inspect your kit before every trip and at least once per year. Replace all expired medications. Evaluate all packaging for discoloration, signs of disintegration or other damage, moisture, rust, residue or mildew. Ensure penlights, otoscopes and flashlights have new batteries, and inspect scissors or shears for rust, corrosion or other defects. If you have any doubt about whether an item is in working order, err on the side of caution and replace it.

For more information about health and diving, visit *DAN.org/Health*. AD

CLAMS AND FRIENDS

Text and photos by Ned and Anna DeLoach

For 20 minutes my camera lens has been trained on a blue antenna the size of a cat's whisker. It's all I can see of a rarely seen shrimp that lives exclusively inside the gills of giant clams (*Tridacna gigas*), the largest bivalves on Earth. The one-inch shrimp, as white as the milky tissue of the clam it inhabits, wasn't easy to find. Yan, my friend and dive guide, spent the week looking inside every clam we passed, and this is the first shrimp he found. So I am happy to remain right where I am until the air in my tank runs low or I finally get a shot of an animal I've been tracking for years.

By Raja Ampat standards the clam I'm kneeling next to isn't large, maybe 20 inches at most — nothing like the colossus I was introduced to a decade earlier by liveaboard cruise director and diving pioneer Larry Smith.

* * * * *

It was our first trip to that region of Indonesia, and Larry, always full of himself, kept carrying on about a gigantic clam he had recently discovered. His unrequited enthusiasm got to the point that guests lounging in the salon one evening began referring to the object of his infatuation as "Larry's Giant Clam." This was just the sort of thing Larry loved. Disappearing into his cabin he returned waving a tattered field guide. He tossed it on the table and flipped through the pages until a series of bivalve images appeared. Leaning myopically close to the page, Larry read triumphantly, "maximum length 4½ feet."

"Dagnabbit, that's nothing — my clam will beat that hands down," he added in his singsong East Texas drawl. And from that moment he was bewitched with the idea that his clam would set a new world record. Who could resist joining in such fun? Everyone aboard decided to become part of the quest to measure Larry's Giant Clam for science, posterity and interplanetary acclaim.

So the next morning we backtracked to the lagoon where Larry had found his clam. And sure enough there it sat, upright and solitary, on a shallow white-sand apron that spilled seaward from a coral thicket. At first sight we were taken aback by the clam's huge size. No one doubted Larry any more as we swam reverently around a pair of shells the size of a bathtub. Eventually we inched forward and one by one

Clockwise from top left: **Female giant-clam shrimp, *Conchodytes tridacnae*; Deman's giant-clam shrimp, *Anchistus demani*; male giant-clam shrimp, *C. tridacnae***

Opposite: **Fluted giant clam, *Tridacna squamosa*, one of six giant clam species inhabiting the Indo-Pacific**

estimated its length with our arms spread. Later, over cocktails, we collectively arrived at 4½ to 5 feet.

While reprovisioning in Sorong for the second part of our trip, the steward purchased a measuring tape at the hardware store. Back at the lagoon we bailed out of our skiff, confident of a new world record. The clam was of course right where we left it, as regal as we remembered and waiting to be crowned king of clams. But measure as we might, all we could muster was 50 inches, and even that length was debatable. After all our starry-eyed anticipation there was no record and no glory, but to this day none of us has seen a clam bigger than Larry's.

* * * * *

The hidden shrimp still isn't budging, so my thoughts drift again to Larry's Giant Clam. This time I try to calculate how long it must take for a clam to grow so massive: A hundred years? Maybe more, I'm guessing. By filtering food through their gills and farming symbiotic algae in their meaty mantles, giant clams can grow two inches a year for the first part of their long lives. Judging by this standard, the 20-inch youngster I'm keeping company must have settled here about a decade ago from the open ocean as a wafer-thin larva no bigger than a grain of sand.

While I'm tabulating clam math, the shrimp bolts into the open, moving faster than expected. I snap a shot as it disappears behind the gill folds. Glancing down, my camera display shows a fuzzy tail shot. Before I can chastise myself for allowing my mind to wander, the shrimp reappears, making the first of several passes over a white, sun-bright background before disappearing for good. I straighten up, snowblind and blinking. Yan, patiently hovering off to my left, gives a thumbs up.

Later, my downloaded images reveal that somehow I photographed not only the brawny female but also the smaller male. With this unexpected success, Yan and I become as quixotic about photographing clam shrimp as Larry had been about his giant clam. The next afternoon we locate a second shrimp species living inside the smaller, closely related giant clam.

This blue-speckled beauty is a dream to work with, repeatedly posing as if it wants its portrait taken. The other critter hunters aboard are now into the game, but a dozen eyes inspecting 10 dozen clams over the remainder of the trip turn up nary another shrimp. AD

EXERCISES TO REDUCE AND PREVENT KNEE PAIN

By Jessica B. Adams, Ph.D.,
and Jaime B. Adams, M.S.
Photos by Stephen Frink

You rely on your knees for most of your daily activities, and this use adds up over time. Simply walking up stairs, for example, increases the pressure on your knees by up to four times your body weight. Knee pain can cause discomfort when climbing a ladder, doing a frog kick or just standing up in full gear. It is important to keep your knees healthy to reduce the chances of knee pain negatively affecting your diving.

Proper maintenance, including stretching, strengthening and mobility exercises, can facilitate movement and alleviate pain. The same training principles apply to people recovering from minor knee discomfort and those seeking to prevent knee pain.

Remember, it took your lifetime to get to this point with your knees. So take it slow, and always listen to your body. If an exercise hurts, stop. The pain could be because of improper form, which you can correct, but there may be an underlying cause.

Knee pain can have a variety of causes, so if you have pain consult your doctor or physical therapist to determine if these exercises are right for you.

In the age of technology, society as a whole suffers from weak butts. Weak glutes put more stress on the knees and ankles. Weak abs promote an exaggerated lower back curve that causes knees to roll inward. A strong core promotes healthy spinal alignment, reducing stress on your knees.

The following exercises target your glutes and core. Complete one set of each exercise initially, and progress up to three sets of each. Allow at least one day of rest after performing these exercises before trying them again.

BENT-LEG KICKBACKS

1. Get on all fours on a soft surface, with your knees under your hips and your wrists under your shoulders (table-top position).
2. Lift one leg behind you while keeping your knee bent.
3. Lower the leg to just before your knee touches the ground, and repeat.
4. Complete 10-20 repetitions, and switch legs.

STRAIGHT-LEG CROSSOVERS

1. Start in table-top position.
2. Extend one leg (hip and knee) straight behind you; this is the leg you will be working first.

3. Lift the leg as high as you can, and cross it laterally over your foot on the ground.
4. Lift the leg as high as you can, and return it back over your foot to the position in step two.
5. Complete 5-20 repetitions, and switch legs.

Tips:

1. *Maintain tight abdominals to keep your trunk in a table-top position.*
2. *Fold a mat or towel under your knees and/or the palms of your hands to alleviate pressure as needed.*

Challenge: Try to hold the highest position of each repetition for 2-3 seconds.

Unfortunately, as we age we lose flexibility. Reduced flexibility has a direct impact on mobility and can lead to knee pain. Fortunately, this is reversible.

It is important to stretch the muscles surrounding your knee every day, if possible. You can stretch the muscles that support the front, back and sides of your knees. The most common sources of tightness, and therefore pain, are on the lateral side (outside) and back of the knee.

The following exercises stretch the muscles surrounding your knee and can (should) be done every day.

STRAP HAMSTRING STRETCH

1. Lie on your back with a towel, strap, belt or rope.
2. Place the strap around the arch of your foot, and hold one end in each hand.
3. Pull your foot as high as possible, and hold for 20-30 seconds.
4. See if you can pull a little farther, and hold for another 10 seconds.

STRAP ILIOTIBIAL (IT) BAND STRETCH

1. Lie on your back with a towel, strap, belt or rope.
2. Place the strap around the arch of your foot, and hold one end in each hand.
3. Pull that foot across your body as far as possible, and hold for 20-30 seconds.

STRAP ADDUCTOR STRETCH

1. Lie on your back with a towel, strap, belt or rope.
2. Place the strap around the arch of your foot, and hold one end in each hand.
3. Pull the same foot away from your body as far as possible, and hold for 20-30 seconds.

Tip: Try to keep both hips on the ground. This is particularly important during the IT band and adductor stretches.

Challenge: Move the strap closer to your toes, and you will feel the stretch more in your calves. 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.

LOOE KEY

A FLORIDA KEYS GEM

Text and photos by Jim and Deb Garber

After a week of diving Florida's Upper Keys in rough conditions, we were encouraged by a forecast of diminishing winds and calming seas. The timing was perfect for a drive south through Marathon and over the Seven Mile Bridge past Bahia Honda State Park and on to Big Pine Key. The turquoise water and blue skies there are endless, and life slows to a true Keys pace.

Colorful sponges and corals adorn the *Adolphus Busch Sr.*, one of nine wrecks in the Florida Keys Wreck Trek.

The following morning we took a 30-minute boat ride south to Looe Key. As the first boat there, we had our choice of moorings and selected one at the west end of the reef. We were amazed by the conditions and initial sightings — a passing reef shark, a resident 400-pound goliath grouper in the shade under the boat and 90- to 100-foot visibility. It was a great start to some of the best diving we've had in the Florida Keys.

Looe Key is a spur-and-groove reef with coral fingers that extend out to sea, separated by white-sand channels. Located 6 miles offshore of Big Pine Key and Ramrod Key, Looe Key is entirely submerged; the depth ranges from 7 feet to 30 feet. The reef is shallow, but that doesn't preclude visits from large marine life such as reef sharks, spotted eagle rays, goliath groupers and big barracuda.

Looe Key became a National Marine Sanctuary in 1981, following in the footsteps of the Key Largo National Marine Sanctuary that was established in 1975. Both areas were incorporated into the Florida Keys National Marine Sanctuary, which was designated in 1990. The Looe Key Existing Management Area covers 5.3 square nautical miles and includes the Looe Key Sanctuary Preservation Area (SPA) and the Looe Key Special-Use Research-Only Area. The sanctuary designation restricts spearfishing, lobster harvest and tropical fish collection and provides other protections for the reef. The research-only area is off limits to the public, giving scientists a controlled setting for studying the impacts of environmental change compared to those of human use.

Good visibility is never guaranteed, but conditions were nothing short of spectacular during our visit. The reef's coral fingers make navigating the site easy. The shallows are covered in fan and soft corals that undulate in synchronized movement with the surge. In deeper areas are stands of elkhorn corals shading schools of French grunts. These delicate, endangered corals are susceptible to disease and temperature stress. Corals thrive in a narrow temperature range, and coral bleaching can occur with sustained temperatures outside this range. Shallow reefs around the world, including Looe Key and others in the Florida Keys, are particularly susceptible to warming from higher ambient temperatures. We found transplanted nursery-grown staghorn corals along with star, brain and fire corals as well as small but pristine pillar corals.

The reef is home to more than 150 species of fish. Grouper, parrotfish and hogfish are frequent customers at the plentiful cleaning stations. Abundant schools of sergeant majors, Atlantic spadefish, horse-eye jacks and midnight parrotfish pass through the reef. The inhabitants seem accustomed to divers, which is one of the pleasures of diving a marine protected area. The highlight of the day was a trio of spotted eagle rays that soared majestically just above the coral.

We finished the day with a snorkel trip to American Shoal Lighthouse. The 109-foot-tall lighthouse, completed in 1880, sits in the middle of the sanctuary. Offshore of Sugarloaf Key, American Shoal stands in 5 feet of water and was the last of six lighthouses constructed in the Florida Keys to warn mariners of dangerously shallow reefs. The local birds, now the sole residents, aggregate on the structure to dry their wings in the sea breezes. In the flat sand and rubble beneath the lighthouse are the usual suspects: barracuda and

Clockwise from upper left: **Divers are often greeted by large goliath groupers waiting in the shade of dive boats. Large marine life such as reef sharks are frequent visitors to Looe Key, even in the shallows. A midnight parrotfish exits a cleaning station nestled in pillar coral. Schools of grunts huddle beneath large stands of elkhorn coral.**

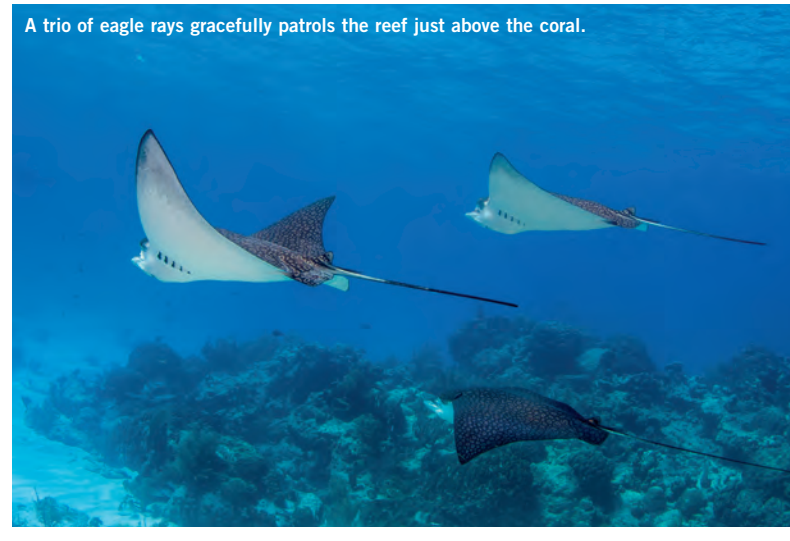
small schools of grunts, snapper and sergeant majors.

For our next trip to Looe Key we decided on a private charter to explore the deeper areas of the reef and the wreck of the freighter *Adolphus Busch*, which was sunk in 1998 between Looe Key Reef and American Shoal. The ship was sunk within the Florida Keys National Marine Sanctuary, so explosives were not used because the concussion might harm marine life. Instead 12 holes were cut in the ship above the waterline, and water was pumped into the hull. The 210-foot-long ship slipped beneath the waves on Dec. 5, perfectly upright at 110 feet. Adolphus Bush IV, an avid diver and great-grandson of one of the founders of Anheuser-Busch, donated $200,000 to help purchase, prep and sink the vessel, which was then known as the *Ocean Alley*. The ship was rechristened the *Adolphus Busch Sr.* and is part of the Florida Keys Wreck Trek, a series of nine wrecks from Key Largo to Key West.

Conditions were again excellent, with water so clear we could see almost the entire ship from the mooring ball. We had the *Busch* to ourselves, and the descent down the mooring line was easy with very little current. The marine life was timid, and the three resident goliath groupers kept their distance, watching us cautiously. A school of barracuda eyed us intently as we got nearer to the wreck. A school of permit patrolled the wheelhouse at around 70 feet. Two lionfish declared themselves captain and first mate and were two of only a few of that invasive species that we saw on all our dives. In summer the wreck is thick with silversides as warmer Gulf Stream waters move closer. Moray eels, lemon sharks and schools of grunts and snappers frequent the site. The vibrant colors of the corals and sponges were muted somewhat by a layer of silt covering the wreck.

The deep reef area has flat, gently sloping terrain in depths from 50-100 feet. Currents can be strong at depth. Two reef sharks greeted us, while angelfish, schools of grunts and Atlantic spadefish swam among the soft corals and large barrel sponges.

Our final dive of the day was at the eastern end of Looe Key, an area where the reef is more dramatic with steeper coral formations and more pronounced ledges. Barracuda were plentiful, large rainbow parrotfish chomped on the coral, and schools of gray snapper and yellowtail were abundant. This reef was absolutely stunning in the late-afternoon light.


A trio of eagle rays gracefully patrols the reef just above the coral.

HOW TO DIVE IT

Getting There

Big Pine Key is 26 miles north from Key West International Airport and 20 miles south of Florida Keys Marathon Airport. Shuttle buses, taxis and car rentals are available at both airports. As is typical throughout the Florida Keys, most air arrivals connect through Miami International (MIA) 133 miles to the north. Flying into Miami allows diving in other Keys spots along the way southward. If you have the time, they have the dive diversity. Dive operators leave for Looe Key from Big Pine and Ramrod keys.

Conditions

Diving is year-round, though the summer features calmer seas, warmer water and better visibility. The Keys have a subtropical weather bias — very warm in the summer and mild in the winter. Air temperatures range from 75°F to 80°F in winter and 85°F to 90°F in summer. Water temperatures range from a low of 72°F in winter to 85°F in summer.

Topside

The Lower Keys are home to the Florida Keys National Wildlife Refuges Complex, which encompass 410,000 acres of protected land and water. The complex comprises four refuges: Key West National Wildlife Refuge (NWR), Great White Heron NWR, Crocodile Lake NWR and National Key Deer Refuge.

The National Key Deer Refuge is the only habitat of Key deer. This is the smallest subspecies of the North American white-tailed deer and is federally listed as endangered. Most easily spotted on Big Pine Key at dawn or dusk, these animals are highly protected to ensure their survival in their natural habitat. Once almost extinct, they now number close to 1,000. Speed limits are aggressively enforced in Big Pine Key, specifically to protect Key deer from being killed by cars.

Bahia Honda State Park, often appearing on lists of the top-10 beaches in the U.S., is 12 miles south of Marathon. The 524-acre park offers boating, camping, kayaking, fishing and snorkeling trips to Looe Key. The sun setting behind the pilings of the abandoned Bahia Honda Rail Bridge, a remnant of Henry Flagler's "Railroad that Went to Sea" (the Florida East Coast Railway Key West Extension), is a treasured and iconic Keys visual.

A few days later we dived with one of the local dive operators. Unfortunately, the beautiful conditions we'd experienced earlier had deteriorated, and visibility was only 30-40 feet. The dives were still enjoyable, and we explored beyond the tips of the coral fingers in the flat sandy areas thick with giant barrel sponges and were fortunate to witness the wondrous display of spawning sponges. This spawning may have contributed to the diminished water clarity, but it was inspirational to observe the fecundity of the sea. Our return to shore was a special treat, as we enjoyed a close encounter with a large pod of bottlenose dolphins joyously surfing our stern wake.

Visitors to the Florida Keys should not miss Looe Key. A scenic hour-and-a-half-long drive south from Key Largo or a half-hour drive north from Key West will bring you to this Lower Keys paradise where there are dives appropriate for all skill levels. The shallow reefs and bright white sands provide wonderful lighting for underwater photography, and the lovely corals and plentiful marine life will beguile divers and snorkelers alike. It's almost certain you'll be welcomed by one of the large resident goliath groupers, a success story in marine conservation. AD

In regions where temperatures remain warm and nutrients are plentiful year-round, species can become specialists, which leads to the abundance of symbiosis that can be observed on tropical reefs. In addition to water temperature and nutrient availability, geography, climate, plate tectonics, habitat variety and oceanic current circulation also influence the wild array and distribution of underwater life.

MARINE BIOGEOGRAPHY

Text and photo by Ethan Daniels

More marine organisms live on Indo-West Pacific (IWP) reefs than anywhere else on Earth. The IWP region covers a significant portion of the planet's surface, ranging from the shores of eastern Africa across the Indian Ocean, the Andaman Sea, the Philippine Sea and much of the tropical Pacific. Within this immense zone lies a unique hub called the Indo-Malayan Triangle, also known as the Coral Triangle. Covering 2 million square miles of ocean, the Coral Triangle includes the diving utopias of the Philippines, Indonesia, Malaysia, New Guinea and the Solomon Islands, and it's where underwater biological diversity reaches its zenith.

Divers travel the globe to submerge in places such as the clear and colorful Caribbean, New England's shark-filled seas, the eastern Pacific's sinuous kelp forests and the dazzling reefs of the Coral Triangle. Each body of water, each coast and each island, no matter where in the world it lies, has its own particular community of life. This diversity keeps divers roaming from one destination to the next. But what underlies regional differences in marine biodiversity? And why does the Coral Triangle support so much underwater life compared to any other place on Earth?

SOMEWHERE WARM

For millennia, warm waters have bathed the Coral Triangle's flourishing reefs with virtually no seasonal temperature variation. Warmth and just the right amount of nutrients allow corals to effectively outcompete algae for space and sunlight, thus providing shelter for innumerable fish and invertebrates. Sea temperature is a major reason for latitudinal variation in diversity of marine life. There is longitudinal variation as well; marine life is generally more concentrated on the western sides of both the Atlantic and Pacific Oceans. In a nutshell, this has to do with oceanic current circulation. Cold, nutrient-filled upwellings generally occur on the eastern sides of these bodies of water, while the western sides have fairly clear, balmy waters.

In temperate seas, where algae outgrow corals, organisms must be able to handle seasonal swings in temperature and food sources. Temperate and polar species tend to be ecological generalists, while tropical species can become specialists due to constant temperatures, primary production and plentiful food. Specialization in the tropics leads to a profusion of symbioses. A dive on any healthy IWP reef will reveal dozens of commensal associations: anemonefish living with host anemones, shrimp and gobies, squat lobsters dependent on crinoids for food and shelter, cleaner wrasse ridding fishes of parasites, remoras hitching rides on sharks, and the list goes on.

A CHANGING SEASCAPE

Another factor underpinning the mind-boggling diversity of life in the Coral Triangle lies deep in the past, when sharks were much larger and humans were just a twinkle in the eyes of our primate ancestors. The land and seascape of the Coral Triangle looked very different 50 million years ago, when what are now islands of the southern Philippines, Indonesia, Malaysia and New Guinea were more widely spread across four different tectonic plates. Since that time the Pacific, Indian-Australian, Philippine and Eurasian plates have been thrust together, forming the convoluted conglomeration of thousands of islands and reefs that is the Coral Triangle. Fish and invertebrates that evolved in separate habitats, originally far from one another, have amassed in what is known as a biogeographic sink. The great number and diversity of marine habitats and environmental conditions make for an area that attracts species.

The Coral Triangle can be viewed not only as a place where species have aggregated but also as a source of marine biodiversity. Some marine biologists point to evidence that the Coral Triangle is where many reef species originated before proliferating across the planet's seas.

"Concepts of the Indo-Malayan area as a cradle of diversification or as a museum for species that originated elsewhere are not mutually exclusive propositions," said Gustav Paulay, Ph.D., of the Florida Museum of Natural History, "nor are they the only ones."

While the Earth's tectonic plates have been in constant movement, sea levels have risen and fallen during periods of cooling and warming, forming and razing barriers to fish and invertebrate dispersal through the oceans. When sea levels fall, these intermittent barriers, such as land bridges between islands, ultimately lead to new species evolving through what is known as allopatric speciation. This is the most common means of species creation; it occurs when a population that is geographically separated and genetically isolated from its ancestors eventually adapts to its slightly different environment due to random beneficial genetic mutations that arise in the course of sexual reproduction. This process explains how one

fish or invertebrate might evolve into two or more species over time. As sea levels rise and land barriers are once again covered with water, expanding marine habitats allow the now genetically dissimilar populations to mix again. Thus, climatic events in combination with tectonic movements have caused previously isolated species to evolve, congregate in and disperse from the Coral Triangle.

HABITATS AND NICHES

Geography, climate, plate tectonics, recurring ice ages and oceanic current circulation play large roles in species' aggregation in and dispersal from given regions, but another vital factor in determining a place's biomass and biodiversity is the number of habitats and niches available. The more habitats and niches, the more species an area will have. For example, the cold, coastal waters of Cape Cod, Mass., offer few habitat differences, while the seascape among the islands of Indonesia offers many. Flooded by daily tides, extensive mangrove forests support juvenile fishes. Seagrass meadows also act as nurseries for a large number of reef dwellers. Nearby lagoons offer protected patch reefs as habitats for large reef fishes. The three-dimensional, honeycomb structure of barrier reefs adds even more niches.

VARIETY, NOVELTY AND ADVENTURE

Marine biogeography — the wild array and distribution of underwater life — is a vital ingredient in making recreational diving the adventure that it is. Each time divers venture beneath the surface, no matter where in the world, they have the opportunity to observe a creature, a behavior or a relationship that they never seen — and perhaps one that no one has ever seen. It is now estimated that there are roughly 8.7 million species on Earth. Somewhere between 35,000 and 60,000 reef dwellers have been described to science, including many, but certainly not all, shallow-water fish and invertebrates. At present, about 76 percent of the world's coral species and 37 percent of all reef fishes, an estimated 3,000 species in all, flourish within the Coral Triangle. Beyond simply keeping divers fascinated, this biodiversity is a vital cog in the interconnected ecosystems of planet Earth. Every species and individual plays a role, and humans cannot separate themselves from this interconnectedness.

"Our understanding of the origin of diversity and distributional patterns in the Indo-West Pacific is still rudimentary," Paulay said. So far it has been impossible to unravel the mysteries and explain all the reasons underlying coral reef life. Besides a handful of well-studied fish and invertebrates, most coral reef dwellers are not well understood because of the difficulties in studying them. It is clear no single explanation for the distribution of plants and animals will suffice — a variety of complicated processes are at work, and they create a plethora of unique diving situations around the world.

One of the most captivating aspects of this planet is that life, which is constantly and continually evolving, is unevenly distributed. The observable variability of species that inhabit each diving destination is what drives recreational diving around the world. It's a big part of what keeps divers enduring long travels across the globe — the will to be in the midst of flourishing and ever-evolving life, discovering just a bit more about the unknown, no matter how far we must go. AD

RESEARCH EDUCATION MEDICINE

With a largely transparent body interspersed with opaque white muscle lines, the *Melibe colemani* nudibranch is very difficult to spot among the soft corals on which it resides. When it feeds, it expands its massive mouth as if casting a net, nearly doubling its size. This one was seen in Anilao, Philippines.

MIKE BARTICK

JILL HEINERTH

A hyperbaric doctor examines tech diver Jeff Shirk using 3-D ultrasound. Earlier in the day Shirk experienced a serious case of acute immersion pulmonary edema during a dive

Research and Outreach

By Jill Heinerth

"Your research saves lives, and your outreach efforts inform an entire community about safe diving practices," I recently wrote to DAN® research director Neal Pollock, Ph.D. I penned the letter after a long day in Newfoundland, Canada, that began with a stunning dive on a World War II shipwreck and ended with a friend taking an ambulance ride to the Health Sciences Center in St. John's.

DAN had been there for me before in the most classic sense. More than 15 years ago I was hit with a case of decompression illness (DCI) while exploring new cave passages in Mexico at a now famous site called The Pit. With assistance from DAN, I received a necessary hyperbaric chamber treatment and all the requisite follow-up care. But this time it was DAN's research and educational outreach that made the difference for my diving group. Both Pollock and hyperbaric medicine researcher Stefanie Martina had been filling my inbox with informative medical articles since we worked together on an expedition a few months earlier. In Pollock's words, "Data we gather on these projects is important, but our opportunity for outreach is priceless."

When my diving friend motioned for help beside our boat in Conception Bay, Newfoundland, the entire crew and our group of seasoned divers leapt into action. He was gasping for breath with a rattling gurgle, pulling at his neck seal, desperately trying to say, "I can't breathe!"

Within minutes, we had the victim, a very experienced technical diver, seated on deck and were removing his drysuit and dive gear. He coughed bloody froth into a bucket while we provided oxygen and supportive care.

Some might have guessed this was an embolism or "chokes," and others might have passed it off as an event of uncharacteristic panic, but knowing that this accomplished veteran had managed to suffer through 17 agonizing minutes of decompression and ascend at a normal rate led me to conclude that he

"Data we gather on these projects is important, but our opportunity for outreach is priceless."

was experiencing a little known malady I had recently read about and had witnessed before. His rapid improvement further corroborated my theory that he was experiencing immersion pulmonary edema (IPE).

IPE, which is abnormal leakage of fluid from the bloodstream into the alveoli during immersion, can occur in anyone immersed in water, even swimmers. The injured swimmer or diver develops a cough, has difficulty breathing, develops raspy breathing and often spits up frothy, blood-tinged liquid from the lungs. The symptoms may suddenly become acute when the person surfaces, because this represents the point of greatest ambient pressure differential between the mouth and the chest.

IPE has been reported in healthy, young individuals such as triathletes and combat swimmers as well as across the entire spectrum of the diving community, including people with reported heart and lung conditions. The onset may be very rapid or may develop over time and can even worsen over the course of daily, repeated immersion. During immersion, especially in cold water, blood is redistributed from the extremities to the lungs. When the victim is no longer in the water this edema gradually subsides.

When a diver or swimmer has difficulty breathing, they may panic, aspirate water and possibly drown. A diver may skip decompression obligations or ascend rapidly and experience additional barotrauma. For this reason, and because the symptoms can resolve rapidly once the diver is out of the water (often before reaching the dock or hospital), this phenomenon may be underreported and often misdiagnosed. Whether considered a panic attack or a result of ill-fitting or malfunctioning gear, cases of IPE may be completely overlooked. Despite the fact that our boat included safety officers, first responders, dive instructors and other experts, few of them had ever heard of IPE.

Studies have revealed that several external factors, including cold water, exercise and high work of breathing, may create the perfect IPE scenario. Numerous internal factors, such as hypertension, other cardiac issues, cardiovascular disease and excessive hydration, may also increase the likelihood of experiencing IPE. Some people seem to be susceptible to IPE; these people include, surprisingly, elite athletes as well as people with known cardiac and pulmonary issues.

IPE is diagnosed by exclusion (ruling out other possibilities), so it is vital that anyone experiencing symptoms seeks immediate medical attention. Other conditions that could cause similar symptoms, such as a heart attack or DCI, need to be considered first. Hyperbaric treatment is not needed for IPE, and symptoms generally resolve completely in 24-48 hours. Follow-up care involves medical assessment by a physician (one trained in dive medicine, if possible) who can rule out any other issues that need addressing and look for conditions that may contribute to future IPE susceptibility before recommending a return to diving.

I'm happy to report that within six hours of the emergency's onset, our victim transitioned from his dive accident to socializing with friends at the end of a long day. In between was an evacuation, an ambulance ride, an emergency room assessment, tests and a visit with a hyperbaric specialist. It was great to have a good ending to this very serious event, being in the company of good dive buddies, who all played an important role in our friend's rescue and treatment.

Another positive aspect of this experience was the realization that we were properly prepared to handle a diving emergency. The boat crew were well trained and equipped with oxygen and first-aid equipment. Rescuers stayed calm and levelheaded, as did the victim, who got himself safely to the surface without missing his decompression obligations or making a rapid ascent.

This incident highlights the importance of training, diving research and education. It is foolish, in my experienced opinion, to dive without DAN dive accident insurance; even if you never use it, you will be supporting important work that helps our community better understand and mitigate diving risks. AD

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The Logistics of Exploration

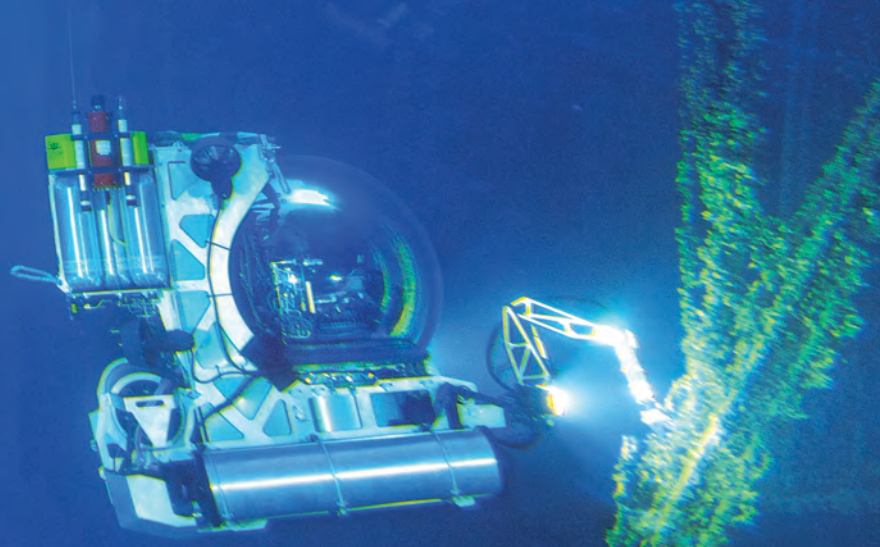
PREPARATION AND PROTOCOLS FOR A DEEP WRECK EXPEDITION

Text and photos by Leigh Bishop

Modern technology brings enhanced opportunities for exploring shipwrecks. But deep wreck expeditions are complex undertakings that require a team of technical divers prepared to work with literally tons of advanced equipment both underwater and topside. The 2016 centenary dives on the *Britannic* involved divers working alongside submersibles and remotely operated vehicles (ROVs) at great depths.

Compounding the need to employ specialized equipment and detailed operational protocols was the filming of the expedition for both a BBC television special and a big-budget Russian documentary to be distributed globally.

Conducting deep ocean dives with free-swimming technical divers has long been the subject of controversy. Members of the commercial diving industry deemed the 1994 *Lusitania* dives by Starfish Enterprise, a British deep wreck diving team of the 1990s with whom I did my first dives on the *Britannic*, unsafe due to a lack of diver safety protocols and the absence of an onsite recompression chamber. The 2016 *Britannic* endeavour was characterized by careful planning, substantial collaboration and detailed safety protocols.



A submersible uses its powerful lights to illuminate the wreck of the *Britannic*, which sank in the Agean Sea on Nov. 21, 1916 — 100 years ago.

LEADERSHIP

Americans Richie Kohler and Evan Kovacs, in conjunction with a group of Russian divers, planned to take deep wreck exploration to a new level. They had made a single checkout dive the year before with the intention of conducting a significant project with the Russians in 2016. Their diver support and safety plan restored my confidence in the complicated endeavor of deep mixed-gas rebreather diving, which had been shaken by the death of my friend Carl Spencer on the *Britannic* in 2009.

EQUIPMENT AND OPERATIONS

A key safety feature of the dive operations was a commercial wet diving bell. A 70-page standard operating procedure (SOP) document outlined the expedition's safety protocols.

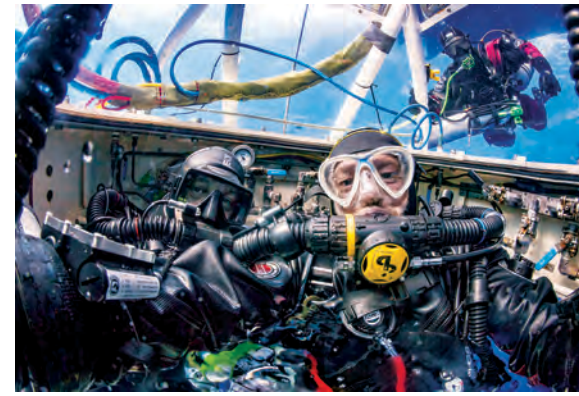
Only four divers would be in the water on dive days, each using his own choice of rebreather with a team-chosen diluent of 9/73 trimix. An emergency bailout profile would be based on a carried three-gas protocol: 13/60 trimix, 20/30 trimix and 100 percent oxygen**.** All other gas would be in the diving bell, the main point of bailout at depth.

Diving-bell operations would be predicated by the surface vessel maintaining a three-point mooring position to keep the bell on station. In the case of a lost mooring or a drastic shift in weather conditions during the 45-plus-minute bottom phase, the diving bell could shift from its position above the wreck to beyond where the divers could see it. Protocols for this scenario would be supported by ROVs and submersibles that oversaw and maintained contact with the dive team — the submersible pilots would direct the divers to an off-station diving bell in mid-water, out of sight of divers on the wreck.

Because the diving bell was a critical element of the safety protocols, the team had to become familiar with all aspects of its operation. Each exploration diver would have to understand oxygen partial pressure (PO_2) calibration and venting, verbal and light communications, buoyancy adjustments, onboard and surface-supplied emergency open-circuit gas, bell master responsibilities and management of an unconscious diver.

One nominated diver would be the dedicated bell master for the dive and communicate with both the dive team and the topside crew. The bell master would confirm each diver was clear to ascend and move the bell only when the slowest profile had cleared the stop.

Any diver ascending into the open bell at depth had to confirm the PO_2 was within the acceptable range before going off his loop (rebreather) and breathing in the atmosphere of the bell. At the maximum depth of the bell (about 300 feet) the atmosphere in the bell would be hyperoxic with a PO_2 in excess of 2.0.



The 2016 *Britannic* expedition employed a commercial wet diving bell for decompression and emergencies. This was only the second noncommercial civilian expedition in history to use a diving bell.

Although the vent gas was air, the PO_2 in the bell could be dropped by venting bailout gas into the bell or having the topside crew pump down bottom gas. With time spent in the bell, exhaled gas from a diver's loop would require a venting phase to prevent changes in buoyancy. In rough seas, buoyancy adjustments could also be used to eliminate the hard recoil of the cables if the bell began bouncing with the ocean.

All diving operations were conducted under the watchful eye of the topside control center via the ROV. Should anyone actually get lost on the wreck, the submersible pilots could simply hold up a directional sign with one hand while eating a sandwich with the other.

EMERGENCY PROCEDURES

For the team of technical divers, using a bell was a new approach to a mixed-gas project. Many emergency scenarios had to be considered and factored into the SOP, including central nervous system oxygen toxicity, air embolism and loss of consciousness. An unconscious diver drill was conducted topside to provide practice securing a diver in the bell with a ratchet strap, maintaining an open airway and performing chest compressions.

In the scenario a diver "found unconscious" at depth was quickly placed inside the bell and strapped against the bulkhead with his head above water. The rescue divers cut away his equipment and secured him. The bell master communicated the mock emergency to the surface and followed the directions of the topside hyperbaric doctor. As directed, the dive team took turns maintaining an airway and performing chest compressions. The rescue divers remained on their loops in the bell, and the topside crew regulated the atmosphere in the bell for the injured diver.

The plan dictated that an injured diver should ascend with the dive team's decompression schedule until the topside team determined they should lift the injured diver out of the water. A support diver would descend to the

bell and take over doing compressions and maintaining an open airway, while the dive team transitioned to the ROV downline. The bell, along with a support diver, would be lifted out of the water and the injured diver treated, after which the bell would be returned to the water for the remaining dive team's decompression phase.

Further protocols covered separated- and lost-diver scenarios as well as out-of-gas emergencies. When in doubt, all a diver had to do in an emergency was swim back to the bell, which would be located just above the wreck.

The bell was loaded with built-in cylinders filled with the gases required for the dive. Each cylinder was equipped with multiple regulators on long hoses. Additional cylinders of deep and intermediate gas mixes were also available.

ALGORITHM SELECTION

Because of the very strong surface currents that can occur over the *Britannic*, decompression model safety factors were considered, and the best protocol was determined to be one that would promote completion of as much decompression as possible at deeper depths where the currents would not be as strong. Thus we were on the hunt for bubble-based deep-stop protocols. The varying permeability model (VPM-B) and reduced gradient bubble model (RGBM) algorithms used to dictate the deep stops on previous expeditions were configured with a 10 percent increase in the "nominal" critical radii of helium and nitrogen bubbles. These models generated an initial ascent rate and a deep-stop profile fairly close to a Bühlmann model with a low gradient factor (e.g., 5 percent). Since these models were based on real bubble mechanics and not fudged to Bühlmann, we figured them to be physiologically better. As a sensibility check we compared the total run times of these profiles and found them to be fairly similar to those generated using the Drogon Dive Planner (DDPLAN) with 5/85 gradient factors, which had been used reasonably successfully on previous deep projects.

With rebreather scrubber durations taken into consideration, run times were capped at 40-50 minutes. Both the Inspiration and JJ scrubbers had been shown to be good for at least five hours on deep warm-water dives, due to their efficiency in warm water in conjunction with the divers' work rate, which was very low except during the first 30-40 minutes on the bottom.

THE EXPEDITION

At the end of an exciting and successful expedition, on our last day of diving I joined three other divers — Italian Edoardo Pavia, American Michael C. Barnette and fellow Brit Richard Stevenson — for a tour around the wreck in a single dive. The visibility was in excess of 150 feet as we cruised the decks of the massive liner using lithium-powered Suex diver propulsion vehicles. We passed by open and covered promenade decks, under huge lifeboat davits silhouetted above us by the midday sun and over the seabed debris field to a maximum depth of almost 400 feet. We passed the three monster propellers and cruised along the stern veranda café. Each scene was truly breathtaking.

The dive team explores the *Britannic*'s propeller, helpfully lit by the expedition's two submersibles.

Watching from the best seat in the house, Richie Kohler followed us in the Triton 3300/3 submersible alongside pilot Dmitry Tomashov, while Russian cinematographer Sergey Machilskiy caught every frame of our journey using Red Epic 5K cameras. Circumnavigating the *Britannic* during its centenary year surrounded by such incredible technology was without a doubt the greatest dive of my life.

Tomashov's father, Evgeny, skillfully maneuvered his unique, specially built one-man minimal-displacement submersible into various positions, lighting up scenes such as the propellers and bow. It was like we had dived into a science fiction movie, but as Kohler remarked as he climbed from the submersible hatch hours later, "Science fiction? No, I think you will find, Leigh, that dive you just made was science fact." AD

NEAL POLLOCK

David Doolette visits the hyperbaric facilities at the Swedish Armed Forces Diving and Naval Medicine Centre.

David Doolette

By Petar Denoble, M.D., D.Sc.

A research physiologist in the biomedical research department at the U.S. Navy Experimental Diving Unit (NEDU) and an assistant professor in the anesthesiology department at Duke University School of Medicine, David J. Doolette, Ph.D., is also an advanced technical and cave diver, an educator and a public speaker. Well published in scientific journals, he has helped make significant advances in the science of diving for more than 20 years.

Born and educated in Australia, Doolette did his postdoctoral research on blood flow and the transport of gases, drugs and physiological substances to tissues and organs such as the brain, heart, lungs and muscles. He became an expert in modeling the effects of blood-flow changes and variations in substance-loading parameters, which is ideal for the study of gas transfer during compression and decompression. While researchers with these skills are in high demand in clinical physiology and pharmacology, Doolette made his way to diving physiology.

After he became a diver, Doolette wanted to apply his skills to the science of diving. Decompression illness (DCI) has various forms and degrees of severity, and diagnosis of DCI in field studies based on self-reporting is elusive. Doolette developed a tool to measure health status in divers and calibrated it to diagnose DCI. This tool was later used to study and improve safety for various groups of divers.

He published several studies modeling various aspects of saturation and desaturation before joining the team at the NEDU. Since then he has been in the vanguard of research and development of safe decompression procedures. We appreciate his willingness to tell us more about his work.

How and when did you become a diver?
I have always lived by the sea, and one high school I attended was very close to a rocky coastline, where I would regularly spend my lunch break snorkeling. One day I watched the bubble trails recede from two scuba divers in the water, and I thought, "I want to do that." In 1979 on the day I turned 16 years old (then the minimum age to learn scuba), I enrolled in a scuba course. I have been involved with diving, for work and play, ever since.

Why did you develop the health survey tool, and what does it do for decompression research?
In the early 1990s a diver-intensive fish-farming industry arose in South Australia. Bluefin tuna were caught at sea and transported to coastal pens, where they were fattened for the sashimi market. At first the industry employed divers with recreational training, and there were a large number of incidents of serious decompression sickness (DCS). I worked with Derek Craig, a diver and health and safety inspector, to characterize the decompression practices. I needed a standardized method for collecting postdive health-outcome information, particularly the symptoms of DCS, from a large number of divers in the field. The ideal method would be having medically trained personnel go into the field to monitor the divers. That was not practical, so I developed and validated the diver health survey, a one-page questionnaire used for self-reporting health status relevant to DCS.

The incidence of DCS in recreational diving is relatively low, and divers are surprised when it occurs because they and their buddies previously dived similar profiles many times without any problem. Could you tell us about variability of decompression outcomes and how that affects your research?
It is because of this question we are having this interview. In 1985 I had finished my undergraduate studies in physiology and was working as a scuba instructor. One day two friends and I were doing a wreck dive; it was a fairly deep air decompression dive, and afterward one of my buddies, who had done thousands of dives previously, developed DCS. That got me thinking, "Why him, and why that day?" and sparked my interest in DCS.

Similar dives may actually be different enough to have a different risk of DCS even if the depth/time profile is the same (which is unlikely outside of research settings). For instance, if divers work hard while at depth or are cold during decompression, their risk of DCS is greatly increased compared to being at rest and warm — as much as if they had doubled their bottom time. Even in a laboratory setting, however, where dives are conducted in a pressurized wet pot where the dive profile, breathing gas, water temperature and work performed can be identical for all practical purposes, we see variability in DCS outcome. In other words, identical dives with the same diver can result in DCS on some occasions and not others.

Since 2000 the Navy has conducted a number of experiments in which an individual dives the identical dive profile numerous times, sometimes resulting in DCS and sometimes not. That is clear evidence that an individual's susceptibility to DCS changes on a day-to-day basis. There are two important messages for divers: 1) Dives are not completely "safe" or "unsafe" — rather they have a higher or lower risk of DCS; and 2) having done similar dives in the past without incident is not a reason to discount DCS. Modern decompression science is concerned with measuring and predicting DCS risk.

How do dive computers handle the variability of decompression outcomes?
Dive computers and decompression tables handle the person-to-person, day-to-day variability in susceptibility to DCS by providing a choice of relatively conservative decompression guidance, so that most people on most days will be safe if they dive properly.

How should dive computers be evaluated in the development phase?
A dive computer should implement a decompression algorithm that has been subjected to human testing so that the DCS risk within the no-stop limits and decompression schedules is well characterized. The dive computer should then undergo validation testing to make sure it faithfully produces no-stop limits and


Doolette inspects a fossil in the Wakulla-Leon Sinks underwater cave system.
DAVID RHEA

decompression schedules exactly as intended. This is the approach taken by the U.S. Navy.

What should divers consider when choosing a dive computer?

Unfortunately recreational divers probably do not have many choices of dive computers that implement a decompression algorithm subjected to the same level of human testing as the U.S. Navy dive computer. I am not an expert on recreational dive computers, but I know many implement variants of the ZH-L16 (Bühlmann) decompression algorithm, and the human testing of ZH-L16 is well documented.

Deep stops have been of interest to the diving public — technical divers in particular. The disputes may not be settled yet, but your team contributed important evidence. Where do we stand regarding the efficacy of deep stops?

We need to consider three types of deep stops. First is the use of deeper than traditional safety stops for recreational no-stop dives, where the total dive time, including the safety stop, is less than accepted no-stop limits. These deep safety stops probably do no harm, but the evidence is conflicting as to whether they are of any benefit compared to traditional safety stops at 10-15 feet of seawater.

Second is the practice that was popular in the early days of technical diving of adding some brief, unscheduled decompression stops deeper than the first prescribed decompression stop and then recalculating (or letting the dive computer recalculate) the additional required decompression time. This will result in a longer total decompression time and, if the stops are not too deep, should be safer than the original schedule, but how much safer has never been rigorously tested.

The third type of deep stop is when a decompression algorithm is designed to redistribute time from shallow decompression stops to deep stops; in other words, compared to a conventional decompression schedule, there are additional deep stops but the total decompression time is the same (or shorter). The theoretical premise is that the deep stops result in fewer and smaller bubbles and so the resulting deep-stops schedule should have lower risk of DCS than a conventional schedule. There is now considerable experimental evidence that these types of deep-stops schedules do not impart a lower risk of DCS than conventional schedules.

How does body temperature affect decompression?

Being very warm on the bottom or being very cold during decompression increases the risk of DCS. Presumably this results from increased blood flow to superficial tissues and therefore faster uptake of inert gas when warm and, conversely, reduced blood flow and slower removal of inert gas when cold. This is probably not of great consequence for divers conducting no-stop dives and certainly not worth divers making themselves deliberately cold on the bottom and risking hyperthermia. For divers conducting decompression dives, however, it is worth considering. If a diver becomes very cold during decompression, the time required for decompression is increased. If divers have active heating, such as electrically heated drysuit undergarments, they should use these only enough to stay comfortable while on the bottom and conserve the battery to ensure they can use the heat during decompression.


JACKIE BOOTH

Doolette helps deploy equipment for dye-tracing the water flow in the Wakulla-Leon Sinks underwater cave system.

What should recreational divers do when dive conditions make them exert themselves more than usual?

Work on the bottom increases blood flow and results in faster uptake of inert gas. This will increase the risk of DCS for a no-stop dive. Recreational divers who exert themselves more than usual on the bottom should add some safety by ascending before they reach their no-stop limit.

We now have more ways to study the venous gas bubbles that may occur after diving. What are some of the tools and methods that allow this research?

Venous gas emboli (VGE), the bubbles that occur in the body's tissues, are transported by venous blood and can be detected in large veins or in the right side of the heart. The number of bubbles is commonly described semiquantitatively (i.e., by a grade on an ordinal scale). Many dives result in detectable VGE but do not result in DCS. VGE after a dive in no way indicates whether the diver will get DCS. In large compilations of experimental dives, however, there is a higher incidence of DCS among dives that resulted in high-grade VGE than in dives that resulted in low-grade VGE. This relationship leads people to use VGE as measure of

decompression stress (an index of DCS risk) in dives that do not necessarily result in DCS. This can produce useful information if VGE are the appropriate outcome measure, if the experiment is carefully designed and well executed, and if the results are thoughtfully interpreted.

VGE, however, are not the appropriate outcome measure for all experiments related to decompression. VGE are only meaningful if the experiment is testing an intervention that changes bubble formation and growth in tissue and thereby influences DCS risk. Examples are tests of decompression schedules, diver exertion and diver thermal status. VGE are not an appropriate outcome measure for interventions aimed "downstream" of bubble formation and growth — at the pathophysiological responses to bubbles. An example would be evaluation of methods of treating DCS.

VGE grades following identical dives are quite variable, both between divers and in the same diver on different occasions. Therefore, the VGE grade after a single dive in a single individual is not informative. Only after multiple repetitions of the same dive profile are VGE grades useful. The number of repetitions depends on the research question, but in my opinion there needs to be good justification for less than 20, and 50 would be preferable.

There are two common experimental designs. VGE might be used to validate a decompression table by evaluating selected schedules. Each schedule is dived at least 20 times and "fails" if more than half of the dives results in high-grade VGE; otherwise it "passes." A more common experimental design, and in my opinion the best use of VGE, is to compare two or more different decompression procedures. Each procedure is dived 50 times, and a significant difference in VGE grades indicates a difference in DCS risk.

There are many technical challenges in executing a good VGE study, but one very important consideration is the frequency and timing of VGE measurements after diving. The only validated index of "decompression stress" is the peak VGE grade measured after diving. This peak might occur any time from immediately after surfacing to several hours later. It is usually practical to measure VGE only periodically, so these measurements need to begin soon after surfacing and continue frequently for two or more hours.

One of many important considerations in interpreting results of VGE experiments is that while a significant difference in VGE grades between two procedures is evidence of a difference in DCS risk, it is not a reliable indicator of how large the difference is. Similarly, for many reasons, failure to find a difference in VGE grades between decompression procedures does not indicate there is no difference in risk of DCS. AD


MATÍAS NOCHETTO

Why Are Fewer Chambers Available for Emergencies?

By Marty McCafferty, EMT-P, DMT

As many health-care institutions face increasing pressure to control costs, the availability of hyperbaric chambers for dive emergencies has been greatly limited. Although there are approximately 1,375 hyperbaric chambers in the United States, only 130 accept patients on an emergency basis. In the U.S. there are only two chambers dedicated solely to divers; all others provide wound treatment.

With fewer hyperbaric facilities available for emergencies each year, those that are available have become overwhelmed by the burden of covering larger and larger geographic areas of responsibility. Emergency department physicians frequently contact DAN® to help them identify available chamber facilities to treat their most serious patients. It is not unusual to find that the closest facility cannot accept patients because the chamber is in use for another emergency treatment and unavailable, necessitating an expansion of the search range.

Compounding the problem is that some injured divers are turned away because of a misconception that divers need a level of care beyond what a facility can provide. In fact, divers are generally healthier and more stable than the average wound-care patient. Nor do injured divers need a chamber that can be pressurized to more than 2.8 ATA (60 feet of seawater), as is mistakenly believed by some health-care providers. The standard of care for the overwhelming majority of dive injuries is a U.S. Navy Treatment Table 6 (USN TT6). This treatment protocol does not exceed 2.8 ATA. Monoplace (single-occupant) chambers are capable of providing a USN TT6.

WHAT CHAMBERS TREAT

The Undersea and Hyperbaric Medical Society (UHMS) has approved the following conditions for treatment with hyperbaric oxygen therapy (HBOT). Insurance companies will not typically cover the cost of HBOT for conditions not on this list.

Acute/urgent indications:

- crush injuries
- compromised grafts and flaps
- central retinal artery occlusion
- acute peripheral artery occlusion
- severe anemia
- decompression sickness
- air or gas embolism
- burns
- carbon-monoxide poisoning
- idiopathic sudden sensorineural hearing loss
- necrotizing fasciitis
- gas gangrene
- intracranial abscess


JOE CLARK


MATIAS NOCHETTO

Less than 10 percent of the hyperbaric chambers in the U.S. will treat injured divers. Because of the costs of being available for emergencies on a 24/7 basis, every year fewer chambers are available for dive injuries.

Nonacute indications:

- select problem wounds
- delayed effects of radiation therapy
- chronic osteomyelitis

HOW CHAMBERS GET FUNDING

HBOT facilities most often treat nonacute indications. Because these indications are not as time-sensitive as the acute indications, patients can be scheduled and insurance coverage issues addressed in advance. These indications pay the bills of the hyperbaric centers, and payment for services is more predictable from these patients. Other factors beyond finances, however, affect a facility's ability to be available 24/7.

As recently as 10 years ago the majority of hyperbaric centers were located in or attached to a hospital, which meant that most patients requiring HBOT were treated at the hospital. Income generated by treating the scheduled patients provided enough financial support to allow the hospital to offer after-hours emergency hyperbaric care. This also facilitated comprehensive treatment of emergency patients who required access to ancillary services such as critical care, vascular surgery, neurology and other specialties.

Reimbursement of chamber facilities' costs by insurance companies and especially Medicare is the same whether the facility is available for emergencies or not. The costs of having staff on call 24/7/365 can be substantial. Accepting emergency and critical-care patients increases the potential liability risk to the facility and thus may increase liability insurance costs for the physician group and the hospital.

In recent years nonhospital-based clinics have dramatically increased, primarily due to an increase in the number of patients who can benefit from nonemergency HBOT. Patients in stable condition who require multiple scheduled treatments are likely to use facilities that are most convenient to them. This migration away from hospital-based chambers has reduced those chambers' ability to absorb the additional costs incurred by accepting emergency patients.

Several years ago one hospital-based hyperbaric facility announced publicly that it was planning to end its emergency HBOT services. In an average year it treated 10-15 acute patients. Compensation for these treatments came nowhere close to offsetting the costs incurred by being available 24/7/365. This is a reality that many facilities face. In this case, local divers organized themselves and were able to persuade the hospital to continue emergency services.

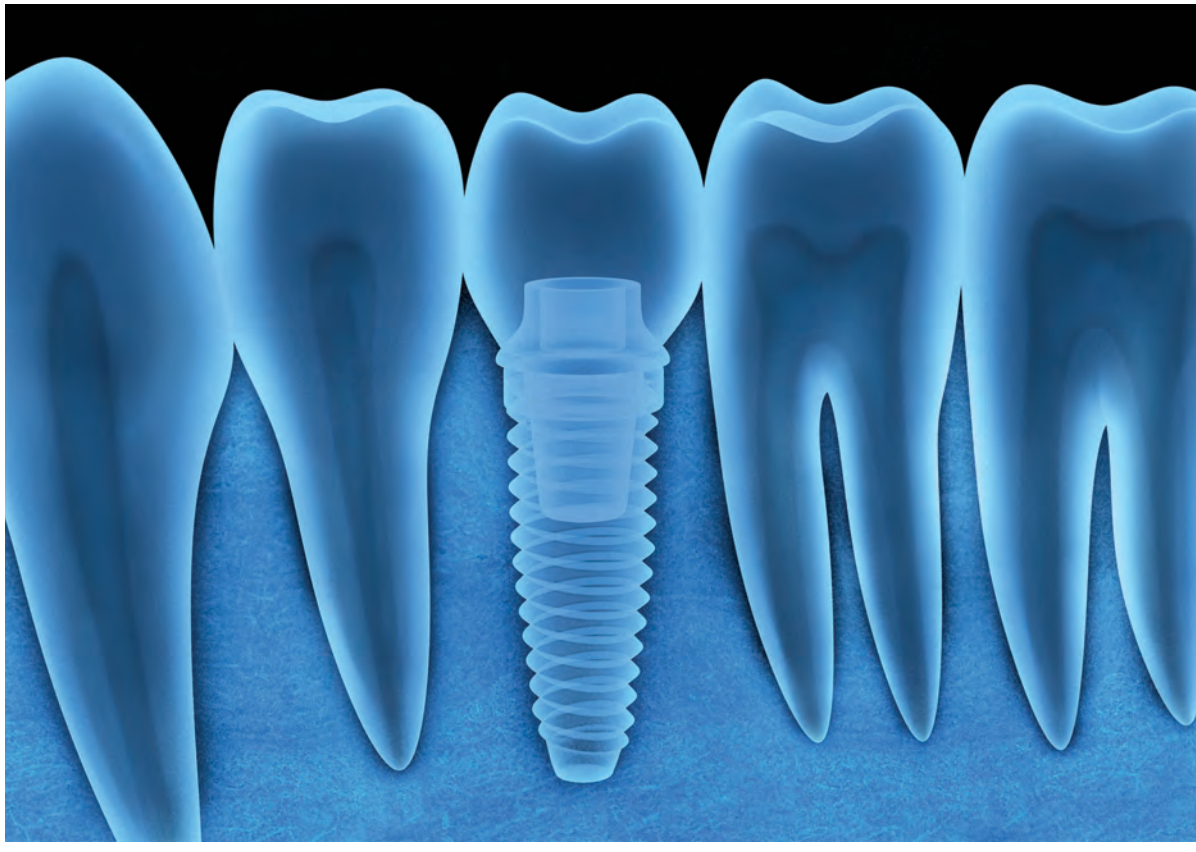
DAN AND UHMS

DAN continues to work with health-care professionals, including prehospital-care providers, to educate them about dive injuries and treatment. DAN also works continuously to stay up to date on each chamber's operational status and willingness and ability to provide emergency care. The UHMS, which promotes dive and hyperbaric medicine, is trying to find a solution to the current state of affairs. Some in the field are working with the appropriate government agencies to address potential reimbursement incentives and remove obstacles to encourage more emergency facilities. One proposal currently under consideration is having similarly capable facilities in a given area provide emergency care on a rotating basis to avoid placing undue strain on a single facility.

WHAT DIVERS CAN DO

The dive community can influence the availability of chamber facilities for dive emergencies. First, divers should make certain they have insurance that covers HBOT, whether through their primary medical insurance or with specific coverage such as a DAN dive accident insurance policy. A community of insured divers means that facilities providing care are more likely to be paid (an important consideration for hospital administrators as they work to keep their hospital solvent) and thus less reticent to treat injured divers.

Divers can also use social and news media to bring attention to the situation. We should, as a community, emphasize that the need for emergency HBOT is not only for divers but also for the other potential acute/urgent indications for HBOT as well. Acknowledgement of the serious financial challenges facilities face should help foster productive dialogue among care providers and local communities of divers, and cooperation among interested parties offers the best opportunity for a solution. AD



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Diving with Dental Implants

DAN MEDICS AND RESEARCHERS ANSWER YOUR QUESTIONS ABOUT DIVE MEDICINE.

Q. I'm going to see an oral surgeon next week for dental implants; will I ever be able to dive again?

A. A dental implant is a titanium post or frame that's surgically placed in the jawbone. An implant replaces a natural tooth root and provides a base for mounting replacement teeth or a bridge. There are multiple steps in the process of dental implantation, and each step has its own restrictions on diving. The steps can be completed simultaneously as a same-day implant or extended over time. Your dentist or oral surgeon is your best resource, but the following information may be helpful. In general, diving is not recommended until all healing is complete, the implant has had adequate integration time and the appropriate dental restoration is in place.

The initial step is extraction of a damaged tooth. At the time of the extraction, several things may happen. A bone matrix (bone graft) may be placed in the socket to provide a suitable site for the future implant. Placement of grafting material depends on the site in the jaw and the density and thickness of the surrounding bone. Alternatively, the tooth could be extracted and the socket allowed to heal naturally. Or the implant might be placed at the time of the extraction.

The placement of the implant is the most critical step. Your implant specialist will drill a precise hole into the bone and screw in a threaded titanium post. Following this procedure, you will need to avoid diving for an extended period to allow osseointegration of the implant.

Fusion of the titanium implant and the surrounding bone is crucial to success. Anything that interferes with this osseointegration, including micromovement of the implant, infection, etc., can cause the implant to fail. There is no specific research on dental implants and diving, and dentists' opinions about time out of the water vary. Some will suggest a minimum of three

months, while others advise six to 12 months before resuming diving (or other activities that put stress on the teeth). Please follow your dentist's recommendations about healing time. While some dentists may not know diving, they should have a recommendation about how long to avoid dental stress.

The final steps are relatively simple and will not appreciably affect diving. The inserted titanium implant is topped with a small post. The dentist will access the post and place the final appliance. This may be a crown, an anchoring point for a bridge or a similar reconstruction. If the osseointegration has already occurred, diving can generally be resumed after a few weeks to allow the gums to heal.

Once the final device or crown is in place, the implant can be treated like any other tooth. Keep it brushed and flossed, and it should serve you well. Consider a trial run in a pool to see how the bite wings of your regulator's mouthpiece fit the final reconstruction.

— Frances Smith, MS, DMT, EMT-P

Q: I have a student who has a neurostimulator for back pain. What exactly is a neurostimulator, and are there any implications for diving?

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A: Neurostimulators are surgically implanted devices that have some similarity to cardiac pacemakers. Used for chronic pain as well as other conditions ranging from gastrointestinal problems to Parkinson's disease, they are implanted under the skin and have leads (wires) that run from the device to the areas in need of stimulation. Neurostimulators used for chronic back pain are often placed in the abdomen or upper part of the buttocks, and the leads are placed in the epidural space near the spinal cord. As with other implanted electrical devices, there are some issues divers should consider relative to both the device itself and the underlying medical condition.

An important consideration relative to the device is the pressure rating. These particular devices are often rated only to an ambient pressure of 2 atmospheres absolute (33 feet of seawater). Medtronic, one manufacturer, states that exceeding this pressure could lead to degradation of the system. Furthermore, exceeding the recommended maximum pressure could lead to changes in the way the device works or cause it to fail, which would require surgical removal and reimplantation. People with neurostimulators can determine the pressure rating of their system by reviewing in the literature provided to them the sections that address sports and other activities. They can also get information by calling the toll-free number on the device identification card and providing the serial number.

Another consideration that shouldn't be overlooked is the underlying reason for the device. That condition must be evaluated with respect to any potential problems with diving.

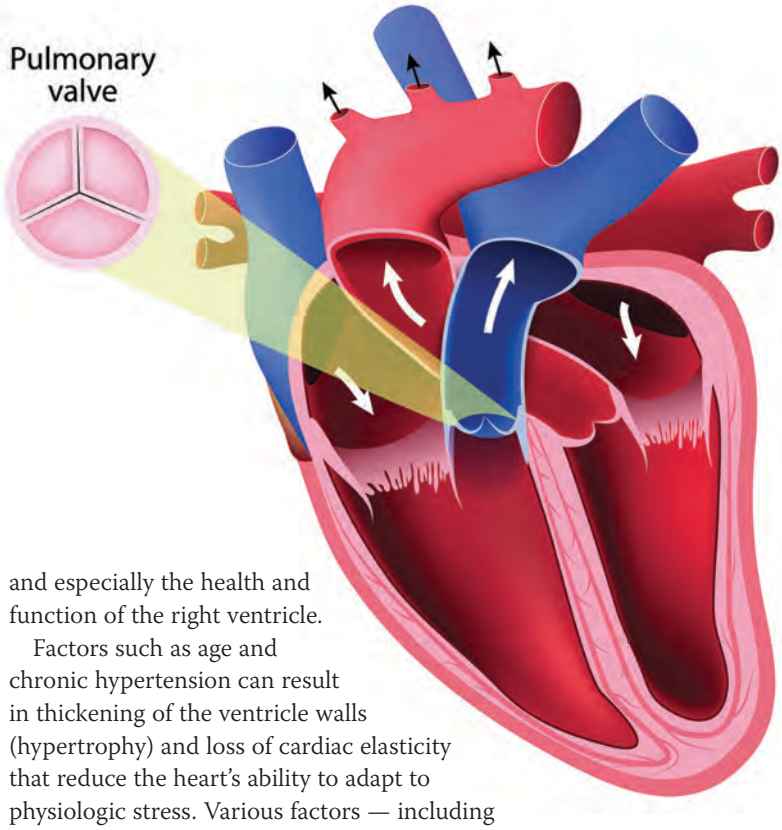
— Scott Smith, EMT-P

Q: I am 48 years old and have moderate hypertension. I was diagnosed with pulmonary stenosis, which was surgically corrected. The pulmonary valve, however, is allowing some blood to leak, permitting backflow. Is this a disqualifier for scuba diving? What short-term and long-term risks are involved in diving with this medical issue?

A: Whether or not a medical condition disqualifies a person from diving depends on several factors, including the severity of disease and the presence of associated medical conditions. The diver must undergo a thorough evaluation by a doctor, and fitness to dive must be considered on a case-by-case basis. The general comments here are intended to provide background on pulmonary valve insufficiency and some of the associated cardiac issues that influence decisions regarding fitness to dive.

Deoxygenated blood returning from the body enters the heart before making its way to the lungs for reoxygenation. Pulmonary valve insufficiency may result in the backward flow of blood (regurgitation) into the right ventricle of the heart. Minimal or mild pulmonary insufficiency is common in many people with otherwise healthy hearts and rarely requires medical intervention. Although mild pulmonary insufficiency may not manifest with symptoms, individuals with a more severe condition may experience fatigue, shortness of breath (especially during physical exertion), exercise intolerance, fainting, palpitations or chest pain. Backflow may result from a number of medical conditions, including congenital malformation, pulmonary hypertension and pulmonary stenosis.

Pulmonary stenosis, a narrowing between the right ventricle and pulmonary artery, results in an obstruction in the flow of oxygen-poor blood from the heart to the lungs. Even after being corrected, pulmonary insufficiency may still be present. Whether or not regurgitation disqualifies someone from diving depends on the severity of regurgitation, the existence of underlying myocardial disease



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and especially the health and function of the right ventricle.

Factors such as age and chronic hypertension can result in thickening of the ventricle walls (hypertrophy) and loss of cardiac elasticity that reduce the heart's ability to adapt to physiologic stress. Various factors — including immersion, exercise and cold water — shift fluid from the body's periphery to the core and increase cardiac workload. If the muscle of the right ventricle is compromised in some way, the heart may not be able to handle these diving-associated fluid shifts.

If the leak is mild enough that symptoms are not apparent and the right ventricle is of normal size and function, it is likely that diving can be done safely. Valvular incompetence can result in increased right ventricular stress and result in hypertrophy (independent from systemic elevations in blood pressure). How the heart muscle responds to this overload depends on the severity of the condition and how long it has been present. Chronic overload can result in hypertrophy, which reduces cardiac efficiency and requires increased blood flow to the heart muscle itself. During physiologically stressful states such as immersion, exercise and extreme temperatures, the heart may not be able to meet the demands of cardiac muscle. Hypertrophic disease also increases the risk of irregular heartbeats (arrhythmia), which may lead to heart failure or unstable heart rhythms. Hypertrophic ventricles are also less able to accommodate significant fluid shifts.

Valve repair can require lifelong anticoagulant therapy, although this is more common with the aortic and mitral valves. Although the use of anticoagulants alone is not necessarily an absolute disqualifier from recreational diving, it should factor into an overall decision about one's medical fitness to dive.

It is important to seek medical evaluation prior to diving, and it would be prudent to consult a cardiologist, who may order a cardiovascular stress test or other testing to determine cardiac function and your ability to perform at the higher levels of activity needed for diving. If you have additional questions, call the DAN Medical Information Line at +1-919-684-2948. AD

— Payal Razdan, MPH, EMT, and Nicholas Bird, M.D., MMM

STEPHEN FRINK

Regularly practicing emergency skills such as sharing air is a great way to gain the kind of experience that can prove helpful when problems occur.

Experience and Risk

By Karl Shreeves

Although it is clear that diving experience reduces divers' risk of injury, *experience* is an imprecise term that conjures different ideas in different people at different times. In contemplating how experience reduces risk, we need to consider the following:

- Training provides experience.
- Practice provides experience.
- Diving provides experience.
- Not all experience is helpful.
- If some factors are present, experience can *increase* risk.

TRAINING PROVIDES EXPERIENCE.

As much as we like to say, "There's no substitute for experience," there actually is a substitute: training. And this is a good thing — you wouldn't want to learn through experience that you shouldn't hold your breath while scuba diving. Training lets us benefit from the (sometimes painful or deadly) experience of others, which is why it's the first step in becoming and growing as a diver. But we must be willing to learn from others' experience. As Douglas Adams (author of *The Hitchhiker's Guide to the Galaxy*) observed, "Human beings, who are almost unique in having the ability to learn from the experience of others, are also remarkable for their apparent disinclination to do so."

PRACTICE PROVIDES EXPERIENCE.

During training and (one hopes) outside of training, divers practice skills including emergency procedures. This practice gives us experience in controlled circumstances in which we can mess up, learn from our mistakes and try again until we succeed — without actually getting hurt. Fortunately the brain does not really differentiate between simulated circumstances and reality. When faced with the real thing, people do as they trained and practiced, and the more realistic and varied the practice, the better the responses.

This outcome assumes that you actually train and practice. Explorer, instructor and rebreather designer Kevin Gurr once said, "Practice a skill on every dive." By that he meant an emergency skill. Following his advice is easy and takes little time. Divers can also

gain experience by simulating (within the scope of their training) and managing realistic emergencies in confined water. Another instructor and explorer, Phil Short, said, "I do it when I don't have to, so I can when I do."

DIVING PROVIDES EXPERIENCE.

Diving provides experience that's hard to get though instruction (this is what we really mean when we say there's no substitute for experience). By going diving we subconsciously learn normal patterns — how things are supposed to be and what we are supposed to do in different circumstances and underwater environments. When something violates our subconscious expectations, we go on alert, sometimes reacting intuitively even before a problem occurs.

There are numerous examples of this intuition in different endeavors. One example documented by cognitive psychologist Gary Klein, who is one of the primary researchers in this area, involved an experienced firefighter who led a crew into a house to fight what seemed to be a routine kitchen fire. They sprayed the fire, but it almost immediately roared back to life. Uneasy, the commander ordered his crew out. Moments later the floor collapsed as a huge undetected fire in the basement engulfed the structure; everyone would have died if they had stayed in the house.

Right after a close call, those involved often say they didn't know how they knew something was wrong, they just did. Deeper analysis commonly finds multiple subtle pattern deviations that even trained people may not have noticed consciously, but their subconscious apparently did. The lead firefighter said he saw no threat, but he somehow knew something was terribly wrong. Later examination found that besides the fire roaring back to life, the room was much hotter than it should have been, and the men reported it was unusually quiet (the hidden fire was muffled in the basement). Unconsciously, these pattern mismatches warned the commander.

Experience will keep us out of trouble — if we allow it to. In other words, if something doesn't feel right when diving, don't wait to find out why. Trust your intuition, and act accordingly.

NOT ALL EXPERIENCE IS HELPFUL.

It's not just the quantity but also the quality of experience that counts. We need enough repetitive experience to learn patterns, but beyond a certain point, more doesn't benefit us.

Consider two divers, one with 1,000 dives and one with 200 dives. The first is an open-water diver who has made all 1,000 dives on about a dozen shallow tropical coral reefs, all from a boat in a wetsuit and wearing an aluminum 80 cubic foot cylinder. The second diver has about 50 dives on similar reefs, plus 40 dives in kelp, 20 dives in a cold-water reservoir, 15 dives in a river, 20 dives on Atlantic wrecks, 25 in Florida's springs and the rest in inland quarries and off Florida's gulf coast. The second diver is certified as an advanced open-water diver, cavern diver, rebreather diver and drysuit diver and has dived from boats and shore, including through surf. Which diver has the most useful experience that will help reduce risk, especially when visiting a new environment for the first time?

There's nothing wrong with making a dive you like for the umpteen-billionth time, but be realistic about how much it is or is not contributing to your experience.

EXPERIENCE CAN INCREASE RISK.

Be cautious of normalization of deviance, which can be summed up as getting used to not following your training because nothing bad happens. If someone violates safe diving practices (e.g., exceeds training limits, omits standard gear, skips checklists, etc.) and nothing goes wrong, there's greater likelihood the person will violate these practices again. Experience makes this worse, because repetition without negative consequences makes the safe practices that were omitted seem unnecessary, until the deviation becomes the new normal practice. Researchers cite normalization of deviance as primary factors in the loss of the *Challenger* and the Chernobyl nuclear disaster.

Culture can magnify normalization by failing to correct the deviation or even encouraging it ("Oh, you had to do that in training, but no one really does it."). Normalization of deviance is particularly common in endeavors such as scuba diving that tend to have redundant safety practices to account for unintended and random human error. Nothing goes wrong because a redundancy accounts for the deviation — until one day the redundant factor is accidentally omitted, too.

If you find yourself skipping things you learned to do in training (such as predive safety checks), exceeding limits (diving deeper than you were trained to or entering overhead environments without training) or omitting gear you were trained to always have (such as snorkels or surface signaling devices), you're exhibiting normalization of deviance. If you and your buddies reinforce these behaviors, you're in a microculture that is normalizing deviation.

Because experience can reinforce normalization of deviance, experience is only a cure if something bad happens due to the deviation (and even then some divers go right back to the unsafe practices). The cure and prevention are the self-discipline to follow your training, honesty about the safety of your diving behaviors and refusal to listen to other (sometimes more experienced) divers who encourage deviations. AD

DO SOMETHING!

EVEN IF YOUR SKILLS AREN'T PERFECT, YOU CAN STILL MAKE A DIFFERENCE.

By Carolyn Dobbins

STEPHEN FRINK

My husband, Doug, and I were diving in Cozumel. I was 56 with about 100 lifetime dives, and he was 61 and a newly certified diver. Doug has controlled high blood pressure and some allergies. I took a refresher course with him when he took his open-water certification class, and in it we learned lessons about buddy diving that would later prove invaluable.

Doug weighed 240 pounds, so as a new diver with a wetsuit he used more than 20 pounds of weight. I still struggle with my own buoyancy issues and uneasiness about currents, and it was overwhelming at times to be looking out for my buddy, too. We had a successful week of diving until the last day, when Doug had difficulty descending. Later I found out he had removed some weight without communicating the change to me.

Our group usually descended together, regrouped on the bottom and then began the dive. Doug and I always descended within reach of one another. During our descent on the last day of the trip the current had begun to separate Doug and me when the divemaster signaled that everyone should descend on his or her own. By the time Doug and I regrouped on the sandy bottom at 70 feet, the rest of the group had already made their way over to the wall we would be diving and begun descending on it. We began swimming toward the top of the wall against a heavy current.

A moment later I felt a touch on my head and turned to see a thumbs up signal. I blindly followed Doug as he ascended — I didn't know what was going on. I could see he was watching his gauges. I never saw his face until we were just about to surface. He was slightly above me, so I had been looking at his stomach the whole time. I don't know why, but I never thought about what might be happening.

At the surface he turned toward me and started to mouth words. A pink frothy foam filled his mask and came out of his mouth. I guess my training or experience kicked in as I screamed at him to inflate his BCD. He rotated away from me, and I grabbed for his inflator button. I inflated his BCD until air flowed out of the dump valves.

I waved my arms at the boat and screamed, "Medical emergency!" — I didn't want the crew to think we just didn't feel like diving. From there the events became a blur punctuated by clear snippets of reality. Doug was still facing away from me. His head bobbed with the swell. Maybe he was just resting. I will never know why I didn't turn him toward me, why I didn't look at him. Maybe if I didn't look then this would not be real. I handed off Doug to the crew. They pulled and pulled, but he wasn't moving. I stared at the ladder.

Finally the crew began to make progress hauling up Doug, who was still wearing all of his gear. When I saw the integrated weights of his BCD, I remembered, "drop the weights." He was moving so slowly I had plenty of time to remove each weight and place it on the deck. I removed his fins and then my weight belt and fins. I was so proud of myself. I placed all the gear on the deck out of everyone's way and didn't lose any of the rental gear. Then I looked up and saw the ugly truth. Doug was unconscious and a ghastly gray color, with his head hanging to the side. This was real; this was happening to us.

I saw a crew member getting the oxygen, and I instinctively started pushing on Doug's chest. I saw and heard the oxygen tank. "*Wait, my mom uses oxygen,*" I thought. *"There shouldn't be a whishing sound."* I continued pushing on Doug's chest. Each compression produced more pink foam from his mouth. I wanted him to be neat and clean, so I kept lovingly wiping the foam away.

I tried to fit my mouth over his nose and mouth. "*Damn, why does he have such a big nose?"* I thought. *"Oh yeah, nose and mouth is child rescue breathing — mouth-only for adults."* I performed the rescue breaths. I didn't feel much or see his chest rise. I provided more chest compressions, and more foam came forth. I performed another rescue breath. "*How long should I do this? What if he survives with brain damage?"*

During the third cycle I felt something different; it must have been a breath finally going in. "*Had I been doing it wrong?"* I thought. Then a gasping breath came from Doug's mouth — then another breath. He was breathing. It was gasping, labored breathing. "*Should I have done the CPR? Was it too long?"* Later I learned drowning victims can have reflex laryngeal spasms, which can block rescue breaths.


CAROLYN DOBBINS

Douglas Kirk recovers in the hospital after experiencing acute pulmonary edema during a dive. His wife, Carolyn Dobbins, may have saved his life by not only remembering her training but also advocating for him and taking control of the situation to the best of her ability.

The crew didn't know what to do; they had set up the oxygen cylinder incorrectly, and all the oxygen leaked out. No one else took charge, so I did, albeit badly. Somehow I rolled Doug onto his side, and after what seemed like an eternity I looked up and saw we were at a dock. The boat had pulled up at the closest dock to the dive site, a small hotel/condo complex in south Cozumel. "*Why wasn't any one helping us?"* I thought. I jumped up and screamed to the building for help.

Doug was breathing but still unconscious. He remembers regaining consciousness as he was placed into the ambulance (which had arrived a few minutes after our boat docked). The saga continued with an eventful ride to the hospital that included the ambulance getting a flat tire, us flagging down a passing SUV, stuffing all 6 feet 2 inches of Doug into the back of it and then discovering the road we needed was closed for construction. I couldn't believe I saved his life on the boat and he was going to die on the side of the road.

Fortunately, we made it to the hospital, where Doug was diagnosed with pulmonary edema. After two days in the hospital, lots of diuretics and repeated lung X-rays, he was released.

We learned a lot from the experience: Complete a refresher course, always stay close to your buddy, know how to administer oxygen, stay current with CPR training, and purchase the best DAN dive accident insurance.

Doug is fine today, and we have completed several dive trips since the incident. We have taken CPR classes, and I am now certified as a rescue diver. We are grateful every day for a second chance. AD

STEPHEN FRINK

Although symptoms after diving are not always due to DCS, it behooves divers who experience postdive symptoms to contact DAN and seek medical attention promptly. Avoiding denial can greatly improve outcomes.

Self-Aware and Prepared

By Tara Narowski

THE DIVER

The diver was a 45-year-old male dive instructor with approximately 300 lifetime dives. He denied taking any medication and reported no history of medical conditions.

THE DIVES

The diver was teaching an advanced open-water course at a local lake popular with divers. The water temperature ranged from 78°F to 92°F. He was accompanied by his wife, who was assisting the class as a divemaster, for a series of five dives over the weekend. They completed three dives on Saturday with long surface intervals between the dives followed by a 16.5-hour surface interval before the first dive on Sunday.

The first dive on Sunday was 34 minutes long with an average depth of 53 feet and, to meet the depth requirement of the course, a maximum depth of 98 feet. After a 90-minute surface interval, the divers began their second dive of the day, which focused on search-and-recovery skills. It was a 48-minute dive with an average depth of 50 feet and a maximum depth was 63 feet. The diver reported nonstressful dives with minimal exertion besides following and monitoring his students. The dives were within recreational limits, and his dive computer was in a conservative setting. His fastest ascent of the weekend was at a rate of 29 feet per minute.

COMPLICATIONS

As everyone was packing up after the fifth and final dive of the weekend, the diver began to experience a

"This incident is a good example of how being a prepared diver and having an emergency action plan can prove fortunate."

dull ache in his right shoulder and numbness in his right leg. When he began to have difficulty walking, he asked his wife to make the drive back to the scuba shop. After a few minutes in the car, the diver's right arm started feeling cold. He checked to make sure the cold sensation was not because of the damp, long-sleeved rash guard he was wearing or the cold air blowing from the air conditioner. He then noticed that the cold sensation had turned to numbness and slight tingling that progressed down his right arm and leg.

They pulled over the vehicle and set up their DAN® oxygen unit, and the diver began breathing from the demand valve. They also set up the nonrebreather mask in case the diver lost consciousness. Once the diver was breathing 100 percent oxygen, his wife called DAN. The DAN medic assessed the situation and directed them to the nearest emergency room.

Fortunately, the diver's symptoms subsided after approximately 45 minutes of breathing pure oxygen. When he reached the hospital, there was no more numbness or tingling in his arm, and he could walk normally again. Although his symptoms were gone, he was admitted to the emergency room for further analysis. When the diver arrived, he was put on a nonrebreather mask with a flow rate of 15 liters per minute. The emergency room doctor was in contact with DAN medics, who provided contact information for multiple hyperbaric medical specialists in the area for further consultation.

The diver continued to breathe pure oxygen for about two hours, and his symptoms never returned. He underwent multiple tests, including an electrocardiogram, MRI, CT scan and chest X-rays, all of which were unremarkable. The doctor monitored the diver for three and a half hours before releasing him. In total, the diver breathed 100 percent oxygen for approximately five hours, with the exception of during testing and necessary breaks.

The doctors ultimately determined this may have been a case of decompression sickness (DCS) that resolved before the diver was admitted to the hospital. The diver's report of mild unilateral upper- and lower-extremity paresthesia that were resolved by surface-supplied oxygen suggests central nervous system DCS. The general recommendation in such cases is to treat with hyperbaric oxygen therapy (HBOT) regardless of symptom resolution. In this case, after extensive testing and prolonged monitoring, the physician was confident HBOT was not necessary.

DISCUSSION

This incident is a good example of how being a prepared diver and having an emergency action plan can prove fortunate. The diver ensured he was properly hydrated, well fed and sufficiently rested throughout his weekend of diving. Although the reported dive profiles were within the diver's computer limits, with slow ascents and adequate surface interval time between dives, he still recognized and acknowledged the signs and symptoms of neurological DCS. If the diver had ignored the symptoms and waited longer to seek professional medical attention, his eventual recovery might not have been so swift and/or complete.

In many cases, divers choose to neglect DCS symptoms or attribute them to a separate cause such as heavy lifting, a tight wetsuit or overexertion. The diver contemplated the numbness and tingling sensation in his extremities, astutely recognized these symptoms and took immediate action. He acknowledged that there are risks associated with scuba diving and was adequately prepared with an emergency oxygen unit with various types of breathing apparatus. Both the diver and his buddy were trained in how to use the emergency oxygen and how to determine when medical intervention is necessary.

The diver's doctor advised him to discontinue repetitive deep dives, consult a neurologist for other possible explanations for his symptoms, get screened for a patent foramen ovale (PFO) and wait 30 days before returning to diving. The diver has returned to diving since the incident and has not experienced further problems.

This incident can serve to remind all divers of the importance of self-awareness and having an emergency action plan. It is crucial to be mindful when considering symptoms, to have an immediate oxygen supply available and to seek professional medical attention promptly when necessary. 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.

RESCUE PAK

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.

RESCUE PAK EXTENDED CARE

The Rescue Pak Extended Care unit offers the same features as the Rescue Pak but comes with a larger Jumbo D cylinder that boosts oxygen-delivery capacity to approximately 45-60* minutes. Includes a brass multifunction regulator, demand valve with hose, nonrebreather mask, oronasal resuscitation mask, Tru-Fit mask, and a waterproof Pelican 1600 case. Ideal for wet environments and locations slightly farther from emergency assistance.

DUAL RESCUE PAK EXTENDED CARE

The Dual Rescue Pak Extended Care oxygen unit features two Jumbo D cylinders that deliver approximately 90-120* minutes of oxygen. This unit comes complete with a brass multifunction regulator, demand valve with hose, nonrebreather mask, oronasal resuscitation mask, Tru-Fit mask, and a waterproof Pelican 1600 case. Ideal for wet environments and locations farther from emergency assistance.

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.

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.

Optional second cylinder shown.

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Oxygen **Tips**

- Breathing pure oxygen at the surface may alleviate or even resolve symptoms of DCS.
- Emergency oxygen is not a definitive treatment for a scuba injury, and symptoms may return. Even after symptoms have resolved, seek urgent medical evaluation.
- If a diver presents neurological symptoms, duration of surface oxygen breathing should last at least 90 minutes, even if symptoms resolve after the first few minutes.

Oxygen **Grant** and EO_2 **Matching Grant**

DAN provides emergency oxygen units to individuals, businesses and organizations that have a connection to diving and can demonstrate a financial need.

To apply, contact OxygenGrant@DAN.org

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JARDINES DE LA REINA

CUBA'S PRISTINE PARADISE

TEXT AND PHOTOS BY STEPHEN FRINK

I had never known a trip to garner such demand. Every year we organize a couple of photo tours to distant and exotic destinations in the tropical diving universe. This year we arranged our first trip to Cuba — to the *Jardines de la Reina* (Gardens of the Queen) — and it sold out in only two hours. I've heard of similar success from others in the dive travel business, too. There was tremendous pent-up demand for Cuba, it seemed, among North American divers. This was curious to me, because I'd dived Cuba before and was underwhelmed.

UNDERWHELMED?

"Underwhelming" is not a word you typically see used to describe diving in Cuba, but context is important to understand my experiential baseline. In the mid-1980s a popular strobe manufacturer of the day, Subsea, invited me and several other professional underwater photographers to teach a seminar to their best dive shop retailers, destination Cuba. We traveled to the Isle of Youth and enjoyed some relatively good diving on its walls and shipwrecks. The scenery was nice, especially the huge sponges against blue water backgrounds, but I was struck by how few fish I was seeing. This makes sense when you consider that the Isle of Youth is the seventh-largest island in the West Indies and has a population of 86,000. That many people can consume a lot of fish, so it's no surprise the fishing pressure was discernible. This was 30 years ago, and Cuba's initiative to develop marine protected areas

One of the highlights of a dive tour to the Gardens of the Queen is the chance to swim with a crocodile in a pristine mangrove and seagrass environment. Habituated to the proximity of snorkelers, these animals offer a unique and productive photo opportunity.

(MPAs) was nascent, but I still found myself wondering in 2016 whether the Gardens of the Queen would be any different.

Jardines de la Reina has a few things going for it. It's situated 60 miles south of Cuba's central coast near the village of Jucaro, which is itself a six-hour bus ride from Havana. (I'm no political science whiz, but it occurs to me that if for the past 50 years you didn't want your citizens to drive their boats 90 miles to Key West you probably shouldn't allow them to have enough fuel of go fishing somewhere that involves a 120-mile round trip.) Perhaps even more important, Jardines de la Reina was a favorite spearfishing and scuba diving spot for Fidel Castro, and he had no desire to see it get fished

out. Fishing was discouraged even before the area was officially a marine preserve.

According to the group EcoWatch, which interviewed Castro on the subject in 2014, he deemed marine conservation to be important for Cuba. "Castro told us that he had fished and dived the extraordinary reef (Jardines de la Reina) over its entire 60-mile length.… He also told us about his personal evolution as an environmentalist. He began as an avid marlin fisherman and spearfisherman who slaughtered many marine species on the reef, assuming the oceans were infinite and could never be depleted, … then he met with marine conservationist Jacques Cousteau. That meeting helped transform Castro into a committed environmentalist. He has committed to preserve 25 percent of Cuba's waters from extractive fishing as marine preserves, while the U.S. lags, preserving less than 2 percent of our coastal waters."

In 1996 the Gardens of the Queen officially became a marine preserve — one of the largest in the Caribbean. This is significant in many ways; it goes far beyond the dive tourism we enjoyed for a week this past July. As the *New York Times* observed in an article on July 14, 2015, the U.S. and Cuba are two countries whose ecosystems are closely interconnected, the environmental successes or missteps of one affecting the health and productivity of the other."

"When you have two areas that are 90 miles away, it's not only possible but it's probable that a considerable number of eggs and larvae are moving between Cuban and American reefs," Jake Kritzer, an ocean and fisheries expert at the Environmental Defense Fund, told the *New York Times*.

Jorge Angulo-Valdés, a senior scientist at Havana University's Center for Marine Research, also observed, "Our two countries are connected by the water, and fish and other organisms move freely there. They don't need a visa to come down or go up."

A study by marine biologist Fabián Pina Amargós, director of Cuba's Center for Coastal Ecosystem Research, found that fish populations have increased 30 percent since the preserve was established, and shark populations are 10 times greater within the protected zone than in the waters outside.

Now that I've visited the Gardens of the Queen I can revise my assessment of Cuba diving. With an impressive density of marine life and pristine coral reefs, "overwhelmed" is more like it.

THE TRAVEL

We traveled to Cuba on a People to People International program. Even though diplomatic relations are thawing and commercial flights from the U.S. to Cuba resumed Aug. 31, 2016, travel to Cuba is not without regulation. Simple tourism is still prohibited by statute, but there are 12 categories of authorized travel, including journalistic activity, public performances or sports competitions, professional research and meetings, humanitarian projects and educational activities.

As part of our program we visited Havana, which was worth the trip if for no other reason than to see the people, the architecture and the cars from 1950s Detroit that still rule the roads. Having grown up in an era when as a child I could name every car on the road, whether DeSoto, Studebaker, Ford, Plymouth or Chevrolet, Havana was astonishing. To the endless fascination of American tourists of a certain age, the city was filled with dream cars from the days before I could drive. The Baby Boomers on our bus kept shouting out "'57 Bel Air," "'58 T-Bird," "'52 Buick," "'56 Fairlane!" My 23-year-old daughter didn't share our enthusiasm for old cars, but even she knew this was a situation unique in the world — a function of five decades of embargo that forced Cubans to be resourceful and respectful of their cars. There was much to appreciate about Havana; I don't think you could visit and not be impressed by the culture, history and fine dining.

The Jardines de la Reina are a group of 250 coral and mangrove islands 60 miles offshore, so factoring in our travel time from Havana and the boat ride to the dive sites, the first day would be fully dedicated to travel. Once we joined our liveaboard we quickly shoved off to sea, enjoying lunch and what was to become our collective passion for the week: mojitos — concoctions of white rum, lime juice, sugar, soda water and crushed mint. We were happy to indulge in a drink or three, as we wouldn't be diving that day.

GARDENS OF THE QUEEN

Checkout dives are often done at some crappy reef where nothing can be harmed by an errant fin stroke or poor buoyancy control. With that in mind I was pleasantly surprised to see massive and pristine pillar corals punctuating the seafloor at **Boca de Anclitas**. A friendly queen angel darted between the spires of this giant coral colony, making for a great photo op with my daughter as model. A pair of Nassau grouper kept nudging ever nearer my housing's dome port. Whether they were seeing themselves in the reflection or had targeted me as a potential fish-feeder, I wasn't quite sure. Soon after our first giant stride it became clear that these fish did not associate divers with

"THERE WAS MUCH TO APPRECIATE ABOUT HAVANA; I DON'T THINK YOU COULD VISIT AND NOT BE IMPRESSED BY THE CULTURE, HISTORY AND FINE DINING."

Above: Vast fields of intact elkhorn and brain coral can be found in Jardines de la Reina.

Left: Part of the charm of Havana is the fleet of 1950s-era American automobiles — cars that defy age and have survived the challenges of the embargo.

The Gardens of the Queen are a no-take marine preserve, without which protection the healthy populations of Nassau grouper would not exist.

Opposite: A queen angelfish swims among the spires of a pillar coral.

HOW TO DIVE IT

There aren't a lot of variables in Cuban dive travel to Jardines de la Reina. You can do it only with a couple of nonprofit organizations recognized and licensed by the Cuban government. The trip will be carefully choreographed to optimize your pleasure but also to minimize American tourists wandering amok throughout the country. All that may change with the advent of commercial air arrivals and cruise ships in Havana Harbor, but for now it is blessedly constrained. You'll be met at the airport and be with guides either topside or underwater each step of the way. I found the attention helpful rather than obtrusive, and the Cuban people were so friendly and engaged it was fun to just be around them.

ENTRY REQUIREMENTS: Visitors must have a current passport, a visa (which tour operators often can obtain for their travelers), adequate funds to support themselves, a return airline ticket, proof of travel health insurance and a verification letter from their organizing agency to travel to Cuba. You might be asked for the letter upon exit, though we were not.

CURRENCY AND CREDIT CARDS: You won't be able to use your credit cards in Cuba. Most expenses will have been prepaid, but you'll need cash for incidentals and gratuities. Bring only crisp bills without undue wear or damage. I tried to buy a Cohiba cigar with a torn $50 bill and was turned down.

WATER TEMPERATURE AND SEA CONDITIONS: Jardines de la Reina is protected from most prevailing winds. Unless there is a tropical storm or hurricane, the seas tend to be calm. The seasonal variability is in the water clarity. In the winter, when the water drops to 78°F, the visibility ratchets up to more than 100 feet. When we were there in July, the water was 84°F-86°F and the viz was 50-90 feet.

CURRENTS: Some sites have currents, including passes between the islands where channels accelerate the tidal flow. There are also sites without any current. We had no current at all during our week of diving. These dive professionals are very skilled in delivering safe diving opportunities, and most have been guides here for many years. Though these dive sites are new to Americans, Canadians and Europeans have been nibbling our forbidden fruit for decades.

spears. No Nassau or black grouper could survive to this size in these waters without protection.

THE SHARKS OF JARDINES DE LA REINA

We enjoyed many dives with Caribbean reef sharks. I expected them — part of my research for this trip was watching a *60 Minutes* episode about the Gardens of the Queen with Anderson Cooper. It aired five years ago but was still very informative and well done. The significant populations of sharks were a big talking point in the program, with healthy shark populations being directly correlated to healthy reefs. (See *youtu.be/K2nMUnK7S-A*.)

We did not have sharks swarming around us like in that video. We might see four or five on a dive, and occasionally they'd come near enough for a good photo. The crew noticed how excited we all were whenever a shark photo was in the evening's image reviews, and eventually the cruise director asked our opinion about putting a bait box in the water. He assured us it would be a very low-key thing — more of a "scented" dive than a "baited" dive. The divemasters wouldn't be donning chainmail and actually feeding the sharks. Would we mind? We assured them we'd be quite happy with that.

The bait box was transformational in facilitating close encounters with the Caribbean reef sharks. They circled the box constantly, and divers who had no interest in shark photography proceeded with a relaxed dive on a gorgeous coral reef. Divers who were interested in shark proximity could have many close encounters on these scented dives. We were consistently rewarded with beautiful environmental portraits of shark and coral reef. All in all, the action with these sharks on the reef was very mellow.

We didn't bother with the bait box on every dive. It was so productive early in the trip that we tended to concentrate on other subjects later in the week. But sharks were there on almost every dive. Most were Caribbean reef sharks (*Carcharhinus perezii*), but a couple of dives purposely featured silky sharks (*Carcharhinus falciformis*).

While *C. perezii* are reef sharks, *C. falciformis* are dwellers of the open sea. According to *sharksider.com*: "[Silky sharks] have an extremely strong sense of hearing. This acts as a great advantage for locating their prey, mostly consisting of bony fish (especially tuna), octopuses, and squids.… They dive together into large groups of fish and attack them with lighting-fast speed and wide-open mouths."

To find the silkies we motored westward and dived along some deep coral canyons in 60-80 feet. The bait box was deployed about 10 feet beneath the boat. We did our dive, and when we ascended back to about 30 feet we saw the silkies had come to play. Probably 12 or 14 large sharks were darting about, but always in a fairly subdued and deliberate manner. They did amp up when small bits of bait were tossed into the water, as they raced to claim their share. But it was never overly frenzied, and I don't recall any bumps or uncomfortably close encounters. Anyone preferring a more passive encounter could stay a few yards farther from the bait box. The combination of very clear water and abundant sharks made this the most productive spot for silkies I've ever dived.

THE QUEEN'S CROCODILES

Since I've been home and posted some of my crocodile shots on social media, I've had several inquiries about when we'd do our next "croc trip," as if that was the reason we went to Cuba. I found this kind of comical, because a typical Cuba dive expedition does not involve a lot of time with these crocodiles. But the high probability of an encounter, especially for someone who has never seen a crocodile up close and in clear water, means for that day, that hour, it is a croc trip.

There is an area back in the mangroves where dive operators over many years have developed a relationship with a few resident American crocodiles (*Crocodylus acutus*). Less aggressive than the infamous Nile and Australian crocodiles, American crocodiles are normally shy, but not in the Gardens of the Queen. Once we get near the site the guides call out the name of a familiar crocodile, "Niño, Niño!" If it is the right time of day and the mood strikes, he'll often swim out to the boat. Almost all the crocodile photos you've seen lately in photo competitions and dive magazines are of Niño. He works hard for the little bit of raw chicken they give him

From left: Schooling grunts and snapper are a common sight on the shallow reefs. A hawksbill turtle swims along a mini wall. A black grouper opens its mouth wide, presenting itself to cleaner wrasse for parasite removal. A silky shark snatches a bit of bait tossed from the boat.

as a reward, but the popularity of these photos isn't just because the animal is so charismatic, it's also a product of the remarkable background. This is an absolutely magic environment of clear water (at high tide anyway), with abundant seagrass below and mangrove forest above. If an over/under photo with a crocodile is on your wish list, there may be no better place on the planet to get one.

THE CORAL REEFS

The liveaboard's two dive skiffs would motor out to nearby reefs, but never the same one to prevent overcrowding. At **Five Seas** we were rewarded with an excellent tarpon encounter. While relatively rare on dive sites elsewhere in the Caribbean, we would find tarpon in residence at many of these sites. These weren't huge aggregations, but groups of four to eight were common, usually under ledges. They were quite tolerant of approach, and the colorful sponge and coral backgrounds made a stark contrast to their silvery shimmer.

The diving was uniformly excellent, and many sites shared common features. We would typically tie up to a mooring buoy and drop in onto a shallow plateau at 15-20 feet. Then there would be a slope, quite often to a mini-wall that dropped to 60 or 80 feet. Often there were ledges and undercuts that were brightly decorated with sponges. This was a favorite hangout for nurse sharks as well as tarpon. On certain sites, such as **Octopus Cave**, giant schools of grunt, porkfish and schoolmaster snapper comingled.

We'd often see large black grouper and quite a few Nassau grouper as well. This may have been just good luck, but I think they have been fed over the years — classically conditioned to associate the sound of a boat with food. They are resident to that reef and forever optimistic. Even though our crew did not feed them, they were very attentive.

GOLIATH GROUPER

I should note that we didn't see any goliath grouper, which are apparently considered a consistent highlight of Gardens of the Queen diving. I wasn't all that surprised, however. This was about this same time of year that we see them leaving the reefs in the Florida Keys and also the time of year they are observed in aggregations off the deep reefs and wrecks of Jupiter, Fla. With a spawning season of July-September, goliath grouper have at least 10 spawning aggregation sites in Cuba. Jardines de la Reina and Canarreos archipelagos were cited as possible recruitment and nursery sites. The biggest conservation concern, however, is fishers targeting the goliath grouper during their spawn, which is when they are most vulnerable and most important to the perpetuation of their species.

There were many other highlights during this truly inspirational week of diving. I have a hard time calling out specific reefs because they were all so very good. I could say "on this one a friendly turtle swam with me for 200 yards, a Caribbean reef shark passed right by my shoulder, and a school of porkfish posed in perfect symmetry." But, frankly, that could have been on almost any dive. We became accustomed to extraordinary Caribbean marine life, yet what astonished me the most was the density of coral cover.

If you want to go back in time, my recommendation is to go to Cuba. I started diving Key Largo in 1978, but on most of the reefs we dived in the Gardens of the Queen in 2016, the coverage by boulder corals, sea fans and gorgonia was even greater than we had in Key Largo back then.

We never really traveled very far to the north or south along the Gardens of the Queen reef, which is 75 miles long. I assume this was because the operator knows the reefs well. Even though liveaboards with greater range now ply the waters, for many years a floating hotel with small dive skiffs motoring out to explore only the range they could reach before they had to head back for lunch or dinner was the only way divers could experience the Gardens of the Queen. The operators discovered the best ones, cultivated them by befriending sharks and grouper and kept coming back. This is fine, because the coral is still excellent and shows no obvious signs of diver impact. It was all new to us. But there must be countless dive spots yet to be discovered. That's reason enough to book a return trip to "the Caribbean that time forgot." As great as it is now, I'm sure it will continually evolve as a dive destination. AD

THE EDGE OF THE Boomerang

NORTHERN NEW SOUTH WALES

A gray nurse shark patrols Fish Rock – slowly.

Opposite: North Solitary Island boasts a unique array of both temperate- and warm-water species.

TEXT BY ALLISON SALLMON
PHOTOS BY ANDY AND ALLISON SALLMON

Tell divers you're headed to Australia, and they'll almost certainly ask you about the Great Barrier Reef. Some hardcore divers might wonder if you're headed to South Australia or Tasmania. But beyond those spots, this huge country is a bit of a dive-tourism mystery for many North Americans. You can hardly blame us; it's pretty easy to be distracted by the planet's largest living structure up north and the white sharks and sea dragons down south.

Of course, the locals know better, which is why many of their favorite in-country dive destinations go beyond the familiar. Local knowledge is how our attention was first drawn to the details of the "Boomerang Coast," the curved, populous expanse of coastline extending from Brisbane to Adelaide. Along this shoreline are innumerable renowned dives, including several sites that make it onto Australian Top 10 lists year after year. A full exploration of the region would take months, so we narrow in on a 350-mile stretch of northern New South Wales. This area, where warm water meets cold and the marine life lineup reads like a bucket list, is worthy of our focused attention.

WAITING FOR ZOMBIE SHARKS

The sleepy town of South West Rocks is celebrated for a single but spectacular dive: **Fish Rock**, a low-lying, unassuming islet surrounded by underwater ledges and pinnacles, most of which are shallower than 100 feet. The islet itself is a major underwater draw, as a 400-foot-long cave runs through the center of it. This site is a critical habitat for gray nurse sharks, and not just one or two, but hundreds of these threatened creatures swarm around the rock and fill the shallow end of the cave.

Well, they normally swarm and fill these places anyway. The water has been unusually warm (79°F when we arrived), and for the first time in more than a decade the gray nurses have disappeared from the area altogether, with no sightings of them for two weeks. Reports of a single shark the previous afternoon has prompted a mood of cautious optimism. Our dive guide briefs us on their behavior: Gray nurse sharks have a disconcerting, snaggletoothed appearance, but because they exert low levels of energy during daylight hours, their movement is sluggish. Rapid movement, bubbles and bright light may startle them. We consider these tips and hatch a cunning plan: When we happen upon a shark, we will stay perfectly still, keep our lights off and try not to exhale. Seems easy enough.

We can't test our strategy right away, as the sharks remain absent that first morning. Fish Rock isn't considered one of Australia's best dives for nothing though: Tasselled and spotted wobbegongs are piled on top of ridges and bommies and nearly hidden by swirls of shimmering, angular bullseye. Huge bull rays pass by at a regular interval, as do turtles — several green as well as a stubborn geezer of a loggerhead that practically shoves us out of his way. We see a squadron of eagle rays and swim through a spectacular cave containing more wobbegongs and bull rays, several large black cod and two lovely Spanish dancer nudibranchs. No sharks? No problem. But when we descend hopefully for our afternoon dive, we hit a rush of cool water that wasn't present earlier, and our guide immediately begins gesturing toward a long, slender lump in between the ledges. Keen observation reveals that the lump is moving

(albeit nearly imperceptibly) and that it has a mouthful of sharp choppers — both identifying features of a gray nurse shark. Another one is visible in the distance, so we drop into the surgey gutter between the ledges to put our plan into action. I grip a rock and attempt to stay still. I am occupied by two major contemplations as I wait for the shark's approach (goodness knows I have plenty of time): One, limited exhalation means limited inhalation, and two, a better name for these dawdling creatures is "zombie sharks."

Over the next two days, the temperature below 30 feet drops, resulting in cruel, 10°F-plus thermoclines. We're baited by warm, clear water at the surface, which switches to ice-cream-headache-inducing, cold, murky water at depth. We suck it up. This chilly, nutrient-rich water is frustrating for photographers, but it's happy news for zombie sharks. In an attempt to appear well-rounded, we gamely revisit the wobbegongs and traverse the cave, but it's the gray nurse sharks that have our devotion. By our final dive day, their numbers are finally swelling, and as we glumly pack our gear into the car, we promise our dive guide that we'll be back soon.

MANTA MAYHEM

We arrive to see the dive boat being launched across the beach — more specifically, a kelp-covered beach. I glance toward the captain. "The water's warm, you say?"

"Yep," he replies. He sees me warily inspecting the kelp and says, "There's colder water right off the beach. But not out at the islands. They're in the East Australian Current."

That seems like quite a temperature differential, but it's what this place is known for. The colder, inshore current comes from the temperate environs of Tasmania, while the East Australian Current

Left: During the summer, mantas sometimes congregate at Northwest Solitary Island.

Below: Soft corals adorn the rocks at Mackerel Run, a dive site at the tip of North Solitary Island.

transports warm water from the Coral Sea and Great Barrier Reef. The two collide at the Solitary Islands, producing a unique environment with features and marine life from both regions, key to why this marine park is so fiercely protected.

Sure enough, 24 miles offshore the water is as warm and blue as any emblematic tropical destination, with not a shred of kelp in sight. Conditions prevent us from mooring at North West Rocks (the location of legendary site **Fish Soup**), but we're able to moor at the northern tip of North Solitary Island to explore equally famous **Anemone Bay**, a sloping, boulder-strewn reef with a maximum depth of 80 feet. Two large shovelnose guitarfish are patrolling the area, so I spend most of the dive hoping to come face-to-face (or better yet, camera-to-face) with one of these bizarre sharklike rays. When I finally throw in the towel on that endeavor, I begin to truly appreciate the beauty of the site's namesake invertebrates. Overlapping anemones carpet the seafloor, forming a veritable field of McMansions for the exceedingly prosperous local clownfish.

Nearby **Mackerel Run**, a rocky, soft-coral-covered finger that juts into the open ocean, is no less striking. The medium depth (75 feet) is tame enough, but the current off the point is fierce. I squint into it, knowing that on any given day this spot probably bears witness as hordes of amazing marine wildlife swim past. No sooner has that thought entered my mind than a large eagle ray whizzes by, soon followed by a school of barracuda, another eagle ray and a huge black cod. **Elbow Cave**, on the protected side of the island, grabs my interest as soon as I see a free-swimming wobbegong. Wobbegongs! I've completely forgotten to admire this area's wobbegongs, and they absolutely litter the site (although most are represented by tails sticking out from under ledges). The namesake cave

Clockwise from top left: A school of bullseye swirl over a resting wobbegong shark at Fish Rock. An octopus busily hunts for its next meal at the Julian Rocks Marine Reserve. A zebra shark passes overhead at Julian Rocks Marine Reserve. A loggerhead turtle circles Fish Rock.

here, a sponge-lined grotto stuffed with bullseye, fortunately contains a face-forward wobbegong who glares moodily at me as I photograph him.

The next morning the boat heads for Northwest Solitary Island, a tiny spit of land only 18 miles from the mainland. We moor in a shallow bay called **Lion's Den**, where mantas were sighted the day before our arrival. Our first dive is manta-free, though certainly pretty enough. The site is an easy 40-foot depth with lots of hard and soft coral, busy schools of bullseye and butterflyfish, and some truly beautiful green turtles. Still — and I know it sounds petulant — I feel a little ripped off: only a few gray nurse sharks up north and weather-limited dive sites here. We want some mantas. Thankfully, the universe agrees. We are halfway through our second dive when the first manta shows up; before long, we have seen five different ones. The next three hours are total bedlam. A manta (or two or three) is within sight at any given time. Soon we've memorized them by size and coloration, and I have chosen a favorite — a large melanistic beauty, with a fractured wingtip, that follows me around like a puppy. We make good use of all the extra air in the hold, only calling it a day when the sun is low in the sky and every

tank on board has been emptied. The boat heads back to the mainland, and we watch wistfully as Lion's Den disappears on the horizon.

HOW THE ZEBRA GOT HIS SPOTS

Our guide looks sternly at me as we motor, *Perfect-Storm*-style, through the surf zone. "I'm glad you're not gonna debate me on whether they are leopard sharks or zebra sharks. Everyone here calls them leopard sharks."

I dismiss an urge to discuss the "other" leopard sharks, the ones that inhabit the waters off our home state of California. Fact is, we are here to see (apologies to our guide) zebra sharks. Aside from the fact that leopard sharks appear more stereotypically sharklike while zebra sharks' faces resemble that of the Pillsbury Doughboy, it's easy to see how a misunderstanding could arise: True leopard sharks are spotted throughout life, and the stripes that adorn juvenile zebra sharks fade to become spots as the animals mature. The end result is the same: spotted sharks that can be reliably seen at certain times of the year, though in different locations.

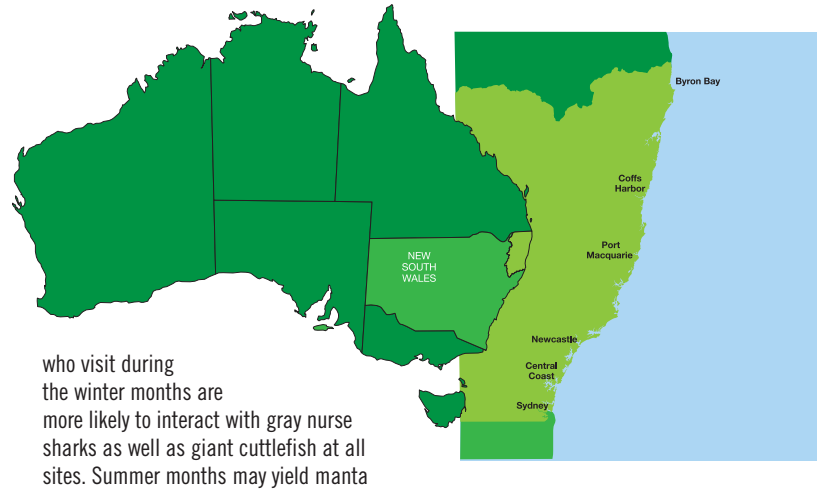
We moor near the eastern edge of the rocks and drop into 30 feet of water, kicking over to **Needles**, a series of ledges, rocks and sand channels. When we arrive at what seems to be the epicenter of shark action, we settle behind a rock, hoping that our gray nurse shark plan will work equally well here (and feeling quite thankful that zebra sharks swim at a comparatively faster pace). Before long, zebra sharks are swimming overhead at regular intervals. Shortly thereafter other marine life is also passing us, including various rays, hunting octopuses and jellyfishes, the latter occasionally pursued by a hungry turtle. Between the cartoonish faces of the zebra sharks and the near-constant trigger-pulling motion of depressing a camera shutter button, the whole setup has a bit of a video game vibe: zebra shark, zebra shark, bonus eagle ray, zebra shark, zebra shark, triple bonus loggerhead. This is a lazy, entitled shooter's delight: The zebra sharks seem to operate on a circuit, so there is little need to move other than to slightly adjust one's shooting angle. As we climb back on board, another boat has called to tell us about a manta sighted on the other side of the rocks. We look at one other with amusement, smiling benevolently. (ONE manta? And we'd have to move?)

The ridiculousness of our reaction is not lost on me. In just two weeks we have become so utterly spoiled that the prospect of a single manta is unexceptional, less than a dozen zombie sharks per dive is thoroughly inadequate, I forget to appreciate wobbegongs, and I compare dozens of zebra sharks to a game of Space Invaders. The Boomerang Coast warrants its name for several reasons; one is that my return is absolutely guaranteed. And next time, no matter how much New South Wales spoils me, I will make it a point to photograph every wobbegong I see. AD

HOW TO DIVE IT

GETTING THERE: Many international airlines fly into Brisbane and Sydney, and local connections are available to Coffs Harbor (adjacent to the Solitary Islands Marine Park). From Brisbane or Sydney, the drive to South West Rocks can take six hours. Many visitors (including U.S. citizens) will need a short-term visa or an Electronic Travel Authority (ETA) to visit Australia. Visit *australia.gov.au* for details.

SEASONS, EXPOSURE PROTECTION AND MARINE LIFE: Water temperatures fluctuate greatly with the seasons in this part of New South Wales, with winter (May-August) low temperatures dipping to the low 60s°F and late summer temperatures getting into the upper 70s°F; a 5 mm wetsuit is adequate in summer, but a 7 mm wetsuit with a hood is a better choice during the winter. Because of the wide differences in water temperatures, the marine life also varies by season. Divers who visit during the winter months are more likely to interact with gray nurse sharks as well as giant cuttlefish at all sites. Summer months may yield manta ray and zebra shark sightings. Wobbegong sharks, black cod and many types of rays can be viewed year-round. The waters around Fish Rock (which can have cool thermoclines year-round) are a good place to view gray nurse sharks regardless of season. (Note: We visited in March.)



SKILL LEVEL AND CONDITIONS: Sites in this area can vary widely in terms of depth, current and surge, so be sure to inform the dive operation about your skill level to ensure your dives are enjoyable. The closest hyperbaric chambers are in Sydney and Brisbane.

SUSTAINABLE SEAFOOD: AN EVER-EVOLVING LANDSCAPE

[BY TWILIGHT GREENAWAY]

Having spent time below the surface of the ocean, divers are more likely than most other people to care about the various impacts of our seafood choices. But that doesn't necessarily make it any easier to decipher what it means to eat seafood sustainably.

For one, the seafood industry isn't static. A great deal has changed in recent years, leaving many consumers with questions such as these: Is wild seafood always a better choice than farmed? What's the carbon footprint of my choices? And where should we turn to find the latest science-based information?

While wild seafood is still popular with many consumers, Ryan Bigelow, outreach manager for the Monterey Bay Aquarium Seafood Watch program, sees the commercial fishing industry as too successful for its own good.

"It's one thing to go out and catch a fish with a pole and line; it's entirely another thing to go out with satellite tracking, sophisticated radar and nets that are large enough to catch a small plane," he said. "We're so good at it now that fish don't really stand a chance.

"It makes a lot more sense to move away from that — at least to some extent," he continued, "and focus on farming, which can be done in controlled situations."

Farmed seafood, however, has gotten a bad rap among ecologically minded consumers — and for good reason. Escapes, disease and pollution were often commonplace in the early days of the industry.

"The American public still has a bad image of aquaculture," Bigelow said. "But a lot of that is based on

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Purchasing responsibly harvested or cultivated seafood is not straightforward, so organizations such as the Marine Stewardship Council, Monterey Bay Aquarium Seafood Watch and Oceana are working to inform consumers and increase transparency in the seafood industry.

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historical tropes — some that were not very accurate and some that were accurate in many cases but not across the board."

Seafood Watch, which is known for compiling the latest science on farmed and wild fish and informing the public with its trusted consumer guides,[1] has begun to include more farmed fish in its green "best choices" and yellow "good alternatives" listings. Bigelow says that trend is likely to continue — mainly out of necessity.

"If we were to have all of our wild fisheries managed at 'best choice' level, we still wouldn't have enough fish to feed us all," Bigelow said. "There is no future without aquaculture. So when you look at it through that lens, it behooves us to find the most sustainable way to farm our fish."

Fish farms now provide more than half of the seafood eaten globally, and that number is rising quickly to accommodate a growing population. It makes sense then that, like most relatively new industries, aquaculture has had to do a lot of growing up recently — and fast.

CHANGES IN THE AQUACULTURE INDUSTRY

For years, the biggest challenge associated with aquaculture was the fact that farmed fish often required sizable quantities of wild seafood to grow to market weight. Known as the feed-conversion ratio or "fish-in/fish-out" ratio, the quantity of wild fish required to feed popular carnivorous species such as salmon, tuna and shrimp was generally much higher than the quantity of fish harvested. In the case of salmon, it often took as much as three pounds of wild fish to produce one pound of salmon.

Now the bulk of the industry is working to replace a portion of that feed with high-protein plant materials (soy meal, brewers grains, etc.), farmed insects and fish oil. There is also a shift toward farming herbivorous species such as tilapia, mussels and clams.

Bigelow also mentioned the trend of aquaculture companies to move toward contained, on-land systems and systems located in areas where escaped fish can't compete with their wild counterparts. Indoor fish farms that use recirculating systems — wherein the water is filtered and reused — are especially likely to be sustainable. "You can drop almost any species in a recirculating aquaculture system (RAS), and it's going to get a Seafood Watch green recommendation," he said.

When companies build fish farms in the ocean, Bigelow said, "many have stopped saying, 'there's wild salmon here, so let's just build a farm here.'" For this reason and others, the likelihood that the fish will carry disease or wreak biological havoc if and when they escape into the wild is decreasing.

Taylor Voorhees, Seafood Watch senior aquaculture scientist, agrees. He said he has seen fish farmers make much more careful decisions about where to build their farms in recent years.

"We've realized that deeper water with more tidal flushing is typically better," Voorhees said. "And sites that have hard bottoms are typically better than those that have softer, muddy bottoms. All of those things are more likely to be able to disperse the waste that comes out of the pens and therefore have less of an impact."

THE ARGUMENT FOR WILD

Not everyone sees aquaculture as the future of seafood. Geoff Shester, the California program director at Oceana, a global nonprofit aimed at protecting and restoring the world's oceans, would rather see more consumers opt for wild seafood that's low on the food chain.

Shester echoes the sentiments of Oceana's chief executive officer, Andy Sharpless, whose book *The Perfect Protein* proposes a radical shift in the way American consumers view seafood. Both Sharpless and Shester invite seafood eaters to take an especially close look at what's happening to forage fish — species such

as mackerel, sardines and anchovies — which are being caught at massive rates and fed to farmed fish and land-based livestock in the form of fishmeal and fish oil.

"Globally more than 90 percent of the forage fish that are removed from the ocean are fed to other animals. It's an inefficient use of what we're already removing," Shester said. The solution? We should eat many more of the foraged fish ourselves. If we did so, Oceana calculates that there would be about 400 million more seafood meals available worldwide every year.

"The rest of the sustainable seafood world has gone down this path of, 'It's OK if you feed them, as long as you feed them less fish,'" Shester said, "but the problem is whenever you feed an animal, you have to take into account the full life cycle and the effect upstream — the water and energy use and all that."

As Shester sees it, the ocean is much more than a source of food. "It provides air, it provides the weather, it provides for amazing wildlife…," he said. "So the question we need to ask ourselves is: Do we want a future where the ocean is feedlots or a food web?"

He believes the solution is seafood that doesn't need to be fed: forage fish, farmed bivalves (oysters, mussels, clams, etc.) and more responsibly caught wild seafood.

When it comes to greenhouse gas emissions — a piece of the environmental puzzle with a direct impact on the ocean via acidification[2] — some studies show that wild fish have one of the lowest carbon footprints of any protein available.

"North American seine-caught sardines have half the carbon footprint of organic lentils and about a quarter of the footprint of tofu or peanut butter," Shester said.

CONSUMER DISCONNECT AND FRAUD

On a macro level both Shester and Seafood Watch's Bigelow pointed to Americans' lack of connection to the source of their food and the resulting gap in basic understanding. "Divers, surfers and costal residents are some of our biggest supporters," Bigelow said, "but most other Americans have no real contact with the ocean, so it's difficult for them to imagine what a fish farm is, let alone what sets apart the sustainable ones."

Shester agreed. "We have a pretty strong disconnect between what we eat and where it's coming from," he said. "So the more you can become familiar with what species you're eating, what method was used to farm or catch it, and who the fishers were, the better."

Oceana is one of a number of groups that have tested seafood in restaurants and grocery stores to identify how often the species being sold is the one actually appearing on consumers' plates. The group

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released a report in September 2016 that found that of the of the 25,000 seafood samples it analyzed, 20 percent — one in five — were incorrectly labeled.[3]

"You can walk into a store or restaurant and get something other than what you're buying ... but the store owner or chef may have been lied to. It's a symptom of the larger lack of traceability," Bigelow said. And more important, fraud makes other consumer decision-making moot.

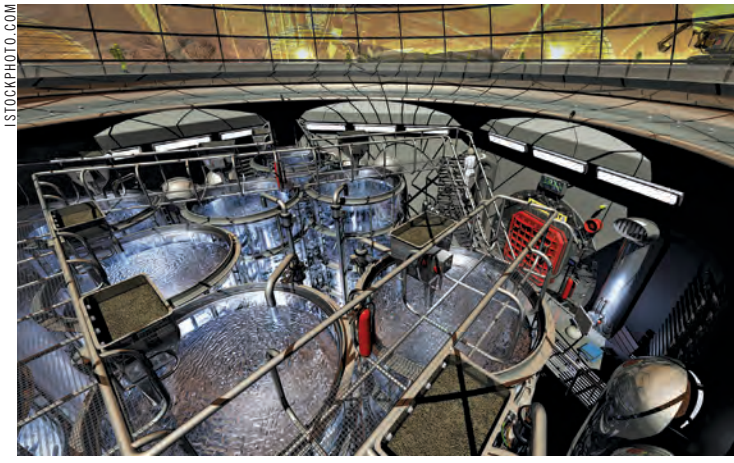
"We're very interested in figuring out the traceability issue," Voorhees said, "because the lack of it has the real potential to undermine the work that we do here [at Seafood Watch] in putting together these recommendations."

TRACEABILITY IN WILD SEAFOOD

When it comes to traceability in wild seafood, the Marine Stewardship Council (MSC) oversees the largest global effort to connect consumers with fish that has been managed and caught responsibly.[4]

"When you buy MSC-certified wild fish," said John Corsiglia, the organization's U.S. media manager, "you're supporting fisherfolks who have gone through an extensive evaluation to prove that the way they're fishing isn't depleting fish stocks, and there's good government management of the fishery." The group uses a single, easy-to-recognize blue label, and it does not rate fisheries against one another like Seafood Watch does. But the organization makes a map available on its website where a user can locate and

The aquaculture industry has grown rapidly in recent years, and its growing pains (problems such as escapes, disease and pollution) affected its reputation among ecologically minded consumers. Wild-caught seafood, however, is not without its own problems, including bycatch and diminishing stocks.



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read about, for example, the West Greenland cold-water prawn fishery or the North Pacific albacore tuna fishery, among dozens of others around the world.

"If you want to keep it simple, just look for the MSC label," Corsiglia said. "Or if you want to look under the hood, there are public assessment reports for every fishery. All the stakeholder comments are available publicly."

"MSC has a staff of about 150 people working around the globe to analyze government data and assess fisheries," he continued. "The group's sustainable fisheries standard was developed in the late-1990s with input from industry, governments, nongovernmental organizations (NGOs) and the science and academic communities. The standard is also periodically reviewed (with multiple stakeholders) as new science emerges, and the latest update occurred two years ago."

About 10 percent of the total global catch is MSC certified. While in some regions it's much higher (in the U.S. Pacific Northwest, for instance, 83 percent of the fisheries are certified), the developing world can pose a challenge for the MSC — especially nations in which the government doesn't collect data on fisheries.

In these cases, the MSC tries to help. "We do a lot of work with fisheries to help them find funding — both charitable and government — to help them gather data," Corsiglia said.

CHANGES AFOOT INTERNATIONALLY

More than 85 percent of the fish and shellfish Americans eat is imported, and a great deal of it comes from Asia. A cascade of news reports about slavery and other human rights violations in the fishing industry,[5] as well as growing concern about farming practices and antibiotics use in China, Thailand and other parts of Asia, have raised concern among some consumers interested in fair and sustainable food.

While there has historically been a lack of transparency about Asian seafood in the U.S., Seafood Watch's Bigelow and Voorhees can attest to some significant changes on the horizon. While Bigelow says the vast majority of Asian imports still fall into the red "avoid" category in their seafood guides, a number of Asian companies are expressing interest in reaching consumers who care about how their fish is caught and raised.

"Those companies are coming to us for advice about how to get out of the red and how to get into the green," he said. "In the beginning it was just [Seafood Watch] talking to consumers, and now that has shifted completely to where we are sitting down with these governments to talk about how they can create sustainable products."

Voorhees has made several trips to Asia to consult on best aquaculture practices, and he and other Seafood Watch staff are working with a group called the Asian Seafood Improvement Collaborative to broker a stronger connection to Asian producers.[6] In the Thai shrimp industry, for example, which was particularly hard-hit by disease recently, Voorhees says he has seen "almost the entire industry switching to a more closed-pond system" in an act of self-preservation that will also cut down significantly on pollution.

"We're excited about where it's going," Bigelow added. "We hope a lot of those industries are turning the tide." AD

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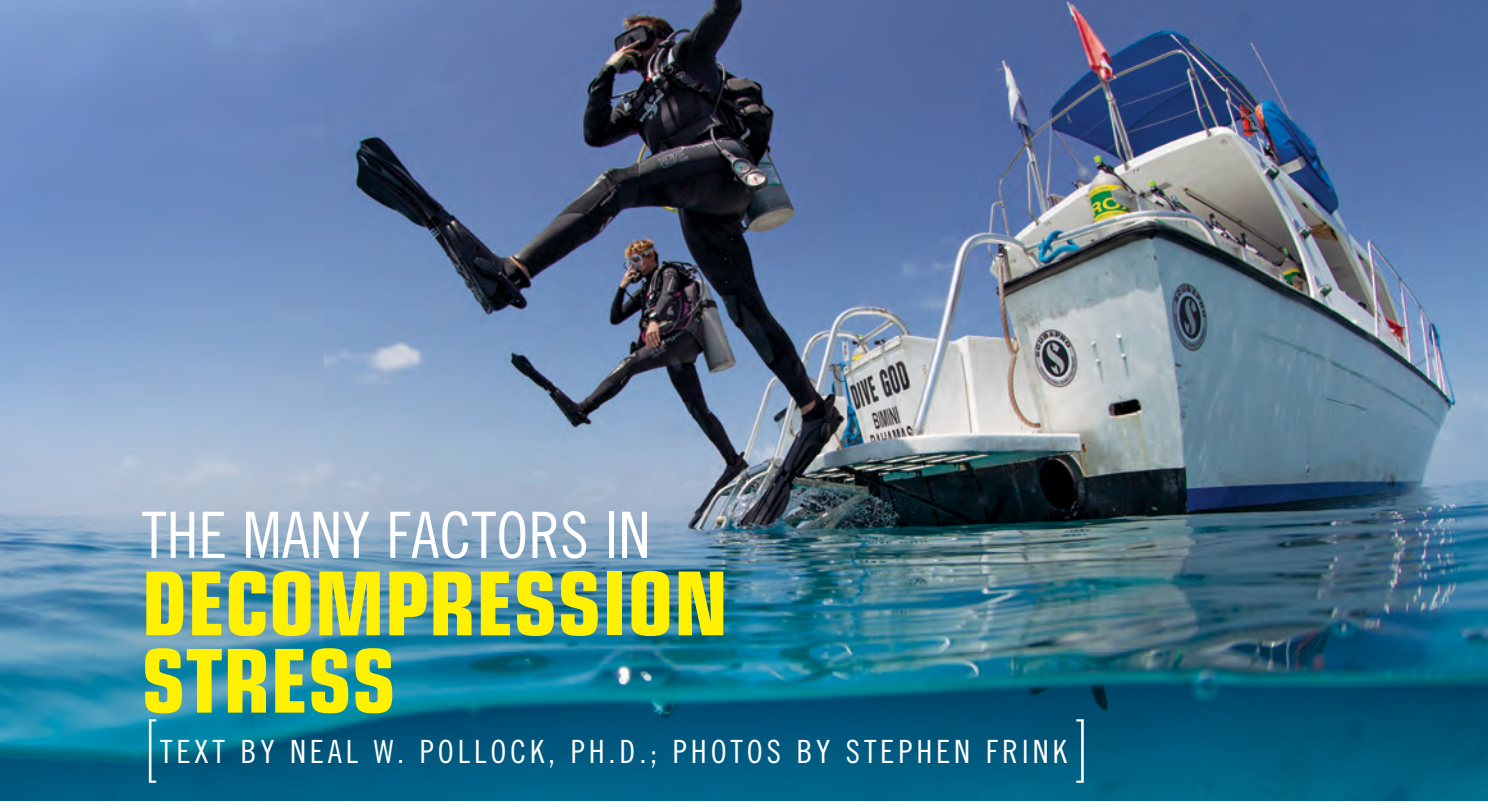


THE MANY FACTORS IN DECOMPRESSION STRESS

TEXT BY NEAL W. POLLOCK, PH.D.; PHOTOS BY STEPHEN FRINK

For much of the past century a small number of algorithms have been used to estimate divers' decompression obligations. Advances in recent decades, however, have produced an array of mathematical models used in personal dive computers. All current computer models base their assessments almost exclusively on the pressure-time profile of a dive. While this is certainly the most important element of decompression sickness (DCS) risk and can provide excellent guidance, many factors influence the totality of inert gas uptake and elimination — and ultimately decompression safety.[1] Divers can reduce their risk by thinking beyond the current algorithms.

The variables affecting decompression stress can be clustered into four broad categories: dive profile, exercise profile, thermal profile and predisposition factors (Figure 1).

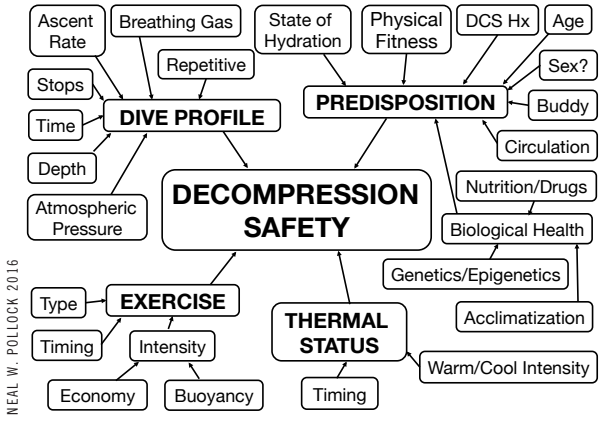


Figure 1. Factors affecting decompression safety[1]

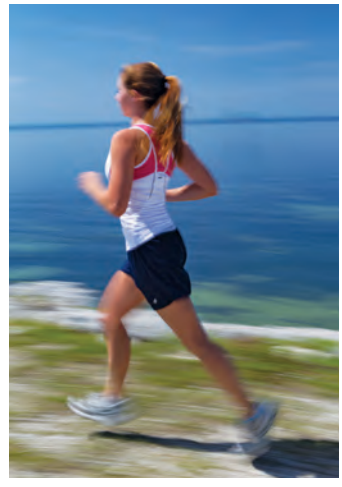
DIVE PROFILE

Even for situations in which all other factors work against decompression safety, if the dive profile does not generate significant decompression stress, DCS will not develop. Critical elements of the profile include time spent at each depth, ascent rate, stop depth(s), stop duration(s) and breathing gas(es) used. Recent previous dives can alter the impact of these variables. Subtler effects are created by the water density, whether it is fresh or salt, and the atmospheric pressure at the surface. The lower the atmospheric pressure is at the surface, the greater the decompression stress for a given dive. While the greatest reduction in atmospheric pressure comes with increasing altitude, fluctuating weather conditions also have a minor effect.

Most algorithms used in dive computers provide adequate protection for typical recreational exposures, but DCS can develop even in people who dive within the limits of decompression models. The risk results from the complex interplay of the dive profile, thermal and exercise states and a host of individual factors. For some, the level of risk associated with current decompression algorithms is acceptable. Others may desire additional

buffers to address differences in susceptibility or risk tolerance. Gradient factors offer one useful option for altering conservatism (see "Gradient Factors," *Alert Diver* Fall 2015 or *AlertDiver.com/Gradient_Factors*).

EXERCISE



The timing and intensity of exercise can have substantial influence on decompression safety. In the broadest sense, exercise during the descent and bottom phases of a dive promotes circulation and increases inert gas uptake, effectively increasing decompression stress. Conversely, light to moderate exercise during the ascent and stop phases will increase circulation and promote safe inert gas elimination, thus reducing decompression stress. Problematically, though, higher-intensity exertion during the ascent and stop phases or soon after the dive can promote bubble formation and increase the effective decompression stress. The best prepared divers will have the equipment and skill to control the amount of exercise needed before, during and after diving.

The best prepared divers will have the equipment and skill to control the amount of exercise needed before, during and after diving. Exercise intensity should be kept as low as possible during the descent and bottom phases. Light exercise — on the order of no more than two to three times resting effort (2.0-3.0 metabolic equivalents [MET]) and with very low forces on the joints — is appropriate during the upper ascent and stop phases to help increase the rate of inert gas elimination. High-intensity exercise and exercise involving high joint forces should be avoided before and after dives. If undesirable physical activity is required, dive profiles should be made conservative to compensate for the increased risk.

THERMAL STATUS

The thermal status of a diver can also have substantial influence on decompression status. A study by the U.S. Navy provides an elegant example.[2] Dives were divided into two phases: descent and bottom, and ascent and stop. The water temperature was kept constant in a given phase to produce "warm" or "cold" (more accurately, "cool") status.

Dives were carried out with the phases matched ("warm/warm" and "cold/cold") and mismatched ("warm/cold" and "cold/warm") with divers exercising throughout. The greatest differences in DCS were evident between "warm/cold" and "cold/warm" exposures (Figure 2). The "warm/cold" condition yielded a DCS rate of 22 percent. The "cold/warm" condition was extended to more than twice the bottom time and still yielded a DCS rate of only 1.3 percent. Even if the effects of this study are exaggerated by a prolonged ascent/stop phase that allowed for bottom-time changes, the results document a dramatic impact by the timing of thermal status variations.

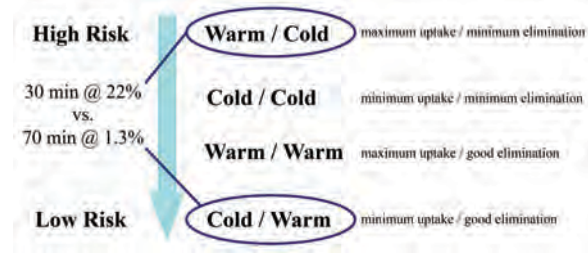


Figure 2. Thermal status and decompression stress (developed from material in Gerth et al. 2007[2])

Diver thermal status — not water temperature, a potentially very different thing — will almost certainly be measured in the future, but meaningful monitoring will require new devices and much research data to adjust algorithms appropriately.

Maintaining a neutral thermal status during the descent and bottom phases — certainly avoiding unnecessary overheating — and trying to achieve a mild warm status without high-intensity exercise during ascent will reduce the risk of DCS. The difficulty comes in reconciling optimal practices for decompression safety with divers' desires and normal practices. Pouring warm water into wetsuits predive or placing chemical hot packs inside suits is being replaced by active heating garments available for both wetsuits and drysuits. The problem with these strategies is that they increase inert gas uptake early in the dive when uptake is already typically highest. Since warm water and chemical hot packs lose their effectiveness over time, and active heating systems can weaken or fail, the warm-cool pattern associated with the greatest risk of DCS can develop.

Active heating garments can have legitimate value but should be used thoughtfully. Warming should never be greater than is needed, and divers should consider a low or off setting early in the dive and a gradual increase in warming during ascent. Caution is required in increasing active heating during ascent since gas solubility decreases in tissues as they warm, potentially promoting bubble formation before blood perfusion increases sufficiently to remove the gas.

Divers must also be aware that postdive warming can increase DCS risk. Taking a hot shower or getting into a hot tub will decrease the tissue solubility for inert gas and can promote bubble formation.

Ultimately, divers need adequate warmth to preserve clear thinking and physical performance, but they should be mindful of the decompression hazards created by thermal manipulation. For many divers passive systems are adequate to maintain physical and cognitive performance. Those who need or desire active warming systems should be aware that those systems can increase decompression stress even if they work correctly and that they may substantially increase decompression stress if they fail.

PREDISPOSITION

Predisposition is a catch-all category that includes an array of personal factors that can influence decompression stress. The impact of each may range from negligible to substantial for a given individual and/or dive. None of these parameters can currently be quantified sufficiently to incorporate into decompression algorithms. Understanding the potential impact, however, can help divers manage their true risk.

State of hydration. Proper hydration is important for general and diving health. Dehydration can increase the risk of DCS, and hyperhydration can promote immersion pulmonary edema. Practically, it is probably fair to say that the diving community has sometimes focused too much on dehydration as a risk factor in decompression stress. This may arise from two realities. First, since fluid shifts and indications of marked dehydration can be a consequence of DCS, there can be some confusion over cause and effect. Second is the human desire to find something simple to blame.

Physical fitness. Divers should be physically fit enough to meet the normal demands of diving with sufficient reserve capacity to handle emergency situations. The higher the level of physical fitness, the lower the relative strain of a dive. Optimal body composition reduces the amount of ballast weight that has to be carried to achieve neutral buoyancy and, in the case of an obligatory postdive climb out, reduces the absolute effort required. Limited data have associated higher levels of physical fitness with reduced postdive bubble formation and lower risk of DCS.

The biggest practical challenge typically arises with efforts to schedule exercise around busy diving schedules. While limited findings suggest that a single bout of high-intensity exercise conducted 24 hours before diving may have a protective effect, the data concerning exercise closer to the start of diving are fairly confusing. Exercise should probably be avoided pre- and postdive where possible.

DCS history. An individual's history of DCS may indicate a greater predisposition, either physiologically or behaviorally. The importance of history may also extend to a buddy since his or her actions can influence the outcome of a shared activity.

Age. The impact of increasing age is difficult to assess since it may be confounded with reduced levels of physical fitness and changing health and practices. Increasing age is associated with increased bubble formation, and this potentially indicates a reduced tolerance for decompression stress.

Sex. There is no compelling evidence in the diving literature to confirm that sex plays a role in the development of DCS. This runs contrary to a limited

amount of data from hypobaric chamber exposures that suggest that the physiological risk may vary somewhat across the menstrual cycle, with a slightly elevated risk during the first half of the cycle. Practically speaking, even if women do have a slightly elevated physiological risk in comparison to males, a tendency toward more conservative practice may reduce the net risk.

Circulation. Compromised circulation resulting from prior injury has been viewed as a possible risk factor, but with little empirical evidence. The presence of a patent foramen ovale (PFO) has the potential to alter circulation by allowing a volume of blood to reach the systemic circulation without undergoing filtration through the lung. PFO has been identified as a risk factor in serious DCS. Perspective is required, though, for while the frequency of PFO is fairly high (about 25 percent of the population), the incidence of serious DCS is low. The degree of patency varies and can be important. PFOs are also not the only way to move bubbles into arterial circulation. Bubbles can cross in the lungs, particularly during exercise (while or after climbing out of the water, for example). Dive profiles that minimize bubble formation provide the greatest protection since there will be no bubbles to cross over.

Biological health. A host of factors falling under the category of biological health may influence decompression stress. Some probably play minor roles, while others may play important roles that have not yet been fully defined. Nutritional status, for example, is important for general health and physical fitness and may influence the biochemical response to decompression stress.

Similarly, the potential interaction between drugs and diving is another area with virtually no research data but legitimate concerns. Genetic predisposition and epigenetic expression likely also have importance that is just beginning to receive research attention.

Acclimatization. Acclimatization is defined as adaptive change in response to repeated natural exposure. The effect may be positive or negative. Repetitive diving could influence decompression stress, and not just through the presence of residual inert gas. Positive acclimatization could produce a reduction in the biochemical response — effectively a desensitization that may reduce the magnitude of the insult. Negative acclimatization could produce a heightened response — effectively a sensitization to decompression stress. The published data relevant to diving are conflicting, which may be in part a reflection of how divers dive. The effect of positive acclimatization could easily be masked by patterns of increasing exposure intensity over dives in a series.

SUMMARY

Most personal factors that affect decompression stress can be modified. Maintaining reasonable levels of physical fitness, nutrition, restfulness and hydration all contribute to good health and good diving health. Good health can reduce physical limitations and the need for medication.

When selecting dive buddies, divers should consider compatibility of goals, risk tolerance, skills, knowledge and capabilities. A shared understanding of both risk and best practices can improve operations and readiness.

Thoughtful and well-informed divers know far more than current dive computers about conditions that may affect risk during a dive — and likely they will know far more than dive computers for many years to come. Being conscious in real time of conditions that may alter risk can make it easier to build in appropriate buffers to promote safety. Small changes toward conservatism, when applied across a variety of factors, can enhance safety with little impact on what can be accomplished during a dive. AD

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IMAGING

DOUGLAS SEIFERT

SHOOTER

THE ENDLESS SUMMER OF DOUGLAS SEIFERT

PHOTOS BY DOUGLAS SEIFERT; INTRODUCTION BY STEPHEN FRINK

Maybe there was something in the water. Douglas David Seifert learned to swim at what is now one of the most revered macrophotography destinations in the United States: the Blue Heron Bridge in Riviera Beach, Fla. In the early 1960s Palm Beach County was an absolute paradise; there were very few dive shops and hardly any tourists who were interested in viewing the near-shore underwater world through a facemask. But Seifert's childhood obsession was doing just that while growing up on Singer Island, Fla. He went deep-sea fishing with his father every weekend and had aquariums at home for which he collected invertebrates and tropical fish. He became a keen observer of fish behavior at an early age.

Although Seifert failed the classroom portion of his first scuba class at age 12 — the math involved in the dive tables was too much for him at the time — later in life he overcompensated and became a scuba instructor, actually teaching the math that had once confounded him. His immersion in the dive industry brought him in contact with one of the early icons of marine conservation in South Florida, Norine Rouse. "Take only pictures, kill only time, leave only bubbles" was her mantra, and Seifert was her protégé. He had great admiration for her, whom he called "this funky, crazy, fearless 60-something-year-old woman running a dive shop." He recalled that she was not a fan of shark baiting, but at that time there might be 20-30 bull or lemon sharks on a dive even without using bait. This was also a time when any given day diving Palm Beach County would reveal 12–24 turtles, mostly loggerheads. Rouse would dive with a buffing pad, and the turtles would recognize her at a distance and swim right up to her to have their shells cleaned. She had a true rapport with marine life. Her passion for the welfare of marine life was infectious, and helped shape Seifert's lifelong commitment to conservation issues.


STEPHEN FRINK

Douglas Seifert photographs a silky shark in Cuba's Jardines de la Reina.

Wanderlust and an ambition to sell TV and movie scripts in Hollywood drove Seifert west. Soon disenchanted with the entertainment industry, he sold everything he owned to buy an around-the-Pacific ticket, back when such things existed. That meant he could go somewhere such as Australia, spend a few weeks (or months) and then hop on another jet to Fiji or wherever. His parents gave him a Nikonos camera system as a going-away gift, though he knew very little about how to use it. While in Sydney, he wandered into the Dive 2000 store and met underwater photographer Kevin Deacon, who fortuitously offered lessons to the uninitiated.

"In the film days, learning underwater photography without instruction was a very slow and unforgiving process," Seifert recalled. "Kevin accelerated my learning curve, as did a book I read almost daily for four months: *Howard Hall's Guide to Successful Underwater Photography*. Howard and I have since become good friends, but I doubt he'll ever know how meaningful that book was to me at that time in my life." Deacon's instruction proved invaluable when Seifert dived with great white sharks at Dangerous Reef, South Australia, guided by the incomparable Rodney Fox. At the time, fewer than 100 people in the world had ever dived with great white sharks.

Some time later, back in Florida, Seifert met Doug Perrine (see Shooter, Fall 2013) and went with him on a trip to the Azores. Armed with a Nikonos RS and a 20-35mm lens, Seifert managed to get some underwater photos of sperm whales at a time when very few such images existed. He showed them to the publishers of *Ocean Realm*, who happily agreed to publish them along with an article about his

(PREVIOUS SPREAD)

THE MAN IN THE GRAY OVERCOAT

"I have been fascinated with great white sharks since I saw the movie *Blue Water, White Death* in the theater as a child, circa 1971. I traveled to South Australia with my first underwater camera to experience these magnificent animals for myself with the consummate shark guide, host and victim: Rodney Fox. I have been diving irregularly but often with great white sharks in South Australia, South Africa and at Guadalupe Island, Mexico, ever since. Only South Australia offers the opportunity to take a cage to the bottom and see the sharks meander through rocky canyons and around the periphery of kelp and seagrass plains. I was struck by how graceful and serene they were when not being teased with baits suspended from floats at the surface. I was mostly outside of the cage when I made this image. The shark was really a lot closer than it appeared in the viewfinder. I tried not to think about that because the scene was just so electrifying and beautiful."

(ABOVE)

NIGHT MANTAS

"The manta ray night dive off Kona, Hawaii, is one of the greatest spectacles of the underwater world. It's accessible to snorkelers and divers of all skill levels, almost every night of the year. The theatricality of the dive is astonishing to witness; it's a light show with swirling, feeding manta rays, a Cirque du Soleil of the sea. Afterward, when the divers have left, does the show still go on? My team and I spent a few nights with a boat, a generator, and a movie light intending to find out. Of course, where there is food, there are diners. The movie lights provided attraction to lure the copepods to the surface, where the fish gorged themselves, and the mantas did barrel rolls as they fed upon the abundant food. This is a color image made virtually black and white by circumstances, not by processing."

adventures in the Azores. At the time *Ocean Realm* was the most prestigious dive journal, and having his images prominently displayed was momentous. He followed that article with one about manatees and dugongs, which was the cover story for the journal's issue that debuted at the 1996 Diving Equipment and Marketing Association (DEMA) Show. The underwater photo industry noticed those images in particular, and that marked Seifert's induction into the fraternity of underwater photojournalism. Also in 1996 Seifert began writing articles for *Dive International*, a British dive publication (now called *DIVE*). Today he is *DIVE*'s World Editor and the writer of a monthly feature called "Water Column." He has written and photographed roughly 100 features articles.

A hallmark of Seifert's photography and writing is the exacting research that goes into his projects well in advance of travel. "If I didn't read and research, I wouldn't know what I should photograph or recognize the significance of behaviors I might capture," he said. "I go into the sea thinking I know something about what might happen, but nature consistently delights and delivers much beyond my imagination. I could no more dive without my camera than I could write a worthwhile article without the extensive research I do each time."

When asked about his favorite camera for underwater use, Seifert replied, "I think of my camera gear like a toolbox. Sometimes I need a Phillip's head, other times a claw hammer. There is a right tool for each job, and unfortunately there is no photographic Swiss Army knife. It would be more convenient if one manufacturer did everything, but I love the 50-megapixel files of my Canon DSLR, with the beautiful density and ability to crop. They also have my favorite telephotos for topside use. Nikon has a brilliant 60mm macro lens, which is fast and very sharp. Plus, I can use my trusty, 20-year-old Nikonos RS 13mm lens on my Nikon digital camera body by means of a clever adaptation on my Seacam housing. This is my single favorite tool for underwater photography, particularly since I have an overwhelming preference for photographing large marine life such as sharks, whales and manta rays."

Seifert spends as many as 40 weeks per year on the road these days in pursuit of underwater images. He is usually accompanied by his wife, Emily, who was not a diver when they met but now has logged more than 1,600 dives. Much of this time is spent in support of conservation groups such as Shark Savers, Manta Trust and Global Shark Diving.

"I enjoy what I do, and with every dive I gain greater appreciation for my mentors, who taught me so much about the sea in general, and underwater photography specifically," he explained. "Chris Newbert, Doug Perrine, Jim Watt, Avi Klapfer and Howard Hall have all been so gracious to me. Ron and Valerie Taylor, Stan Waterman and Eugenie Clark took me in and brought me to another level of adventure and technique in our decades of diving around the world. I hope I can give some back to the next generation." Despite having had a long and successful career, Seifert has no plans to slow down any time soon. When asked if he ever plans to dial back the travel a little, he readily replied, "I consider Stan Waterman my touchstone, so that means I should have at least another 40 good years in me."

Read along as Seifert describes some of his favorite images.

(OPPOSITE)

DRAGON MORAYS

"Throughout much of their former range, particularly in Hawaiian waters, dragon moray eels have been commercially overcollected to the extent that they are now quite rare. But dragon morays are not collected in the Marquesas Islands of French Polynesia and are thus more frequently encountered. They are by no means common, but on a recent two-week exploration of the Marquesas I had the great fortune to find two together in the same crevice. This was unbelievably lucky, and I spent the entirety of my dive concentrating upon the pair, paying little attention to the manta ray that swam in lazy circles above my head."

LOVE ON THE RUN

"Working under permit in the Kingdom of Tonga, I really wanted to see what goes on in a 'heat run.' Be careful what you wish for. A heat run is a behavior in which male humpback whales compete against each other for the favor of a female in estrus, which they are all pursuing at breakneck speed.

"Jumping in among a group of randy 40-foot-long whales with their intentions alternating between violence and lust is something you don't want to spend time contemplating. As Ron Taylor always advised me, 'You've got to be in it to win it.' So I jumped off the stern into the whales' path. I was overcome by the beauty of the spectacle, and time slowed as it often does in intense situations. To be honest, it was thrilling. To be really honest, it was terrifying. My body floating on the surface was buffeted by cavitation as the whales' bodies and tail flukes passed, and they headed seaward, continuing their love train, indifferent to the dazed voyeur they left in their wake."

MARINE IGUANA

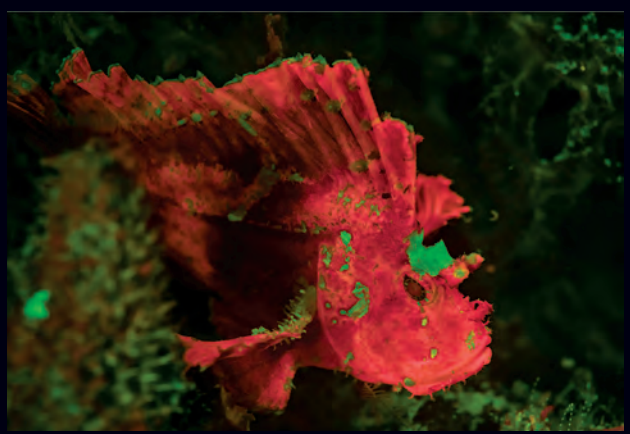
"Only in the Galapagos Islands can marine iguanas be found and only for a short window of time each morning in shallow, near-shore waters with a strong surge and crashing waves over an algae-covered rocky bottom. Underwater photography is most challenging when you're being pummeled by waves, slammed into rocks and protecting a fragile glass lens port (and less fragile life and limb) while giving the iguana enough space to go about its business. I grew up watching Godzilla movies on television, and if ever there were an opportunity to encounter a pint-sized Godzilla, it exists in Galapagos, though solely at the marine iguana's whim."

COCONUT OCTOPUS IN A GUINNESS GLASS

"Every night dive delivers the unexpected, sometimes in weird or funny ways. In Lembeh Strait, Indonesia, we came across a coconut octopus dragging its mobile home — a discarded Guinness glass — across the nondescript muck of one of the dive sites. When caught in the dive torch's beam, the octopus retreated into the relative safety of the transparent glass, perhaps overlooking the fact that it was hiding in plain sight. Working for a UK dive magazine and having attended staff debriefings in a pub or two, I thought it seemed appropriate, perhaps even destined, for *DIVE*'s readership."

LEAF SCORPIONFISH BY DAY AND NIGHT

"At one island we visited in Cenderawasih Bay, Indonesia, there was an abundance of leaf scorpionfish (*Taenianotus triacanthus*), cryptic yet fascinating ambush predators that are often found in pairs or trios. They remain resident at specific coral formations for months or years and can be found in various colorations (for reasons unknown) ranging from pale white to gold to magenta to dark brown. I made the image of a striking magenta specimen on a morning dive and returned to the same reef for our night dive. Instead of using a typical dive light during the night dive, I used Nightsea fluorescence excitation lights and a filter to capture the bioluminescence given off by many coral species as they feed at night. As I shined the blue light of my Nightsea torch into the darkness, the dazzling glow of the same leaf scorpionfish stood out in the darkness from 15 feet away. The orange glow comes from a bioluminescent bacteria associated with the scorpionfish's skin. A companion leaf scorpionfish, which was brown during the day, gave off no bioluminescent glow by night. The bioluminescent glow is believed to be visible to other fish, but the purpose it serves in unknown."



THREE-SPOT FROGFISH

"Masters of camouflage, frogfish play the waiting game, ultimately prevailing as ambush predators par excellence. Their ventral fins are modified for grasping like hands, and they're content to sit motionless for long periods of time. They use another modified fin that they manipulate to move and wiggle like live bait on a fishing rod, luring a feckless fish within swallowing distance of a cavernous mouth. This three-spot frogfish, photographed in the Philippines, has coloration that blends with the reef and is augmented by algal growth, making detection of the frogfish quite difficult, even for seasoned spotters."

SNAPPER AGGREGATION

"French Polynesia is one of my favorite places in the world, and my best dives there have consistently been in the Tuamotu Islands. Normally when one thinks of the Tuamotus, one thinks of sharks. Sharks there are (aplenty), but there is so much more. Visiting Rangiroa at different times of the year will reveal different phenomena. In October, the outside reef and Tiputa Pass are filled with a spawning aggregation of humpback snappers (*Lutjanus gibbus*). The number of fish must reach into the hundreds of thousands if not millions. The reef is barely visible through the mass of fish."

(OPPOSITE)

WHALE SHARK, CENDERAWASIH BAY, INDONESIA

"A whale shark passing overhead allows a different perspective and an opportunity to incorporate the sun and the surface of the sea into the overall mood. In many parts of the world where diving or snorkeling with whale sharks is reliable, authoritarian rule makers have decreed strobe lighting may not be used due to a wholly unsupported pseudoscientific belief, in my opinion, that whale sharks are especially sensitive to lights. I find this one of the truly irritating absurdities of humans' presumptions about animal welfare. As an ambassador for Global Shark Diving's alliance, it is my duty to bring educated reason to the public's and policymakers' perceptions about the true nature of these sublime animals."

LEAFY SEADRAGON

"If an award were given for the animal that looks most like a float in a Mardi Gras parade, the leafy seadragon would have no close second. These unique members of the seahorse family are endlessly fascinating to watch, and they must be watched intently if one is to perceive their appendages among the surrounding kelp and seaweed. The wave-crashed shores of South Australia, where leafy seadragons are found, are dramatic, so in that spirit I framed the animal with wild seagrass and gorgonia forest. I leveraged the strong sunlight, which suggested to me the lighting of an opera — Richard Wagner's Siegfried in a cosmopolitan theater, perhaps." AD

Giant kelp's fronds, stalks and gas bladders together construct beautiful seaweed that follows the ebb and flow of ocean surge. It almost never stops moving or reaching for the surface light. (1/40 sec @ f/16, ISO 400, strobes)

OUT OF THE BLUE

A CHANGE IN PALETTE AND APPROACH

By Jason Bradley

Photography means different things to different people. It's a way to capture a moment or record a memory. It can be functional or artistic. People take pictures to render a scene with a literal perspective or as a medium to translate an abstract concept or feeling.

The reasons I take pictures have changed over time, and my approach over the years shifted as my technical knowledge developed. A few years ago something happened to me totally out of the blue: I became completely bored with color photography. I was just done with it. I know it's strange to become fed up with a whole palette, but it happened nonetheless. As a result I've shot black-and-white images almost exclusively for the past few years, and I've loved it. I have spoken to photographer friends, read articles, and written many words to try and gain some insight; I eventually realized that my underlying reason for taking pictures had changed. The narrative I intended for my work had shifted. My subjects didn't change, but how I looked at them, lit them and developed them in Adobe Lightroom did.

THE GOAL OF EXPERIENCE AND FEELING

As any photographer attempts to do, I hope to create images that are compelling and thought-provoking. I want to create pictures that stick with people, and I believe the best way to achieve that is not to simply present an image of a cool fish but to create a feeling about that fish. My goal is to create work that doesn't show a thing but instead provides a sensation, mood or feeling or leaves an impression relative to that thing. To say it another way, I want my images to translate an experience, not just be a literal visual.

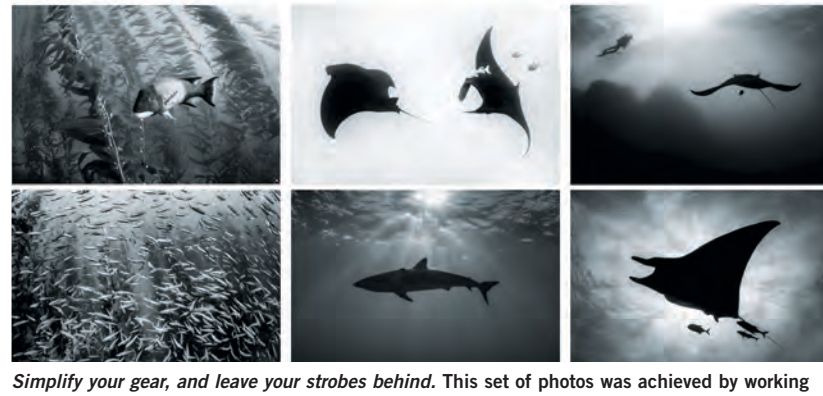
When I take pictures in color, the images tend to be about color, at least to some degree. Color has to work to be part of the frame — it has to grab and contrast, and we photographers tend to want to saturate it, emphasize it and show it in some spectacular fashion. Very little of what I see and experience in the ocean, however, has anything to do with color. For example, one of my favorite things to encounter in the ocean is a giant school of fish. I get mesmerized when I see hundreds or thousands of fish rhythmically and cooperatively moving together through the water. There's something melodic about it; it feels like an organism that's exhibiting a choreography that no solitary animal could possibly display. A lot of the ocean gives me this feeling of many things being together harmoniously, which is an experience that has nothing to do with color. To me, color even distracts from it.

THE PRACTICE OF EXPERIENCE AND FEELING

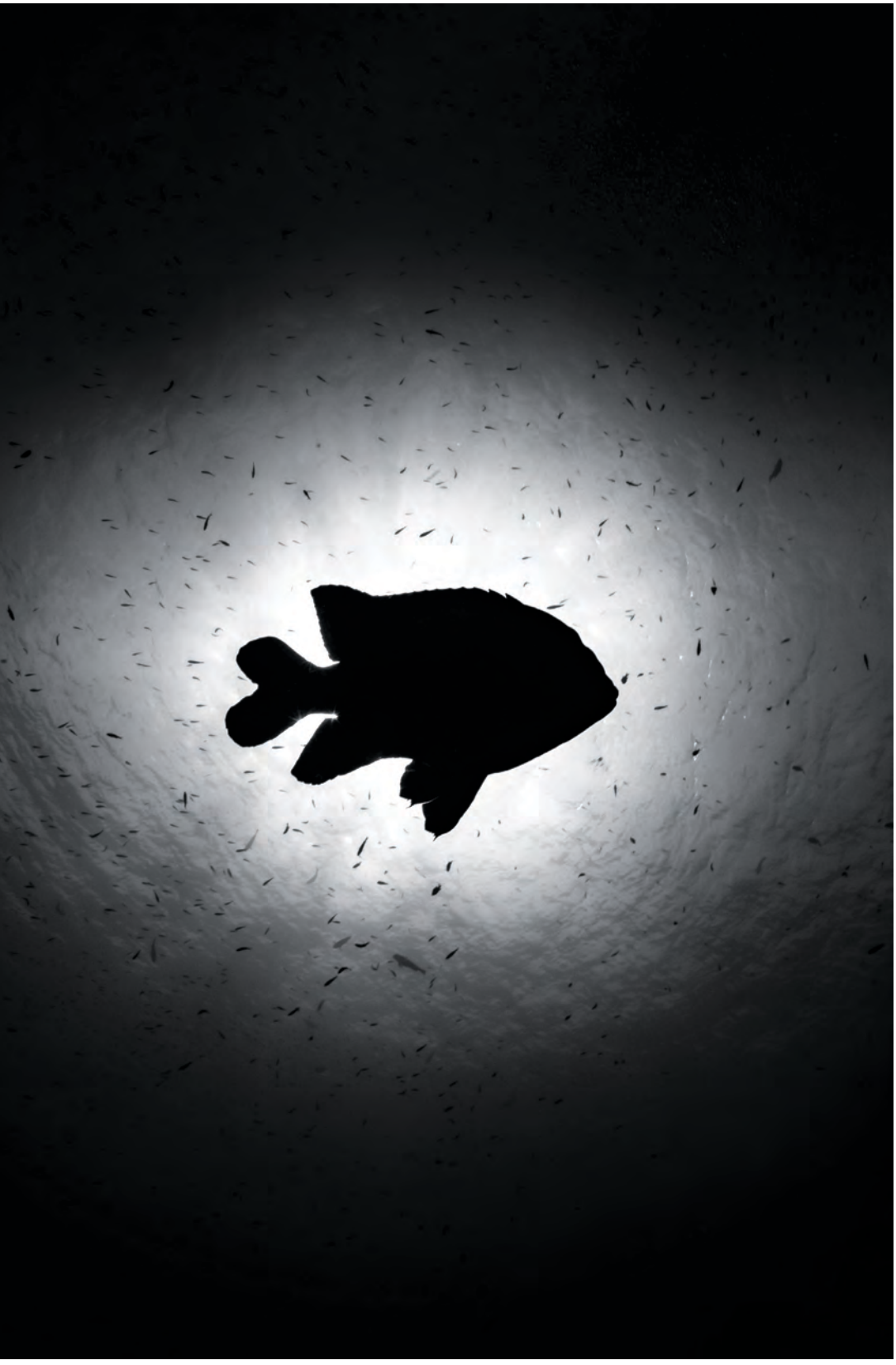
Visualization is the practice of forming mental images of a finished photograph before a frame is ever composed. It's an extremely helpful way for photographers to conceptualize what they are trying to do.

When visualizing black-and-white images during a dive, my frame of mind is vastly different than if I were visualizing in color. By removing color from my thoughts, I'm left with things that are closer to what I'm experiencing. I begin to look at shapes and forms, light and tonality, patterns and textures, details and outlines. By removing color I can escape the idea of wanting to take a picture of the fish and pursue the concept of capturing my experience of the fish.

Visualizing in black and white also changes my technical approach. How and why I light things changes from concerns about backscatter and strobe placement to aesthetics. If my goal is to emphasize a shape, I know to backlight it. If I want to create a texture, I know to sidelight. Or I can deemphasize shapes and flatten a subject or scene by frontlighting. Whatever the case, I connect more with black and white because my mind is in tune to all the things I experience with a school of fish that have nothing to do with color. The following are a few exercises that may help you refine your personal vision in black and white.



Simplify your gear, and leave your strobes behind. **This set of photos was achieved by working solely with ambient light. A strobe would have added little besides backscatter.**



Garibaldis are known for their vibrant orange color, but their shape and the setting in front of the afternoon sunlight at Catalina Island is just as captivating. (1/400 sec @ f/22, ISO 80, no strobes)

Try using grain or noise as an aesthetic. You'll likely have to increase your ISO to capture a scene without strobes, but don't fear that, as the presence of noise can be aesthetically pleasing. In fact, in the Effects panel in Lightroom's Develop module, there is a Grain slider that allows you to add grain to your images. Increase that ISO, jump into those natural monochromatic tones around you, and play. Modern cameras are far more efficient in low light anyway, so higher ISO values should not necessarily intimidate you.

Consider the background to be as important as the primary subject. When color is removed you have to rely on distinguishing the subject from the background by other means. To start, try finding and incorporating simple, clean, uncomplicated backgrounds that contain a solid shade of either white, gray or black. Or use simple gradations from dark to light, but make sure your subject is set in front of a background tone from which it can be clearly distinguished.

TECHNIQUES FOR IMAGE PROCESSING

If you're a Lightroom user, converting to black and white is easy. Although there are a couple of ways to turn your image black and white in Lightroom, I suggest going straight to the B&W panel in the Develop module. Simply click B&W, and your image is converted. The trick is in stylizing what you've captured. Here are a few styles to try for your monochromatic workflow.

Figure 1

High-key and low-key. A high-key image is inherently bright in tone, while a low-key image is inherently dark in tone. With many blue-water images, creating either look can be achieved with a simple wave of the mouse. In Figure 1, notice the small icon in the upper left of the panel. This is called the Targeted Adjustment tool (TAT), and if you click on it, your cursor turns into a crosshair. With this crosshair you can click and drag your mouse on any color in your image that you want to adjust. Click and drag upward for one effect, and drag downward for another.

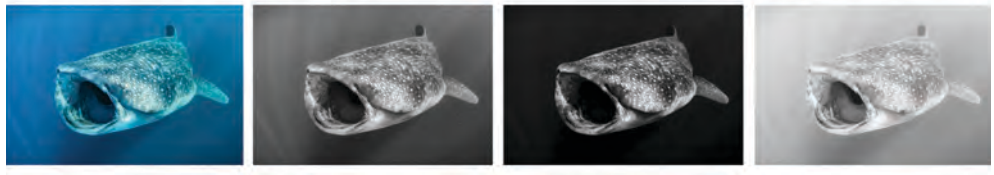


Figure 2: Starting with the image on the far left, we have our original color image followed by the unaltered black and white. The third image moves the Blue slider to the left, thereby darkening the blues, and the fourth image moves the slider to the right, lightening the blues.

To create a high-key image, click and drag your mouse upward. Notice as you do that the blue slider in the B&W panel moves to the right, and all the blue tones are brightened, as shown in Figure 2. To create the opposite effect, or a low-key image, you'll want to click and drag the mouse downward. Note that it's rare to have an image that can work as either a high-key or a low-key image. They usually work as one or the other; experiment to figure out which. Moving just the blue slider left or right will likely be the first in a series of steps to develop the image's final look.

Color toning. In addition to the straight black-and-white look, you can also tone images. To tone your black-and-white images, look no further than the Split Toning panel. There are three sections to this panel, as shown in

Figure 3

Figure 3. You can control the hue and saturation of your highlights and shadows, or you can shift the balance of the two to favor one or the other. My personal preference is to warm-tone images, which imparts a sepia feel. I especially like this look for printing, but Figure 4 shows three different ways you can tone your work. The first image is warm toned, the second cool toned, and the third is split toned.

Figure 4: The first image on the far left is warm toned, the middle image is cool toned, and the third image is split toned with warm highlights and cool shadows.

To create a warm tone, I suggest setting your Hue slider in Highlights and Shadows to 35, and then slowly moving the Saturation slider to the right to taste. Feel free to adjust the Hue slider in either direction to fine tune it to precisely what you like, but I've found 35 to be a good number for warmth. Cool toning an image is similar to warming; just begin with your Hue slider at 220. To split tone, try splitting the difference, but play and experiment as you go. You can set your Highlights to 220 and your Shadows to 35, or visa versa. Whichever direction you choose, toning can help create just the feel or style you're looking for.

Treat my suggestions as starting points for a process that will take you toward a photographic style that only you can discover. Whether you simplify your camera gear and dive without strobes, focus on uncomplicated backgrounds or shift your approach from photographing creatures to focusing on patterns, shapes, textures, tones and moods, the trick for finding what you like is to continue to experiment and be playful with your photography. AD

STEPHEN FRINK

END THE U.S. SHARK-FIN TRADE

A BIPARTISAN BILL BEFORE CONGRESS IS POISED TO STOP THE SALE OF SHARK FINS IN THE U.S.

By Alexandra Cousteau

I grew up in and around the sea, surrounded by pioneers of ocean exploration and conservation. If there's one thing I learned from my experiences with my father, Philippe Cousteau, and my grandfather, Jacques-Yves Cousteau, it's the interconnectedness of ocean life. Every creature has its place, and one group of creatures in particular plays a vital role in ocean ecosystems while also having a special place in divers' hearts: sharks.

The joy of seeing these magnificent predators in their natural habitat, on their terms, is difficult to describe to someone who has not been lucky enough to experience such a moment. A shark's graceful power can make you feel at once vulnerable and deeply privileged to be able to witness the beauty of this animal in its habitat. Seeing a shark while diving engenders a feeling of being a guest in its home.

This is why divers, more than anyone, should be outraged at the degrading, disgusting treatment of sharks. To satisfy a demand for shark-fin soup, sharks are hauled onto boats, where their fins are hacked off, and then their mutilated bodies are tossed back into the ocean, where they drown, bleed to death or are even eaten alive by other fish.

The conservation organization Oceana reports that up to 73 million sharks are killed in the shark-fin trade every year. This is a trade that needs to be stopped. To that end, Oceana has worked with lawmakers in congress to introduce the bipartisan Shark Fin Trade Elimination Act (S. 3095/H.R. 5584), with cosponsors Sens. Cory Booker (D-NJ) and Shelley Moore Capito (R-WV), and Reps. Gregorio Kilili Camacho Sablan (I-MP) and Ed Royce (R-CA). This bill would make the buying and selling of shark fins illegal in the United States. I urge legislators and citizens to do everything they can to ensure this bill passes.

The fin trade is one of the greatest threats to sharks worldwide. The act of shark finning is currently illegal in U.S. waters, and even though 11 states have passed shark-fin trade bans, fins are still being bought and sold in the United States. Once a fin is removed, it is impossible to know whether it came from a shark that

was legally harvested for its meat or from a shark that was finned at sea.

A recent report on shark finning revealed large discrepancies in shark-fin trade data, with other countries reporting sending the U.S. more shark-fin products than the U.S. recorded importing. It is nearly impossible to know the true origin of any fin that enters or leaves the United States. Of the shark-fin products entering the U.S., more than 85 percent come from countries with no finning regulations in place. A 2006 study found that the 14 most common species involved in the Hong Kong fin trade (the historic leader in the global fin trade) were all near-threatened, vulnerable or endangered, according to the International Union for Conservation of Nature. So with no good way to know where a fin comes from, those entering the U.S. could be the product of a practice that is banned in U.S. waters, and worse, they may be the fins of sharks that are at risk of extinction.

An all-out trade ban would solve this problem. There would be no need to try to figure out whether a fin was hacked off a live, endangered shark, because no fins could be sold in the United States. We're already employing this strategy for elephant ivory and rhino horns, and it's time sharks received the same protection. Polls show that 8 in 10 Americans support a nationwide trade ban, and dozens of organizations such as Sierra Club and Sea Shepherd have declared support for the Shark Fin Trade Elimination Act. But for this bill to pass it needs all the support it can get, and I can't think of a better standard bearer for this issue than the diving community.

As you all know, an ocean without sharks is an ocean out of balance. Sharks provide some of the most memorable moments in a diver's career, but they also provide balance that is necessary for every population in any given ecosystem to thrive — from sea grasses to corals to fish. The abundance and biodiversity that we divers live for is dependent upon a healthy ocean, and a healthy ocean needs sharks — and sharks need you.

Please call and tell your members of congress to support this bill. I urge you to make this a central issue for the diving community. Watch the video at the link in the sidebar, and share this appeal with your friends and family.

Since my grandfather took his first scuba dive a little more than 70 years ago, sharks have been giving divers the ultimate thrill. Unfortunately, unless we act as a community, many of our favorite species may not make it another 70 years. Those moments of awe and wonder will become fewer and farther between. It's time to end the buying and selling of shark fins in the United States, and it's time for divers to stand up for a fish that has given us so much. AD

NANCY BOUCHA / MARINE PHOTOBANK

Humans kill up to 73 million sharks every year, many of them for their fins. Although finning sharks is illegal in U.S. waters, and 11 states ban the sale of shark fins, fins are still bought and sold in the U.S. A bill currently before Congress may put a stop to this trade.

"The fin trade is one of the greatest threats to sharks worldwide."

DAVID JACOBSEN-FRIED / MARINE PHOTOBANK

LEARN MORE

Watch the video at *youtube.com/watch?v=IFzKH-09WM0.*
Read Oceana's report at *oceana.org/FinBanNow.*

RETURNING TO DIVING

GETTING BACK UNDERWATER AFTER COMPLEX BREAST CANCER SURGERY

By Connie Crowther


RACHEL HANCOCK DAVIS

The sleek nurse shark shot out of its lair as we swam by the coral ledge. We followed it along the Key Largo, Fla., reef, swimming through thick clouds of colorful tropical fish. This familiar experience felt extraordinary because it was my first dive after two years of breast cancer, tests, surgeries, setbacks, treatment and reconstruction. Last year some people weren't sure I would ever dive again.

I have been an active diver and DAN® member for 28 years, and I've logged around 2,000 dives during that time, at home in South Florida as well as abroad. Since 2007 I have been a trained buddy assisting Diveheart divers with various or different abilities, never considering that I would one day be challenged myself. When my doctor said, "You have invasive breast cancer" and "You are not a candidate for a lumpectomy," I knew I'd have a long trek back to diving.

The following strategies for getting back into the water after breast cancer (or any lengthy illness) might be helpful to other divers:

- From the start, let your doctors know you are a scuba diver and you want to get back into diving after your return to wellness.
- Use your love of diving to lighten difficult moments during treatment. I sat through hours of chemotherapy looking at diving websites on my tablet. During tough MRIs and biopsies, I daydreamed about memorable dives for distraction.
- Be positive. Attitude is everything. An upbeat nature influences everyone, even your caregivers, and creates a positive atmosphere for recovery.
- Join a support group for information, sharing, caring and humor. In my groups we laughed more than we cried.
- Request physical therapy. Along with continued exercise, this was a cornerstone of my recovery. Physical therapy also provides an opportunity to learn about lymphedema and managing your risk of it.
- Keep your dive buddies. Stay in contact through social media, phone calls, visits and social events.
- Remember your dive gear that's languishing in the garage. Have it serviced, and do a trial run in a pool before using it in open water. I had to replace my buoyancy compensator, wetsuit, gauges and several hoses. Everything else needed only a tune-up.

My doctors and therapists established benchmarks for returning to diving: completing chemotherapy and treatments, tissue healing, recovery from complex reconstruction and rebuilding sufficient strength and range of motion for diving. My oncologist approved me for diving while I still had a port implanted in my chest.

"Your attitude, enthusiasm and determination to return to diving were a great part of your spectacular recovery," my physical therapist told me. "After your first dive, you quickly moved to another level of wellness."

My reconstruction involved a deep inferior epigastric perforators (DIEP) flap, which is a complex 10-hour plastic surgery and microsurgery to sculpt flaps of abdominal tissue into breasts. Candidates for breast implants require less downtime for recovery — two to three months compared to my six months.

This summer, with my doctor's permission, I dived often, during the day and at night, shallower than 40 feet. I am planning many more dives, including a trip to Tahiti in 2017. My next challenges are returning to deeper diving and to again assist Diveheart divers for their (and my) physical and psychological therapeutic benefit and for the joy of being underwater. 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.

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COMPRESSORS

THE ART AND SCIENCE OF PRODUCING BREATHING GAS

By Rob Bleser

One of the first things I tell students in compressor maintenance classes is this: "Providing breathing air for consumption in an increased partial-pressure environment is one of the most invasive things you can do to the human body."

As most divers know, air is roughly 20.9 percent oxygen and 78 percent nitrogen. The remainder includes very small amounts of inert gases such as argon and carbon dioxide (CO_2). The air we breathe on the surface also includes a small amount of water vapor. As the air is compressed, the water vapor is compressed into liquid water. Some oil mist (from oil-lubricated compressors) is produced as well, along with any gases or vapors that might have been drawn into the compressor intake. The water, oil and vapors are all considered contaminants and must be removed to provide the diver with clean, breathable compressed air. As the compressed air is breathed, the oxygen, nitrogen and any impurities travel from the alveoli in the lungs into the bloodstream and then to the body's tissues and cells.

There are basically two types of compressors used for breathing air production: low pressure and high pressure. Examples of low-pressure units (approximately 140 psi to 250 psi) are hookah rigs and hard-hat systems. High-pressure units are used to compress air up to 6000 psi for filling scuba and storage cylinders.

The level of impurities in the final output of a compressor depends on the type of purification system used (if any) and how often the filters are changed.

Some recreational low-pressure compressors have little or no filtration included. Diving depths with these are restricted due to hose length and air production, but one must still be very careful about what is drawn into the intake, especially when it comes to carbon monoxide (CO). CO, a product of engine exhaust, is deadly and can be drawn into a compressor's intake if the intake is placed too near a potential source of CO.

High-pressure compressors, on the other hand, have several stages that increase the pressure to levels that allow the air to be pressed into scuba cylinders and/or storage banks. Each stage compresses (and condenses)

STEPHEN FRINK

the air, so the air must be cooled and the moisture/oil mist captured, which is done with cooling coils and separators. The separators must be purged in a timely fashion — usually every 10-15 minutes, depending on the humidity. This is done manually with many smaller portable compressors but usually with an autodrain system on larger stationary units.

The final air delivery then needs to be purified via filtration. A typical purification filter will contain three substances: a drying agent, activated carbon (to remove remaining oil mist and odors) and a catalyst to convert CO into CO_2. The media inside a purification filter has a useful limit, so proper filter changes must be conducted based on the amount of air that passes through it.

There are other gases produced for diving, the most common of which is nitrox. Nitrox (also known as enriched air or EANx) is any gas mix that contains an elevated percentage of oxygen between 23.5 percent and 39 percent. Nitrox can be produced by the following methods:

- Adding pure oxygen to a cylinder and topping it off with pure air is called partial-pressure blending. This procedure, like any process that requires handling pure oxygen, presents an increased risk of fire, equipment damage and serious injury or death and thus requires specialized training and oxygen-clean equipment.

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Divers can help ensure the quality of their breathing gas by smelling it, analyzing it, testing it for CO and, perhaps most important, getting it from a reputable, trustworthy source.

- A nitrox stick mixes oxygen with air in the intake of the high-pressure compressor. This method also warrants caution since pure oxygen must be used. The oxygen is metered into the stick so that the end product produced is the targeted percentage.

- A membrane system moves low-pressure air through a membrane that pulls away nitrogen so that a mix that is higher in oxygen remains. This desired gas is delivered to the intake of the high-pressure compressor.

Regardless of the means of nitrox production, the creation of nitrox is best left to diving professionals for safety considerations. A nitrox course provides the information necessary for understanding what mix to use for diving at various depths.

To help ensure their air is safe, recreational divers can do the following:

- Prior to using a compressed-air cylinder, carefully open the valve slightly and check for any odors. If an odor is present, do not use the cylinder. An odor may indicate that the filtration system on the compressor that purified the air is either past due for servicing, has had a mechanical failure, has drawn in harmful vapors or has been contaminated by an autodrain system failure.

- If the cylinder is filled with nitrox, analyze the oxygen percentage prior to use to ensure that it is as expected. Cylinders containing gases other than air by law must be marked with the gas they contain.

- Consider using a CO sensor or analyzer. CO-Pro by Lawrence Factor, for example, is a quick, effective and affordable way to check for the presence of CO.

- Most important, find a high-pressure air source you can trust. Some states (such as Florida) require quarterly air testing. Ask the facility where you buy your air what preventative maintenance practices they follow. Most dive operations are proud of their air and nitrox systems and would be happy to show them off.

Compressing breathing air or nitrox into a scuba cylinder is hard work — for both the compressor and the technician operating the equipment. Vigilance and regular maintenance are required to ensure that the air produced is certifiable to the Compressed Gas Association's Grade E standards for scuba. Play it safe by knowing your source so you can feel confident about the gases invading your body tissues. AD

For more tips and incident reports, or to report a diving incident, visit ***DAN.org/diving-incidents***.

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PARTING SHOT

By Ivana Orlovic Kranjc
ivana.photography

THE ART OF THE UNDERWATER SELFIE

I think photography is the most powerful way to promote the amazing underwater world to nondivers. I started taking underwater selfies to clearly demonstrate the sizes and colors of my photographic subjects. Selfies are incredibly popular on land but a challenge to do well underwater because of the ocean's natural swell, movement of the subject and difficulty achieving proper lighting. AD

EQUIPMENT: Nikon D810 and D7000 cameras, Tokina 10-17mm lens, Subal housing, Sea & Sea YS-D1 and Inon Z-240 strobes

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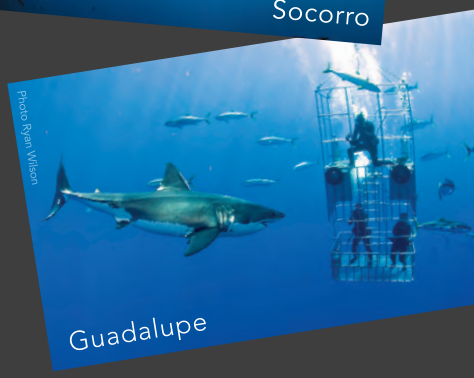

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