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THE MAGAZINE OF DIVERS ALERT NETWORK

WINTER 2016

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VISION

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

DAN® YOUR DIVE SAFETY ASSOCIATION

MISSION

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

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

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

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

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

ALERT DIVER'S PHILOSOPHY

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

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

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Features

ON THE COVER:
A large school of chevron barracuda (*Sphyraena genie*) is typically resident at "The Arch" in Fiji's Namena Marine Reserve. Stephen Frink took this photo using a Canon EOS 5DS with a Sigma 50mm macro lens in a Seacam housing and compact dome port, Seacam Seaflash 150 and Ikelite DS161 strobes, with an exposure of 1/80 sec. @ f/14, ISO 320.

THIS PAGE:
Butterflyfish, like this one at the Namena Marine Reserve in Fiji, have long snouts and other specialized anatomic features to facilitate feeding among the crevices and indentations of the coral reef. Photo by Stephen Frink

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Winter 2016

A hawksbill turtle is silhouetted by the midday sun as it returns to the surface to breathe at Half Pipe in Fiji's Bligh Water region. Photo by Stephen Frink

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PERSPECTIVES

Safety as a Collaborative Effort

By Bill Ziefle

Participation in dive research has consistently provided DAN® with opportunities to discover and better understand dive incidents and has thus helped us design more effective prevention strategies. But information alone does not effect change; what we learn must be shared, and what's shared must be put into practice. Education is the key to better preparation, and that saves lives.

Over the past few years DAN has significantly increased the number of health and safety resources we've made available to the dive community, and we've updated both our printed and digital safety materials to make them more accessible and easier to understand. The information DAN offers is strategically segmented and presented in formats applicable to every diver, from the new open-water student to the veteran instructor with decades of experience, and from the warm-water sport diver to those who explore the deepest caves. Our objective is to extend our reach — we believe that to have the greatest impact on safety, education must happen at every level.

As divers we are responsible for learning new health and safety practices and periodically refreshing our skills. This is an investment that will help each of us better prepare for whatever type of diving we intend to do. Continuing education provides opportunities to reassess personal strengths and limitations, enhance watermanship and update the knowledge on which we base our critical thinking. *DAN.org*, *Alert Diver*, Ask a Medic and other DAN resources give you the tools to evaluate and confirm readiness before every dive — a very worthwhile exercise in risk management.

The cooperative relationship DAN enjoys with dive training agencies is a boon to the dive community. The training agencies are on the front lines, working directly with divers to educate them about physics, physiology, equipment, rescue techniques and emergency management. DAN's relationship with these organizations is symbiotic; for example, training agencies provide divers with in-water practice responding to emergencies under the watchful eye of dive professionals. DAN case summaries complement this training by safely exposing both the diver and the dive professional to a variety of real-life emergency situations from which to learn. In concert this experience and knowledge stimulate critical thinking and improve readiness.

Such collaboration is apparent in the relationships DAN has built with the Professional Association of Diving Instructors (PADI) and the National Association of Underwater Instructors (NAUI). We have worked closely with PADI to disseminate DAN content through their online newsletters, printed materials and social media channels. They also distribute our dive-safety messages directly to their professional members. A new joint initiative by DAN and NAUI will offer DAN's first-aid training programs and an online instructor-upgrade program to NAUI divers and dive professionals. NAUI will also work with DAN to disseminate our health and safety resources. Discussions with other training agencies are in progress, and DAN looks forward to alliances with all who wish to promote safer diving.

> "DAN has significantly increased the number of health and safety resources we've made available to the dive community, and we've updated both our printed and digital safety materials to make them more accessible and easier to understand."

Allying with like-minded organizations to share our information not only directly benefits divers, it also establishes a solid network for communication. As dive research and education continue to evolve, we look forward to enhanced partnerships with stakeholders within and outside the dive industry. Our collective experiences create an incredible resource that we are committed to sharing. AD

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DAN.org/TRAINING


JIM BOILINI

Fit To Dive?

By Stephen Frink


BOB COAKLEY

It's not unusual for those of us who live in the Florida Keys to hear through the coconut telegraph that someone died on a scuba dive. You might find that surprising because most of the reefs here are quite shallow (less than 40 feet), the water is clear and warm, and the dive operations are experienced and professional.

There are deeper shipwrecks to dive, but in the decades since the *Duane* and *Bibb* were sunk in 1987 (followed later by the *Vandenberg*, *Spiegel Grove* and others) there have been few fatalities associated with the specific hazards of shipwreck diving. But diver deaths in the Keys persist — five in 2013, seven in 2014 and five again in 2015.

Most likely it is no more than a numbers game. Bob Holston, president of the Keys Association of Dive Operators, estimates that a million divers and snorkelers dive the reefs and wrecks of the Florida Keys each year, all along the 110-mile island chain that runs from Key West at the southern tip to Key Largo in the north. So percentagewise, five to seven fatalities annually perhaps are not unexpected and may even be quite low. Still, I couldn't help but wonder if there is an underlying thread here. Why do divers die, and what might help them survive what should be (and usually is) relatively safe and exciting recreation?

To gain some insight, I spoke to Petar Denoble, M.D., D.Sc., vice president of mission at Divers Alert Network, who said:

Heart disease is the leading cause of death for both men and women. The most common form of heart disease is coronary heart disease, which causes myocardial infarction in more than 700,000 people every year. In many cases myocardial infarction is the first manifestation of coronary heart disease. A large number of deaths are caused by cardiac arrest (cessation of beating) in the absence of any known history of heart disease.

Among the risk factors for coronary heart disease, one of the most important is lack of exercise. On the other hand, vigorous exercise may precipitate death in people unaccustomed to exercise of such intensity. Divers may encounter circumstances that require bouts of vigorous exercise, and if they are not accustomed to it, they are at risk. Cardiac death occurs in about one-third of all scuba diving fatalities, and the rates increase with age. For divers to mitigate the risk of an unwanted cardiac event while diving, the best approach is to maintain a healthy lifestyle and exercise regularly, including bouts of vigorous exercise.

With that as background I thought about the dives I've done in which circumstances required bouts of vigorous exercise. I tend not to purposely go diving when the winds are blowing 25 knots and the seas are running 6-8 feet, but I have been on assignments where deadlines trumped my better judgment, and I've dived in those sorts of conditions. Recreational divers no doubt have made similar decisions while drinking their morning coffee in the lee of the prevailing wind, having no concept of the conditions that might be awaiting them a few miles offshore.

Jumping off the boat is typically not the issue. Doing the dive is often not the issue either. But getting back to the boat in a heavy sea, perhaps carrying expensive camera gear or swimming against the current, and then trying to climb the dive ladder as the boat plunges in an angry and confused sea — that can be vigorous exercise indeed. On those days you have to be reasonably fit and skilled. It is the days that are the outliers, when the conditions are more extreme than usual, for which divers need to be prepared. It is for days like these that we need to maintain a healthy lifestyle and do regular exercise, especially aerobic exercise. On most days diving is a benign and somewhat effortless activity, but the sea is a capricious mistress, and she can kick your butt. She can also kill you.

I accept that getting back to the boat safely is part of my job. Devoting an hour most mornings to knocking out a couple of thousand meters in the pool with our

> "It is the days that are the outliers, when the conditions are more extreme than usual, for which divers need to be prepared."

group of Masters swimmers is a good investment in my personal safety for future dive expeditions. This is also why we offer a Dive Fitness article in each issue of *Alert Diver*. This series, written by exercise physiologist Jessica Adams, Ph.D., is specifically intended to help divers develop the core strength and cardiac fitness they need. At a glance, the photos that illustrate these articles might make the exercises seem easy, but actually doing the workouts she outlines in these articles will challenge many of us.

Whether it's running, biking, swimming or doing the workouts in *Alert Diver*'s Dive Fitness column, scuba divers need to embrace regular exercise. A collateral benefit is feeling better in day-to-day life. There will be days when you have to kick it into overdrive to make it back to the boat, and your body needs to be prepared. If cardiac death occurs in one-third of all scuba diving fatalities, and risk increases with age, we all need to mitigate this risk and live a heart-healthy lifestyle. AD

WHAT'S NEW ON ALERTDIVER.COM

ZENA HOLLOWAY

ART AQUATIC

After getting a taste of Zena Holloway's work on Page 94, stroll through her online photo gallery and watch a behind-the-scenes video of a photo shoot.

STEPHEN FRINK

FABULOUS FIJI

Travel along with Stephen Frink to the soft coral capital of the world on Page 68, then go online to view a photo gallery and cartoon series of the trip.

JENNIFER IDOL

50-STATE ODYSSEY

Read about Jennifer Idol's quest to dive in all 50 U.S. states on Page 82, and then view online more images of the sites she's seen.

MICHAEL AW

SEEKING CENDERAWASIH

Discover the ancient sea of Cenderawasih Bay on Page 76, and then revel in more of the area's enchanting beauty in a video by Michael Aw.

ALL THIS AND MUCH MORE AWAIT AT ALERTDIVER.COM

LETTERS

A GRADIENT OF EFFORT

In reply to Steve Borgess' letter in the Fall 2015 issue, conservation is not an all-or-nothing game. Small choices do make a difference. I and many others make them every day. I avoid red meat on most days, but I occasionally have barbeque or a steak. See how that works? Pretending that a gradient of effort is impossible or implausible serves only to maintain the cognitive dissonance rooted in one's own inaction.

— Matt Kofron, via email

IT'S ALL IN THE LOOP

Laurent Ballesta's dive to 66 feet for 24 hours employed a protocol that used "10 percent oxygen heliox as [the] basic mix for the first 18 hours and almost pure nitrogen with a small amount of oxygen after that." This purportedly allowed decompression in less than three hours for a dive that would normally require 20 hours of deco. How does such seemingly extreme nitrogen loading work to minimize decompression time?

— Phil Burgiel, Rockville, Md.

My name is Jean-Marc Belin, and I was the diving supervisor for Laurent during the dive to 66 feet for 24 hours. We used a dive protocol that varied the partial pressure of oxygen during the dive and employed two different diluent gases. During the first 18 hours at 66 feet, the rebreather was programmed to deliver a breathing mixture of helium and oxygen with an oxygen partial pressure of 0.49 atmospheres (ata). For such a long dive, this was the maximum partial pressure of oxygen Laurent could breathe without incurring lung damage. Helium was used because it would involve less of a decompression obligation than nitrogen for the long dive.

At the 18-hour mark, the rebreather was programmed to produce a breathing mixture with an oxygen partial pressure of 0.9 ata, and the helium was replaced with nitrogen. The logic behind this diluent switch was that the diver would offgas helium faster than he would ongas nitrogen, and thus the net inert gas load would decrease. During the last three hours of the dive the partial pressure of oxygen was set to 1.3 ata to speed up decompression.

— Jean-Marc Belin, via email


STEPHEN FRINK

TEACH YOUR CHILDREN WELL

I enjoyed the Expert Opinions article "Children and Diving" — it had some excellent insights. I think everyone agrees that establishing a diver's comfort and confidence in the water early, regardless of age, is essential.

But I'm curious about the photos. The first one shows a young diver with an unsecured pressure gauge. That's not a huge deal in and of itself as long as she can retrieve it. The next photo, however, shows the same gauge rigged behind the diver's back and on the opposite side. More important, there is no low-pressure hose connected to her BCD inflator. With a steel cylinder and no thermal protection, she is probably quite negatively buoyant.

I imagine the photos were staged, but to me they set a bad example. All beginning divers should learn buoyancy control early on (for a number of reasons) as well as the need and ability to establish positive buoyancy in an emergency. This skill is essential to preventing fatigue, panic and possibly drowning. I hope every diver is still taught how to manually inflate his or her BCD on the surface. At depth, an out-of-air situation involving a negatively buoyant diver is a much more serious — potentially devastating — situation.

We instill in all divers, regardless of their age, the importance of preparing and checking their own gear before every dive. We guide them through the process. Am I missing something here?

— Mark Windham, via email

Mark, you are correct — the photo should have been structured differently for inclusion in Alert Diver. *The child is my daughter, and the photos were taken some years ago (she is 22 now). She was well supported by our dive instructor and me just a few feet away. But the point is not the relative safety of the moment but the message communicated by unsafe diving protocols when published in the magazine of Divers Alert Network. I apologize for the oversight.*

— Stephen Frink, Publisher,
Alert Diver

SKIN DIVING

It seems you've been hoodwinked. You end your nice article on snorkels (Gear, Summer 2015) with the statement, "When military personnel were required to bring mask, snorkel and fins to water sessions, the acronym SKIN was posted on the roster to stand for 'swim kit is needed.'" A cute story, but I'm afraid it's just a myth.

— Sam Wheatman, via email

Sam, I think you are correct. I hate being the purveyor of myth, but it looks like I am guilty this time. I read a claim to this more than 15 years ago, filed it away as trivia and brought it out as what was supposed to be an interesting nugget in the snorkel article. After seeing your note I reached out to those I know with the longest memories of military diving. I have not found any familiar with the idea, so it is time to eat crow. We want to be accurate, and we appreciate your sharp eyes and willingness to engage to help us stay on track.

— Neal W. Pollock, Ph.D.,
Research Director, DAN

THE INCREDIBLE COELACANTH

The shots in the last issue were amazing, especially the coelacanth shots. When I was a student somebody brought a pickled coelacanth to Scripps, and I had one of its scales for a while. They're amazing critters, and I never thought I'd see a photo of a diver looking one in the face. Phenomenal! The picture of the nautilus close up was also pretty wonderful. Overall it was a great issue.

— George Lewbel, via Facebook

CAVE CONCERNS

I wanted to bring something to your attention. The cave image on Pages 94 and 95 is very upsetting to me. As a professional cave photographer and filmmaker I find this image stunning, but the cameraman in the image shouldn't be sitting on the floor of the cave. The caption says it is an off-limits cave, it's obviously fragile, and I think it looks very bad to have a professional pictured in such poor form in a fragile environment. It is similar to seeing a cameraman kneeling on a coral reef. I'm pleased to see *Alert Diver* focusing on some more tech diving locations and look forward to more in the future.

— Becky Kagan Schott, via email

ENHANCED CONSERVATISM

I read the article on gradient factors in the Fall 2015 issue (Advanced Diving). Are we attempting to take scuba diving backward? The training agencies have spent tons of time and money to make diving safer and open to almost anyone by streamlining the requirements and training, including making dive profiles easier to plan and

understand. It seems the article is trying to complicate dive planning and reduce conservatism. Leave that to the techies, and keep recreational diving for the enjoyment of the dive.

— Les Culbertson, via email

Diving is certainly easy when simply following a computer or a divemaster, but easy is not a guarantee of safety. Your note suggests that you see gradient factors as a means to remove conservatism, but they were developed primarily as a means to add conservatism. A fundamental reason for the article is the fact that gradient factors and other conservatism strategies are increasingly being used in dive computers. Divers should understand why the schedule given by their computer may differ from someone else's. Not knowing that the limits are written more in sand than stone can lead to frustration and misunderstanding. Knowledge is a good antidote.

Adding conservatism is smart, particularly when few truly know their individual susceptibility to decompression stress, or when our dives start to push beyond the most benign basics, or as time takes its toll on our physiological fitness. Tools such as gradient factors can help individuals build buffers to ensure a lifetime of good diving health. AD

— Neal W. Pollock, Ph.D.,
Research Director, DAN

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DIVE SLATE

SUNSCREEN POLLUTION

A SERIOUS AND INCREASINGLY CLEAR THREAT TO CORAL

By Craig Downs, Ph.D.

Some effects of marine pollution are visible, such as the plastic garbage that often litters reefs and beaches. Other effects are similarly obvious, such as the brimstone stench of a nearshore dead zone caused by sewage and fertilizer runoff. Unfortunately, marine pollution goes even further than most people can easily witness, and these less-apparent aspects of pollution have elusive but far-reaching consequences.

I first came to understand the significance of sunscreen lotion in marine pollution during an investigation into declining coral reefs in the U.S. Virgin Islands. A local resident complained to my investigative team about an oily, iridescent sheen on the surface of the water that lingered after the mass of tourists had gone home; it was supposedly caused by sunscreen washing off the swimmers. "Swimmer pollution" threatens coral reefs across the world, from the Gulf of Aqaba in the Red Sea to the shores of Playa Hermosa, Costa Rica, and almost everywhere in the Caribbean. Anywhere humans get into the water on or near a reef is a potential avenue for contamination.

STEPHEN FRINK

Besides washing off swimmers' skin and into the water, sunscreen can get into the sea by other means. Many sunscreen ingredients are readily absorbed through the skin. Oxybenzone, one of the most common ultraviolet-blocking chemicals in sunscreen, for example, can be detected in urine within 30 minutes of application. When you flush the toilet or wash off sunscreen in the shower, chemicals from the lotion enter the sewer. For towns near coral reefs and without sophisticated sewage treatment and management systems, this pollution is rather inevitable. (There is an etymological argument that the word "sewer" comes from the old English word "sea ward," in which household and municipal waste was channeled out of villages and towns toward the sea or other bodies of water.) Any coral reef near significant human habitation is potentially vulnerable to a plume of pollution.

Sunscreen lotions do not threaten every single coral reef in the world. Sunscreen and other personal care products, however, do threaten the coral reefs that are most important to people — those that are focal points of tourism as well as fringing reefs that are critical for protecting coasts from erosion. And they threaten the capacity of local subsistence fisherman to access the abundance of food that healthy nearshore reefs once provided. Not only does intense sunscreen pollution threaten the survival of these reefs, but it also can prevent the recovery and restoration of already-degraded reefs.

ECOTOXICOLOGY OF SUNSCREEN LOTIONS AND THEIR INGREDIENTS

In October 2015 my colleagues and I examined the toxicological effects of oxybenzone on coral larvae.[1] We found that oxybenzone induces coral bleaching by lowering the temperature at which corals will

bleach when exposed to prolonged heat stress. We also showed that oxybenzone is genotoxic, meaning that it damages coral DNA as well as induces severe and lethal deformities. Most alarming, we determined that oxybenzone also acts as an endocrine disruptor, causing the coral larvae to inappropriately encase itself in its own stony skeleton — at a time in its development when it should not even have a skeleton.

Our research demonstrated that these pathologies can occur at concentrations as low as 62 parts per trillion. For perspective, beaches in Hawaii have oxybenzone levels higher than 700 parts per trillion early in the morning before swimmers even arrive. Other emerging research is showing that oxybenzone concentrations on nearshore reefs around the world are commonly between 100 parts per trillion and 100 parts per billion — well within the range of being a significant environmental threat.


STEPHEN FRINK

Oxybenzone is toxic to more than just corals. It's toxic to algae, sea urchins, fish and mammals. It inhibits embryonic development in sea urchins. It can result in gender shifts in fish, in which male fish take on female attributes, while females have reduced egg production and embryo hatchings. In mammals it has been demonstrated to be a potential mutagen and to exhibit procarcinogenic activity. Studies in both mice and rats showed that exposure to oxybenzone increases liver and kidney weights, reduces immunity, increases uterine weights in juveniles and reduces fertility. In recent studies, human couples whose urine contained higher concentrations of benzophenones had a harder time getting pregnant, while men with higher concentrations had higher levels of diseased sperm. Both dolphin and human mothers can transfer oxybenzone to their infants via breastmilk.

There are a host of other chemicals in sunscreen that are potentially toxic to coral reefs, some of which — including methoxycinnamate and camphors — are on the International Chemical Secretariat's SIN (Substitute it Now) list based on their activity as endocrine disruptors to humans and wildlife. Noncoated nanoparticles (less than 35 nanometers in diameter) of zinc oxide and titanium dioxide (referred to as "mineral-based" sunscreens) can be toxic to corals, fish and other reef organisms. Their toxicity arises from both their miniscule size and their interaction with cells, as well as the fact that they cause oxidative stress in sunlight (i.e., they too can cause coral bleaching). Non-nanotized (commercial designation above 150 nanometers in diameter) coated zinc oxide and titanium dioxide don't readily exhibit acute toxicities. Nanoplastic ultraviolet (UV) absorbers, which commonly have diameters of around 350 nanometers, are also not necessarily toxic to the marine environment, though their nanotized property may be a cause for concern.

Oxybenzone and many other common sunscreen ingredients are now known to damage corals, even in extremely low concentrations. Opposite: Fortunately, demand by concerned consumers is leading to increased availability of less harmful sunscreens.

An "organic" certification doesn't mean a sunscreen is safe for the environment. A number of plant-based oils can be toxic to reef organisms, especially arthropods. For example, neem, eucalyptus and lavender oils, which are used in some organic sunscreens, also have applications as insect repellents or insecticides, suggesting they may also have increased relative toxicity to invertebrates. Other ingredients such as beeswax can be contaminated with a variety of industrial fungicides and insecticides. Organic ingredients, or any ingredient in a product, should be subjected to toxicological testing.

Silicone polymers, cyclic siloxanes (e.g., octamethylcyclotetrasiloxane and decamethylcyclopentasiloxane) and other alternatives to oils warrant some concern. These organosilicon compounds are not biodegradable and can bioaccumulate in aquatic and marine organisms, including edible fish.

Many sunscreen lotions also contain preservatives, which a growing body of evidence shows are an environmental threat. Parabens are preservatives that inhibit fungal and bacterial growth. At lower concentrations they can act as pheromone and endocrine disruptors, while at higher concentrations they can be acutely toxic to invertebrates. Another preservative, phenoxyethanol, was originally used as an insecticide and an insect repellant, and it can be toxic at low concentrations to invertebrates from shrimp to sea urchins. It is still used as a mass anesthetic for fish in some aquaculture operations.

We have evidence that many of these ingredients contaminate marine and coastal environments, but our general lack of societal inquiry into their toxicities leaves us with little ability to accurately assess whether they pose a clear and present danger to marine habitats.

IMPLICATIONS AND SOLUTIONS

There is no single, definitive solution to the problem of sunscreen pollution, but a diversity of approaches can be implemented to various effects. All will require further research to determine which ingredients are safe and which pose a realistic threat to marine ecosystems. These approaches also depend on adequate communication of the data to consumers, manufacturers, regulators and other stakeholders. It should be noted that none of these mitigation options require that sunscreen not be used. Sun protection is a significant public health issue, and sunscreens play an important role in the management of this risk.

One approach is to ban the use of products that contain threatening ingredients in areas where coral reefs are most susceptible to exposure. This type of regulatory policy has been in place for almost 10 years in Mexico's ecoreserves, including Xcaret and Xel-Há. This sort of policy might be the easiest and most cost-effective approach, at least in areas crucial for active reef conservation and restoration, such as coral reef nurseries.

A second approach involves a public relations campaign, to be implemented in coral reef managed areas such as marine parks and sanctuaries, that informs visitors and locals about the environmental impact of sunscreen pollution and asks them to use suncare products without threatening ingredients. The best current example of this strategy is the U.S. National Park Service's campaign to "Protect Yourself, Protect the Reef."

I've spoken with a number of dive shop and resort operators about designing and implementing a similar public relations campaign. Many of these businesses promote education and offer a selection of suncare products that are free of the toxic ingredients listed by Mexico's ecoparks or the website *MarineSafe.org*. Some resorts and dive shops are even proposing to offer coral "safe" sunscreen for free to their guests, although the lack of toxicological data showing what is safe and what isn't is the critical obstacle for any such campaign.

A third strategy is to convince people to reduce the amount of sunscreen they use. Applying lotion to only the neck, face, feet and backs of hands can reduce sunscreen loads into the water by 90 percent. Sun clothes designed to reduce UV exposure have evolved tremendously in the past 10 years in both fashion and utility. Gone are the days of tight-fitting rashguards or jumpsuits that are a pain to put on and take off, especially when wet; there are now clothes that are comfortable and well suited to the water, the beach and the cafe.

A fourth option requires consumers to demand innovation from manufacturers regarding the formulation of their products. We are at a juncture in which industry can either demonstrate leadership by developing environmentally sustainable new products that are popular with consumers or dig in its heels, refusing to adapt and suffering economic and reputational consequences. The successful rise of several environmentally conscious companies demonstrates the influence of consumers who demand more sustainable products.

Whatever we choose to do moving forward, we must remember that the best way to keep marketing honest is for the consumer to demand attention to rigorous and unbiased science from both industry and government — the institutions with the power to inform manufacturers and consumers about which ingredients are gentler to marine ecosystems. Scientific data generated by industry alone is often viewed with suspicion and distrust, with ample historical justification. The relevant science should be conducted by financially neutral parties that follow standardized, validated testing protocols. Governments can play a pivotal role by encouraging third-party testing, standardizing methodologies and moderating dialogue among all interested parties. As with many marine environmental issues, divers are uniquely positioned to both lead by example and benefit from healthier and more vibrant reefs. AD

Reference

1. Downs CA, Kramarsky-Winter E, Segal R, et al. Toxicopathological Effects of the Sunscreen UV Filter,Oxybenzone (Benzophenone-3), on Coral Planulae and Cultured Primary Cells and Its Environmental Contamination in Hawaii and the U.S. Virgin Islands. Arch Environ Contam Toxicol 2015 Oct 20. doi: 10.1007/s00244-015-0227-7.

A scatter of amphorae on a rocky reef indicates the presence of a late Roman shipwreck (from the 4th-7th centuries) in the area.

TWENTY-TWO ANCIENT SHIPWRECKS FOUND IN GREECE

By John Stella | Photos by Vasilis Mentogianis

It was Thursday morning, Sept. 10, 2015, and I was eagerly waiting to hear from George Koutsouflakis, Ph.D., director of a new wreck survey. He was leading the dive team from the Greek Ephorate of Underwater Antiquities on a long-planned underwater wreck survey mission to the Fourni Islands.

"This new mission had risks greater than any other mission I had been involved in," Koutsouflakis said. "We would be operating in a new area — completely unknown — with a new team."

Two years earlier I had the honor of diving with Koutsouflakis on a newly discovered ancient Roman shipwreck that he had found off the southeast coast of Greece. That single dive with him turned out to be one of the highlights of my diving career, and it sparked in me great enthusiasm for ancient shipwreck diving. I have been diving on underwater wrecks for many years, mostly in the North Atlantic, but this was something quite different for me.

As we descended through the water column, a spectacular debris field came into view. This was a deep wreck, so the ancient artifacts were intact, adding to my excitement. Koutsouflakis and I surveyed the footprint of this Roman shipwreck and its contents, and I could not help but think of the long-lost history of this find and how honored I was to be the first diver outside of the Greek archeological diving community to visit this historic treasure. After the dive Koutsouflakis told me about the history of the wreck, its trade route and cargo.

"This Roman wreck is loaded with a main cargo of Lamboglia 2 amphorae, which are wine containers made on the Italian peninsula," he said, "with a secondary cargo of wine amphorae originally from the island of Rhodes. Rhodes was famous for its wine and was one of Rome's biggest suppliers. So 90 percent of the cargo on this wreck was wine, and it originated from Italy. The wreck is dated between 130 and 80 BCE."

What we could not see intrigued me the most. We were looking at the top deck of the ancient ship, and there were two more decks below the visible debris field that were covered by sand. An enormous trove of artifacts lay beneath just waiting to be viewed.

Three days later I was invited to join a team of Greek underwater archaeologists that was working on an ongoing underwater site just off the island of Poros. Christos Agouridis, a friend and colleague of Koutsouflakis, invited me to dive with his team at Koutsouflakis' behest. This site was an ancient

Clockwise from above: **The 2015 Fourni Underwater Survey team; amphorae dating to the Archaic Period (800-400 BCE) lay scattered among the oldest shipwreck the team found; the team's conservator painstakingly cleans marine growth from an encrusted amphora; an amphora and funerary table found among a Hellenistic Period (323-31 BCE) shipwreck; the team's conservator inspects a recovered amphora**

Mycenaean shipwreck dated to 1200 BCE. I spent the night in base camp with the team and in the morning headed to the wreck site aboard their support vessel. They were in the process of 3-D mapping the wreck, uncovering its artifacts and documenting their finds. The team, made up of both male and female Greek divers, had training in underwater photography, archeology and architectural design, and several seasoned commercial divers filled out the ranks. I was amazed by the team's experience and impressed with the passion they showed for their work. The experience also made me aware of the enormous challenges these kinds of underwater operations face.

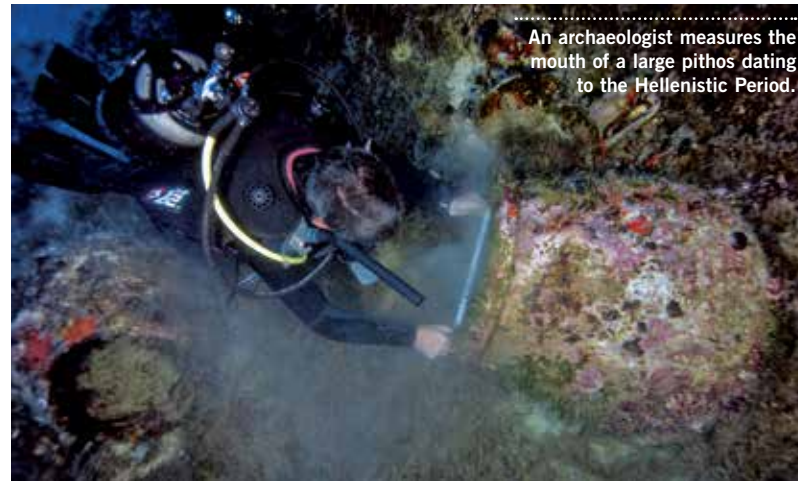
Fast forward to today, Sept. 10, 2015 — I am excited to be joining the team again. This next underwater

survey would take us to the Fourni archipelago, a group of 13 small islands in the eastern Aegean Sea just off the coast of Asia Minor. It has long been thought that these islands, right in the middle of ancient maritime trade routes, could be very fertile ground for ancient shipwrecks. It will be quite an undertaking, and the pressure on the team is enormous.

I got word from Koutsouflakis that the mission was on. The team would be mobilizing in Athens on Monday, Sept. 14, 2015. The support vessel would leave Athens that night and meet the team early Tuesday morning on the island of Fourni Korseon.

Eight of us in the Greek dive team boarded the 4 p.m. Mykonos Ferry for the 11.5-hour ride from the port in Piraeus (Athens) to the Fourni Islands. The team had packed dozens of tanks, a rigid inflatable boat, two vehicles, provisions, water and a compressor for the long ride to the islands.

We would meet the rest of the team on the island. Team members from the RPM Nautical Foundation, including survey co-director Peter Campbell, would join us that morning. After a briefing and some first-day site planning, we readied our gear for the next morning's dives. I think we all knew it would be a very difficult mission. Mounting an underwater ancient-wreck survey from a remote island is a challenge for any dive team. The island terrain is difficult to traverse, and 78 miles of coastline is mostly accessible only by water. We established a base camp on the west side of the island and a secondary camp on the east to enhance



An archaeologist measures the mouth of a large pithos dating to the Hellenistic Period.

our exploration capabilities, and this required overland transport of the compressor, tanks, rigid inflatable boat and dive gear.

After the team's first few dives, the existence of an abundance of ancient shipwrecks was becoming crystal clear. We found huge clusters of intact amphorae along with evidence of additional ancient shipwrecks. On the first day the team found the remains of a Roman-period shipwreck. By day five they had found an additional nine wrecks, and by day 13, a total of 22 wrecks, some of them more than 2,500 years old. These finds represent 12 percent of all known shipwrecks in Greek waters. Could this be the ancient shipwreck capital of the world?

The team's archaeologists were now in the process of 3-D mapping the wrecks and selecting samples of amphorae for inspection and study. Of the 22 wrecks the team found, the earliest dated to 700 BCE and the latest to 1500 CE. Some have called this the archaeological find of the year.

"All of the shipwrecks were left intact on the seafloor for future generations of divers and scientists to explore, except for one representative artifact from each wreck," Campbell said. "These will be conserved, analyzed, studied, and when the artifacts are stable enough, archived for future researchers to study. Some may be sent to a museum for future display. Each artifact has an identification number and a report attached to it."

On the team's final day on the island, we shared our finds with the island's mayor and residents. The residents of this tiny archipelago are now the supreme protectors of these great ancient antiquities.

This experience elevated my enthusiasm for ancient shipwreck diving to a new level, and working alongside this team was an absolute honor for me. They are some of the most passionate, professional people I have ever met, and they do this work not for financial reward or fame, but for the preservation and protection of their country's historical artifacts.

The team will return next year to continue this amazing wreck survey, for this is one of the greatest opportunities in recent years for archaeologists to search the ocean floor for ancient underwater treasures. Who knows what other wonders will be found? AD

Funded by the Honor Frost Foundation, this Fourni survey operated as a partnership between the Greek Ephorate of Underwater Antiquities and RPM Nautical Foundation.

A female leatherback nests in the middle of the night on a remote beach in Trinidad.

TRINIDAD'S LEATHERBACKS

Text and photos by Michael Patrick O'Neill

Picture this: a leatherback sea turtle, a quintessentially pelagic animal, casually swimming in a jungle river in Trinidad. That's right, a leatherback in crystal-clear fresh water with tropical foliage in the background. A freak occurrence? Absolutely. But there it was gliding in front of us, three well-travelled, experienced — and speechless — photographers.

There was no time to waste. This precious opportunity could end at any second, so I went to work, slowly approaching the turtle from the side, careful not to chase or alarm it. When the water got too shallow, I kicked off my fins, tossed my mask aside and walked next to the turtle, shooting from the hip. I was grateful to have a fisheye lens, a huge glass dome and fresh batteries that kept my temperamental strobes happy and firing. Luckily, a rocky bottom — similar to a trout stream's — kept the water mostly free of debris. My two friends and I took turns, synchronizing our efforts and miraculously staying out of each other's way.

The current washed the sand and salt mucus from the turtle's eyes and revealed an animal of extraordinary beauty. Not your typical black leatherback, this turtle was a very pale, bluish gray with a constellation of little white stars covering her body. Every 30 feet or so, the turtle lifted her massive head out of the water to breathe the warm humid air and kept going, soaking in her new surroundings. Roughly a half mile from the sea, this living dinosaur finally realized she was in a very strange neighborhood and turned around, eventually making it back to the mouth of the river and swimming into the murky and angry Caribbean.

A 100-million-year-old species, the leatherback is not your ordinary sea turtle — it's almost an insult to call it one. In a class entirely its own, it is one of the largest reptiles, capable of reaching 7 feet and 1,500 pounds or more. Shaped like a giant, hydrodynamic teardrop, leatherbacks can dive to more than 3,000 feet — deeper than most whales — to eat jellyfish, their main food source. When feasting on these gelatinous invertebrates in the subarctic, leatherbacks keep their bodies warmer than the surrounding water, thanks to their huge body mass and a sophisticated circulatory system. This special adaptation, called gigantothermy, allows these creatures to go where other reptiles would freeze and extends the range of the species to the point that it's one of the widest-ranging animals. They are citizens of the world: Indonesian leatherbacks travel to Monterey Bay, Calif., to forage, while Trinidad's leatherbacks visit eastern Canadian waters in the summer. One tagged on Panama's Caribbean coast was later found alive in a net in Italy and successfully released.

Our adventure with that lost leatherback on our first morning in Trinidad capped off what would be the first of several grueling all-nighters on our trip. While I have photographed them underwater where I live in Florida, I didn't have any photos of nesting leatherbacks. When one of my buddies with local connections in Trinidad suggested we head down there, I agreed immediately. During peak nesting season in May and June, some of the busiest beaches in Trinidad receive nearly 400 nesting turtles every night.

For the next week we settled into a demanding routine: After dinner we and our guides would head out in pairs to local beaches to work. The red glow of our headlamps revealed clusters of leatherbacks — completely oblivious to our presence — entering and leaving the pounding surf and sometimes even crawling over each other and accidentally destroying nests. These excursions were arduous. The uneven terrain, heat, sand, darkness, smell (from broken eggs and dead embryos), rain and biting insects made it extremely tough to remain focused.

We would return to our simple accommodations in the morning for breakfast, showers and sleep. Random turtles nesting under the blazing tropical sun or unlucky hatchlings being devoured by vultures and frigatebirds broke the midday quiet and made us scramble for our cameras. In the late afternoons we explored the coastline by boat with fishermen, who took us to a staging area offshore where leatherbacks

Tourists flock to beaches during nesting season to observe the massive and endangered leatherbacks, bringing revenue to the local economy.

Opposite, clockwise from top left: **A black vulture eats a hatchling at sunrise. To compensate for losses due to predation, female leatherbacks produce an enormous number of hatchlings to ensure the species continues into the future. Compare the size between an adult nesting leatherback and a hatchling. At this stage, the babies are incredibly vulnerable and have to grow up in a hurry — and be very lucky — to survive. A female deposits dozens of eggs in her nest chamber at sunrise. An underwater photographer comes face to face with a leatherback in a freshwater creek near the beach.**

gathered by the dozen prior to storming the beach at nightfall.

During our long boat rides the fishermen described the challenges of making a living during nesting season, unfortunately one of the best times to fish. Almost every time we went out on the water someone at the fishing station was repairing nets that had been ripped apart by 800-pound turtles. Scott Eckert, leatherback expert and director of science at Wider Caribbean Sea Turtle Conservation Network, reports that each year about 3,000 leatherbacks get entangled in gillnets in Trinidad's waters, with a mortality rate of 33 percent, or 1,000 turtles. Local conservation organizations are working with fishermen to develop fishing techniques that minimize bycatch, but it's a long and difficult process.

It would be hard to convince the average tourist visiting Trinidad during nesting season that leatherbacks are endangered. Entanglement in fishing gear, coastal development, poaching, boat collisions and the ingestion of plastic bags (mistaken for jellyfish) all take a huge toll. But there is some good news: While the Pacific population is in extreme distress, the Atlantic and Caribbean population appears to be on the rebound. In 2013 the International Union for Conservation of Nature (IUCN) upgraded the status of these giants from "Critically Endangered" to "Vulnerable," because of the recovery in the Western Hemisphere population. Let's hope conservation and educational programs continue to bear fruit and that leatherback numbers recover throughout their entire range. AD

All flash and underwater photography of leatherbacks in Trinidad were conducted with permits and with guides from local authorities and sea turtle conservation organizations.

JOHN THOMPSON

By Tim Cothren

Years Diving: 26
Hometown: Rincon, Puerto Rico
Favorite Dive Destination: Mona Island, Puerto Rico
Why I'm a DAN Member: "DAN has been a great supporter of SUDS over the years, and it is good to know they have your back in an emergency."

TIM COTHREN

John Thompson with SUDS diver Dan Hendrix in Kona

Opposite, from top: **SUDS diver Marco Robledo and photographer Tim Cothren dive in Guantanamo Bay; SUDS divers in Kona**

"You can't walk through the doors of Walter Reed Army Medical Center [now Walter Reed National Military Medical Center], see our injured young men and women coming back from the wars in Afghanistan and Iraq and not get involved," recalled U.S. Army National Guard paratrooper John Thompson about his first visit to that hospital in 2005. "It was a real gut check."

Thompson had been working for 14 years as a Colorado Outward Bound School instructor and 10 as a scuba instructor. His skills led him to a Red Cross volunteer position in the aquatic therapy department at Walter Reed, where he developed an idea. "There is a pool here, and I'm a dive instructor," he thought, "so let's try to use scuba diving in the aquatic therapy rehabilitation process." He created Soldiers Undertaking Disabled Scuba (SUDS) in February 2007.

SUDS is not a simple jump-in-the-water program. Each veteran completes his or her academic and pool work at the hospital under the care and direction of several core SUDS volunteer instructors who have training in the Scubility Diver Program from Scuba Diving International (SDI). Next, SUDS arranges dive trips so the divers can complete their open-water training at destinations such as Puerto Rico, Hawaii, Guantanamo Bay and others. They finish the program as certified divers capable of diving just about anywhere.

"SUDS pays for all the veterans' expenses, from airfare to meals and lodging," Thompson explained. "There is no cost to the participant." SUDS, a subordinate chapter of Disabled Sports USA, is a grassroots nonprofit organization based at Walter Reed in Bethesda, Md. It has only one paid employee and relies solely on donations from the general public. Local restaurants, residents and dive operators offer assistance during trips.

For some veterans these trips are their first forays away from their hometowns that don't involve deployment, combat or a hospital. Marine Sgt. Greg Edwards, a double amputee, reflected as he looked into the clear blue water of the Virgin Islands: "I've never been anywhere but Mississippi and Iraq; this is awesome!"

SUDS also has a growing number of returning vets who have fallen in love with the sport and are working on advancing their certifications. "Lots of veteran organizations just give stuff away; what I love about SUDS is that it is about bettering yourself," said Redmond Ramos, a U.S. Navy hospital corpsman. "John is adamant about us getting another certification and advancing our skills — it is about becoming a better diver."

Therapy is still at the center of the organization. "The majority of the veterans we work with are amputees," Thompson said, "but we see all sorts of injuries, from severe burns to traumatic brain injuries, PTSD and paralysis. Water is a great equalizer." Volunteers often hear veterans say things like "The pain vanishes when I'm weightless," and "I find peace of mind underwater that I can't find on land."

JOHN THOMPSON

An unusual concert of popping and clicking occurs before each dive as prosthetic legs are removed and replaced with specialized devices featuring mechanical ankles that can be articulated and moved downward as a foot would during swimming. Some divers prefer to go without the finned prosthetic. Greg Edwards uses webbed gloves to pull himself through the water. "Just because you have legs and I don't doesn't mean you're better than me," Edwards said. "I can do anything you can underwater."

One of the more unusual dive destinations for the group is Naval Station Guantanamo Bay (GTMO) in Cuba. Thompson was stationed there in 2003 and built a relationship with Ocean Enterprises, the local dive shop on the base. The warriors meet at a small air charter company in Fort Lauderdale, Fla., and board a flight to GTMO. It takes about three hours to fly there because the small prop planes have to veer all the way around the east end of the island to avoid Cuban air space. The dive shop and the Reef Raiders dive club raise funds to provide accommodations for the veterans. Checkout dives are done right there in the bay, but the big payoff is being able to dive from secluded beaches that are usually off limits even to the individuals stationed there. Since any outside boat traffic has been prohibited there since 1898, the reefs are pristine. You won't find any lost snorkels on the bottom here.

A crew from the HBO series *Real Sports with Bryant Gumbel* joined a SUDS group at Guantanamo and filmed soldiers enjoying the experience for a segment titled "Underwater Heroes," which aired in June 2009. Some veterans used scooters to get around the virgin reefs. Styrofoam fish were floated mid-water to create an underwater shooting range for spearfishing. Virtually untouched by humans, the reefs were thick with life, including some very large lionfish that had invaded the waters.

As the wars have been winding down, the number of wounded service members coming off the battlefield has slowed. SUDS has refocused its efforts toward continuing dive education while still reaching out to the military's wounded, ill and injured. To date, the organization has trained more than 400 injured soldiers to dive.

Thompson is a man of few words, but he is proud and passionate about diving and helping our injured servicemen and women. "I often say I have the greatest job in the world," he said. "I'm blessed — I think I get even more out of this than the warriors. I have a lot of great help, and I get tremendous satisfaction from contributing to the recovery of our veterans"

"A city boy like me never would have attempted anything like this if it weren't for John and SUDS," said U.S. Army Sgt. Javier Torres, a New York native who was shot in Afghanistan. "Now I want to advance my certification and become an instructor so I can help other wounded veterans — just like John does." AD

COURTESY SUDS

Calendar of Events

DIVE SHOWS AND EVENTS

Beneath the Sea

April 1-3: Secaucus, NJ

Join us at Beneath the Sea, where members of DAN's medical and research teams will present a series of informative and interactive dive safety seminars with a specific focus on incident prevention and management. Come by our booth to pick up our new health and diving educational booklets, guides and slates. Remember to bring your DAN membership card and photo ID to receive $5 off show admission.

The Blue Wild

April 23-24: Fort Lauderdale, FL

Targeting "anyone who loves the ocean world," this show appeals to water enthusiasts above and below the surface. Visit the DAN booth to learn more about our health and diving materials, as well as specific information regarding dive safety while freediving, spearfishing and underwater hunting. The Blue Wild is held at the Broward County Convention Center and features more than 100 exhibitors.

Scuba Show

June 4-5: Long Beach, CA

More than 300 exhibitors and dozens of seminars will feature the latest in diving equipment, training and travel opportunities and a day of dive safety by DAN experts. Also, stop by the DAN booth to pick up your copy of our latest in health and diving resources, purchase a new oxygen unit or first aid kit, renew your membership or simply say hello.

RESEARCH/MEDICAL EVENTS

Dive Safety Seminar: "Perspectives on the Eye and Scuba"

April 6: Durham, NC

We are dependent on eyesight for everyday activities, including the atypical conditions of diving. Vision is altered by the properties of the underwater environment. The eyes can also be affected by high partial pressures of oxygen, decompression stress and barotrauma. In this presentation, Stefanie Martina will discuss issues related to the eye and diving and provide practical recommendations for divers regarding vision correction options and gear considerations.

DAN-UHMS Diving and Hyperbaric Medicine Course

May 7-14: Cayman Brac, Cayman Islands

In collaboration with the Undersea and Hyperbaric Medical Society (UHMS), DAN will co-host a six-day program that brings together a diverse and engaging international faculty at Brac Reef Beach Resort to deliver a range of perspectives on dive medicine. While the course is designed for physicians, emergency medical personnel, paramedics, nurses and professionals, as well as instructors, divemasters and nonmedical, diving-related personnel with an interest in dive medicine may also find the course valuable. Event details and registration information are available online at *DAN.org/Events*.

Education Spotlight

FIRST AID CURRICULUM UPDATE

DAN® is updating its first-aid course materials to reflect the latest recommendations from the International Liaison Committee on Resuscitation (ILCOR). Comprised of experts from the major resuscitation organizations around the world, ILCOR meets twice a year to review evidence-based research regarding cardiopulmonary resuscitation (CPR) and emergency cardiovascular care (ECC). The committee typically publishes revised CPR and ECC guidelines every five years and provides resuscitation education recommendations for both lay first-aid providers and health-care professionals.

"DAN first-aid courses are regarded by many as the gold standard in diving first aid," said Patty Seery, DAN director of training, "and to maintain that status in the dive community we must follow the most current guidelines." The 2015 recommendations incorporate changes in everything from basic first aid to neonatal cardiac care, although the guidelines primarily reemphasize the need for providing quality compressions and minimizing time spent "off the chest" (not performing compressions) during CPR, whether for ventilations or for providing other care.

The release of the 2015 guidelines marks the transition to a new publication schedule for ILCOR, which from now on will be continuously updating online materials as new findings become available.

"We welcome these changes in evidence-based medicine," said DAN medical information specialist Scott Smith, "because they help everyone to become better providers — whether they are using first-aid skills or surgical techniques."

New materials are expected to be available in early March.

DIVE SITE REGULATIONS: WHAT TO ASK BEFORE YOU GO

Rules vary depending on where you dive. Local dive operators or governing bodies might regulate anything from the gear you use and the hours you dive to the type of diving you do and who can dive with you. An important part of any trip planning should therefore involve researching the sites you plan to visit. Before you go, find out the answers to these questions:

Does my training match the dive site's requirements?

Not all dive sites allow open-water recreational divers. In fact, some dive sites, such as cavern- and cave-diving sites, require a high level of training. Make sure you either check online or call the local dive operator to determine certification and training requirements.

What equipment is allowed?

Some sites require you to bring special equipment such as surface marker buoys or spare air. Other locations prohibit use of certain items such as gloves or spearguns in an effort to protect the marine environment. Learn what is mandatory and what is restricted before you pack.

What are the site's access requirements?

Protected dive sites or sites located on or next to private property sometimes require divers to purchase tickets or tags to dive. They also occasionally limit entry to specific locations due to environmental or privacy concerns. Some dive sites even require divers to use a guide employed by a local shop or resort. Gated sites such as quarries often have their own regulations. For example, certain quarries require membership before divers can gain access, and many locations restrict the hours in which you can dive. Don't show up to a site only to be turned away — do your research first.

Good diving etiquette dictates that divers should follow the rules set in place regardless of where in the world they travel. Remember that diving regulations are established to protect your safety or the safety of the marine environment or to ensure compliance with local laws and customs of your travel destination. Just as we learn to respect the inhabitants of the underwater world during our open-water training, we should also respect the regulations set by people who facilitate our entry into that world.

ANDY MORRISON

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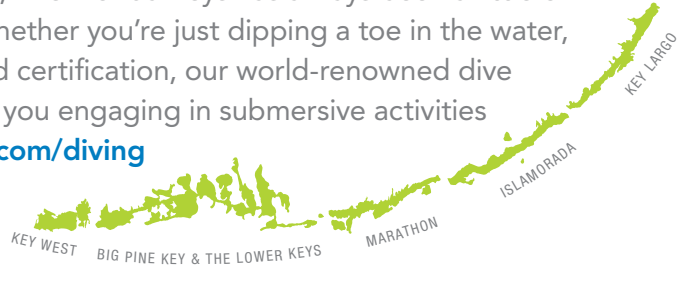

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Below: Dragon moray

Opposite, clockwise from top left: Striped boarfish hanging out beneath a ledge; undescribed Japanese pygmy seahorse; fairy wrasse displaying courtship colors

ON ANOTHER PLANET

JAPAN: PART 1

Text and photos by Ned and Anna DeLoach

Anna and I had been talking for a decade about taking a diving trip to Japan, but we couldn't quite muster the gumption to put a package together. Our reluctance had come to a quick end by the time Richard Smith finished showing us images from his recent visit to Japan's Izu Peninsula and the southern island of Hachijo-jima. One after another, fish we had never seen or even imagined popped onto his laptop screen. He saved the best for last: an exquisite seahorse no bigger than a button.

Eleven months later, five of us, including Smith, find ourselves clutching a thick rope as we shuffle backward down a slope toward a lava-lined cove. The water is turbulent from the early effects of a typhoon that's spinning its way up from Micronesia. Once we're underwater and away from shore it's smooth sailing. We disappear into a world of fishes so offbeat it is as if we are on another planet.

Along the edge of a canyon we come face to face with a whiskered, bony-headed boarfish the size of a platter. A pair of equally outrageous morwongs peers out from a ledge. Nearly every fish is new to us — new damselfishes, new butterflyfishes and new blennies. After an hour our guide, Kotaro, rounds us up and herds us back toward the entry point. That's when it dawns on me that I had totally

forgotten to look for the pygmy seahorse, the reason we are diving the cove under such testy conditions. Our exit isn't graceful. Before we even catch our breath and sort through the strewn gear, Kotaro is on his phone scheduling a boat for the afternoon.

Although choppy, the seas in the lee of the island are manageable aboard the traditional Japanese fishing vessel Kotaro arranged. The captain drops us on an underwater arch loaded with fish — including dragon morays, we've been told. I've always wanted to see one. Who wouldn't? They're one of the flashiest eels in the sea; each wears a personalized coat of cartoon colors.

Dragon morays prefer chilly water, and I don't. That's why I have yet to see one. My gauge reads 68°F, but I'm not complaining. I'm handling the temperature fine in a 5mm wetsuit and vest. And besides, who has time to be cold? In the distance I see a male fairy wrasse showing off for his harem, and I'm after him. I slow down a short distance away to consider my options. In a minute I'm onto the Romeo's routine, and I position myself near a group of his egg-laden females. Sure enough, he sails close in a blaze of color, circles twice and streaks away. My eye is still following him off in the distance when Anna comes flying up, waving wildly. I follow her yellow frog-kicking fins to my first dragon moray. It's a beauty.

During the night the typhoon takes a promising turn to the west. The wind is still gusty, but the sky breaks blue, giving us the confidence to sneak back around the island to look for the seahorse. This time we're diving from the boat. I choose a secluded section of the wall and begin what I intend to be a disciplined search. I would not make a good soldier: Within minutes an unfamiliar brown speck of fish peeking out from a crack catches my attention. Squinting, I lean closer and spook the fish back into the shadows. It takes some time to get a clear view of a green-eyed goby accessorized with oversized fins. By the time I remember my mission I'm 50 minutes into the dive. I cast a guilty glance over my shoulder. Not far away the others remain on task, methodically scouring the wall for the fabled seahorse.

During the night the storm spirals back in our direction, prompting an early morning powwow. Weighing options, we decide to cut our Hachijo-jima stay short and set off for the airport to reschedule flights. With clerical matters settled, we make a late-morning dive in the harbor and then venture offshore in the afternoon for a final dive on a deepwater slope that connects to a shallow-topped seamount.

We make our drop beneath a blanket of black clouds. Eighty feet below it is as dark as night. Instinctively, everyone moves up the incline in search of light until we find ourselves hunkered down inside a gully on a 30-foot-deep tabletop. "A disappointing last dive on Hachijo-jima," I'm thinking at the very instant I see Kotaro lurch back from the wall with both arms flung to the side. Suddenly there is no typhoon brewing, no early departure, no swells and no dreary sky. In their place is a finely cut, wafer-thin seahorse no bigger than a button bathed in the beam of Kotaro's hand light. AD

PREDIVE WARM-UP

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

Divers tend to be very invested in their gear. They clean masks, adjust straps, check computers, test regulators and shuffle weights prior to taking giant strides into the underwater realm. It is important that divers also remember to prepare their most important dive gear: their bodies.

Before you dive, take a moment to inventory your body. If you were sedentary on the ride out to the dive site your heart rate is probably near resting, so it is not circulating much oxygen to your muscles. Your muscles may be tight, which limits mobility. Your joints might be creaky, limiting comfort of movement. If you dive right in, you risk cramping up or starting the dive feeling less than optimal. You have invested a lot in your training, planning and preparation, so take a few minutes to prepare your body.

Diving is a physical activity. A proper warm-up and stretching routine is important for both enjoyment and safety during dives. A smart stretching session can boost circulation, lubricate joints and warm up muscles. It will allow you to don your gear and enter and exit the water with greater ease. It may also allow you to acclimate to the underwater environment more quickly.

A progressive warm-up gradually increases the heart rate and dilates the blood vessels, which promotes oxygenation of muscle tissue. Elevated muscle temperature optimizes efficiency and flexibility. A predive stretch reduces stress on muscles, tendons and joints and increases range of motion.

Before you dive, spend five to 10 minutes to complete a few rounds of the exercises below. Pay attention to how your body feels, and focus on any areas that seem tight.

CALF STRETCH

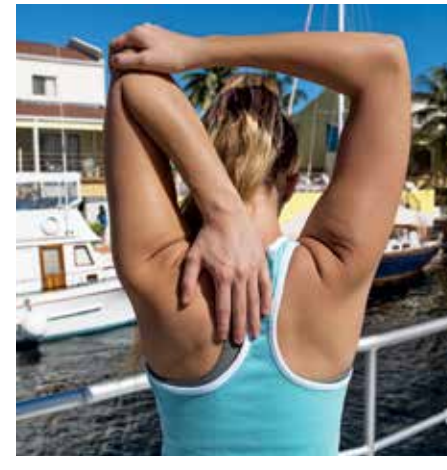
Calf cramps are a common annoyance in diving; the calf muscles (gastrocnemius and soleus) are primarily responsible for pointing your toes during finning. Tight calf muscles can lead to cramping, so stretch your calf muscles before you dive.

If you are already wearing fins, stretch your calves just like you learned in your open-water class:

1. Straighten your leg.
2. Grab the blade of your fin.
3. Pull the blade back toward your knee until you feel the stretch, and hold this position for 30-60 seconds.
4. Repeat on the opposite side.

If you are not wearing fins:

1. Sit with one leg straight (flat on the ground or seated on a bench).
2. Loop a towel under your toes.
3. Pull until you feel the stretch, and hold this position for 30-60 seconds.
4. Repeat on the opposite side.



BACK SCRATCHER SHOULDER STRETCH

You don't want the first time you reach overhead to be when you need to reach a valve or locate your regulator.

1. Extend one arm straight overhead.
2. Bend your elbow, and reach down your spine.
3. Grasp the bent elbow with the opposing hand.
4. Gently pull your elbow, and hold this position for 30-60 seconds.
5. Repeat on the opposite side.

Tip: *Keep your head up.*

HANGING ARM CIRCLES

Rotator-cuff issues are a common ailment as we age. Activation of the rotator muscles prepares the shoulder for action and increases joint mobility.

1. Bend over at your waist while maintaining a flat back.
2. Let one arm hang freely, and rotate it 30 times clockwise and 30 times counterclockwise, gradually increasing the size of your circles.
3. Use the other hand to brace yourself, if necessary.
4. Switch arms after two to four sets.

STANDING OR SEATED TRUNK TWISTS

Lower-back tightness is a common cause of back problems, so warm up prior to donning heavy dive gear.

1. Begin with a tall spine while either standing or sitting.
2. Cross your arms in front of you like a genie.
3. Slowly rotate to your right, hold this position for a two count, and return to center.
4. Repeat to the left.
5. Move smoothly, and maintain control.

WALL PUSH-UPS

Push-ups are excellent for activating the major muscles of the upper body.

1. Stand facing a wall or a solid object at chest height.
2. Extend your hands straight toward the wall with your palms flat and fingers facing up.
3. Lower your chest toward the wall, hold this position for a two count, and slowly push away.
4. Perform 10-15 repetitions.

SQUATS

Squats activate all the major muscles and joints of the lower body including the ankles, knees and hips.

1. Begin with your feet slightly wider than shoulder width.
2. Push your hips back while maintaining a flat back.
3. Lower your hips as if sitting down, and keep your knees from traveling forward of your toes.
4. Once you reach a comfortable seated position, stand up, pushing your hips forward.

Tip: *Keep your heels on the floor at all times. Do squats only in calm seas.* 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.

The *EMBA*, a wooden three-masted schooner barge that was scuttled in 1932, sits upright in 170 feet of water.

Opposite: The Milwaukee coastline

LAKE MICHIGAN

MILWAUKEE-AREA SHIPWRECKS

Text and photos by Becky Kagan Schott

My first dive in the Great Lakes was 20 years ago. I remember vividly the descent into dark green water.

Soon after that dive I moved to Florida with my family and forgot all about the Great Lakes because I had warm water and tropical reefs in my backyard. Fast-forward to five years ago and my next Great Lakes experience: I was blown away by the pristine state of the wrecks I saw in Lake Superior. This ignited in me a new passion for Great Lakes diving. Not long afterward I was fortunate enough to work on a documentary in Lake Huron, where we located and explored several new wrecks. I was surprised by how blue and clear the water was.

The unfortunate introduction of invasive quagga mussels has improved the water clarity dramatically in many of the lakes. They now cover the wrecks in four out of five of the Great Lakes, but visibility can be 100 feet or more. The water looks Caribbean blue on most days, and the lakes are no longer as dark and murky as they once were.

The Great Lakes have quickly become my personal favorite dive destination; there are numerous wrecks within recreational diving limits and beyond. I've traveled to many of the world's top wreck-diving

HOW TO DIVE IT

Getting There

Milwaukee is an easy airport to access, with many direct flights there available. Visitors driving from the Chicago area can take I-94 straight into Milwaukee.

Conditions

May through September are the best months for diving. Air temperatures are typically between 50°F and 80°F, with conditions ranging from dense fog to bright sun. Water temperatures vary by time of year and depth. June water temperatures are in the high-30s°F or 40s°F, but late in August water temps can be 50°F-60°F. There is typically little or no current on the wrecks, and most have at least one mooring buoy for ascents and descents.

Topside Adventure

There are plenty of things to see and do in Milwaukee. The *Denis Sullivan* is a three-masted replica schooner similar to what you would have seen plying these waters more than a century ago. Milwaukee also has many museums, breweries, lighthouses, parks and excellent food.

destinations, and I believe that the Great Lakes are among them. The wrecks here are frozen in time, preserved by the cold, fresh water. Many of the wooden steamers and schooners have sat intact for more than a century; they would no longer exist if they were in salt water. Diving in the lakes is like peering into a time capsule: Here you can read the ships' names, see cargo such as automobiles from the 1920s, find intact schooners with rigging still in place and much more.

I've made a half-dozen trips to various places on the lakes, most recently Milwaukee, Wis. There's much more to Milwaukee than cheese and beer: It's a wreck-diving wonderland for those adventurous enough to take the plunge. The dives range in depth from just 10 feet to more than 300.

S.S. *MILWAUKEE*

Our first destination was the S.S. *Milwaukee*, a railroad-car ferry that once conducted year-round, cross-lake service for the Grand Trunk Railroad. The ship went down in a storm Oct. 22, 1929, killing its crew of approximately 50. It was carrying 27 railcars filled with wood veneer, vegetables, cheese, butter, bathroom fixtures, corn, feed, seed, malt and automobiles. After 1920 all railroad car ferries were retrofitted with a clamshell transom called a sea gate to prevent waves from coming aboard in a following sea. The *Milwaukee*'s sea gate was bent in by the tremendous waves of the gale that sank the ship. Water entered at the stern and filled the lower compartments. Rail cars broke free and smashed through the side of the hull. The sea gate unhinged on the starboard side when a refrigerator car's wheel trucks broke through it as the ship was sinking. The 338-foot steel-hulled *Milwaukee* went down just seven miles northeast of Milwaukee, three miles offshore in 120 feet of water.

As you descend onto the wreck, its reinforced, ice-breaking bow comes into view, standing upright on

the bottom. It's an incredible sight to take in. About 150 feet off of the port side of the ship lies the original wheelhouse, which in 1908 was converted to its chartroom. Even after 86 years on the bottom of the lake, the painted name "Milwaukee" is still visible above the chartroom doors. Farther down the ship are train cars filled with a cargo of sinks, toilets and bathtubs.

The *Milwaukee* has two massive propellers. The starboard propeller shaft sits atop the wheel truck that smashed through the sea gate during the ship's descent to the bottom. The U-shaped sea gate on the stern is bent and mangled, a testament to the ship's violent end. Along the rail deck one of the railcars that breached the hull can be seen. Depths range from 90 to 120 feet, and visibility can be as much as 80 feet. It's a fantastic wreck dive, and those with the requisite training will also find much to explore in the engineering spaces and crew quarters.

S.S. *WISCONSIN*

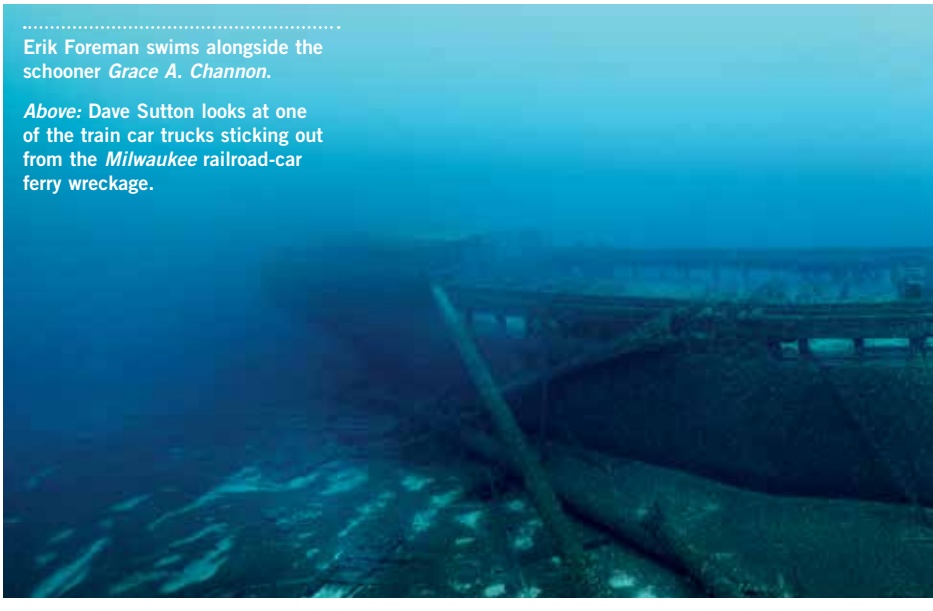
The S.S. *Wisconsin* went down in a violent storm just one week after the *Milwaukee*. A 215-foot steel-hulled passenger and

freight steamer, the *Wisconsin* was operated by the Goodrich Transportation Co. It sank in a storm six miles southeast of Kenosha, Wis., on Oct. 29, 1929. Nine crew members, including the captain, lost their lives.

The wreck sits in 90 to 130 feet of water. Much of the ship's superstructure has collapsed onto the deck or can be found among the massive debris field. It was carrying a mixed cargo of household goods, radiators, heaters, stoves, furniture and other boxed freight. Several automobiles, including a Hudson, an Essex and a Chevrolet, are feet away from an open cargo door. The stern and bow are visually striking and offer great photo ops. The ship is large and difficult to swim around in one dive, so several dives on this site are recommended.

PRINS WILLEM V

The next wreck we visited was a 258-foot, Dutch-flagged steel freighter called *Prins Willem V*,



Erik Foreman swims alongside the schooner *Grace A. Channon*.

Above: Dave Sutton looks at one of the train car trucks sticking out from the *Milwaukee* railroad-car ferry wreckage.

one of the most visited wrecks in the area. The ship was lost Oct. 14, 1954, in a collision with Sinclair Oil Co.'s barge *Sinclair No. 12*, which was being towed by the tug *Sinclair Chicago*. It foundered in 45 to 90 feet of water three miles east of Milwaukee. The Coast Guard rescued the crew of 30, but the ship went down with a cargo of TVs, automobile parts, machine parts, printing presses, instruments and animal hides. Several attempts were made to raise the *Prins Willem V*, but all failed. The wreck lies intact on its side and has large open hatches, several masts and machinery to observe. Many barrels that were abandoned after a salvage attempt remain inside the hold.

GRACE A. CHANNON

The wreck of the *Grace A. Channon* lies in technical-diving depths. This three-masted wooden schooner was built in 1873 and lost in a collision Aug. 2, 1877. It was en route from Chicago, Ill., to Buffalo, N.Y., with a cargo of coal when the steam barge *Favorite* struck its side. The crew of six sailors along with three passengers escaped to the schooner's workboat and were picked up by the *Favorite*. Alexander Graham, the 7-year-old son of the schooner's co-owner, was the only person killed in the disaster. The ship now sits upright in 180 to 200 feet of water with its masts unstepped. It's only 140 feet long, so it's easy to swim around in a single dive.

The ship features rare diagonal outer-hull planking on its transom. Damage from the collision can be seen in the form of a big gash on the port side that's largely below the ship's original waterline. Many intricate carvings on the wooden stem post and along the bow are kept free of mussels by divers. The clear water means ample ambient light at depth, and visibility can exceed 100 feet. This visibility and the incredible degree of preservation on this 143-year-old wooden schooner make for excellent photographic opportunities.

There are hundreds of wrecks in the area, each with its own story of how it ended up frozen in time at the bottom of Lake Michigan. These truly incredible wrecks allow glimpses of American history and Great Lakes shipping. There are still missing ships, and with advances in diving, sidescan technology and remotely operated vehicles, a few new wrecks are found each year. Lake Michigan diving entails rich history, gorgeous shipwrecks and so many sites as to keep underwater explorers busy for years. AD

Below: **A sand tiger shark stretches its jaw while swimming through the wreck of the *Aeolus* 28 miles off the coast of North Carolina.**

Opposite: **The *Aeolus* is a reliable site for diving with sand tigers; they are often seen swimming inside the wreck, and diver presence does not disturb them.**

WRECK DIVING WITH SAND TIGERS

Text and photos by Mike Gerken

While most humans try to avoid sharks, the surge in popularity of shark diving in the past 10 years shows that divers are enthusiastically traveling the world intentionally seeking them out.

North Carolina's Outer Banks are a prime location for diving with sharks. Over the centuries, many ships met their demise there due to war, weather or human error as well as by becoming artificial reefs. These wrecks have morphed into prolific reef communities with abundant marine life from every link in the food chain, and sharks are the dominant predators.

Drawn in by the bountiful food supply, numerous species — including blacktip, sandbar, bull and occasionally hammerhead sharks — can be found on these wrecks. But the stars of the show are the plentiful sand tiger sharks (*Carcharias taurus*).

With small, piercing eyes that seem to stare at you from every direction and rows of ragged teeth protruding from a cruel smile, the sand tiger's visage is reminiscent of a Hollywood villain's. But looks can be deceiving; these sharks are actually docile and sedate animals that do not startle easily. Careful divers who respect the animals' space will be able to achieve proximity without needing bait or chum. Because of the sharks' mild disposition and the ease of finding them, encounters are almost guaranteed.

Geography plays an important role in producing the great diving opportunities off the North Carolina coast. The Gulf Stream heads north along the Western Atlantic, eventually colliding with the barrier beaches that are the Outer Banks. In the summer water temperatures can reach 80°F, with the average on the bottom hovering in the mid-70s°F. Visibility can exceed 100 feet on a good day, and the norm is around 60 feet. The combination of warm, clear water, historic wrecks and plentiful sharks and other marine life makes for world-class diving.

Even after spending hundreds of hours in the water with sand tigers, I still get a rush from being among these menacing-looking but gentle sharks. On a given dive only a handful may be on a wreck, while on another there may be too many to count. Each year in mid-July on the wreck of the *Caribsea*, east of Cape Lookout, sand tigers ascend from the bottom higher into the water column, where the water is clearer and warmer. On more than one occasion I have seen nearly 75 sharks, all females, gently swimming into the current in a schooling formation. It is unknown why they do this, but the sight of it is permanently etched in my mental logbook.

The aggregation of sand tigers on the wrecks is most likely due to the reliable source of food the shipwrecks provide. The wrecks may also serve as navigational aids during the sharks' migrations. Dean Fessler, educational director of the Shark Research Institute, explained it this way: "Sand tigers migrate long distances up and down the East Coast, heading as far north as Maine in the summer and south to central Florida in the winter. They detect the electromagnetic fields the wrecks emit and use them as waypoints along their route, much like we would use a GPS."

Whatever inclinations sand tigers have for the wrecks, recreational divers are happy they have them. Being surrounded by a plethora of toothy sharks while exploring a historic shipwreck makes the diving experience all the more fascinating and educational. As Fessler added, "It's a history and biology lesson all in one."

Also known as ragged-tooth sharks or gray nurse sharks, sand tigers are found worldwide, predominantly in temperate and subtropical waters, including the Atlantic coasts of North and South America as well as South Africa, Australia and Japan. Juvenile sand tigers

are around 3 feet long at birth; the average length for adult males is 8 feet, while females max out at around 10 feet and 350 pounds.

Sand tigers tend to mate in late winter to early spring. The male shark will bite the female on the pectoral fin to latch on during the mating process. Each year in May, at the beginning of the dive season in North Carolina, many females are seen sporting grizzly wounds. But the sharks are fast healers. Come July the wounds are mostly healed with only faint scars remaining.

Every two or three years, after a gestation period of eight to 12 months, females typically give birth to one or two pups, typically one from each of her two uteri. These young sharks are frequently seen on the wrecks and are easy to approach. This small number of births is due to the fascinating but macabre phenomenon of intrauterine cannibalism, in which the larger and stronger fetuses consume the lesser ones. A pregnant female may start off with as many as 40 embryos but give birth to just the one or two pups. Hence, sand tiger sharks obtain their hunting instincts even before birth. The disadvantage of this is that sand tigers have one of the slowest rates of reproduction of any shark species. When their numbers are down it takes longer for them to rebound.

Overfishing of sand tigers has caused their numbers to plummet worldwide. In the 1970s and '80s in Australia, divers purportedly used explosive powerheads to kill sharks for sport. Because of how easy it is to approach sand tigers, little skill was involved in this style of fishing, and the results were devastating. In the United States, recreational fishermen as well as commercial longliners and purse seiners often caught sand tigers unintentionally. Considered a "trash fish," sand tigers caught as bycatch usually died. These and other unchecked and destructive fishing practices took a toll on sand tiger shark numbers to the point that they became a protected species in Australia, South Africa and the United States in 1997. Today they are listed as vulnerable on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species.

The answer to whether sand tiger numbers are increasing depends on who you ask. "I do not have any scientific evidence, but I do believe sand tiger shark populations might be on an upward trend," said Chris Paparo, manager of the Marine Sciences Center at the Southampton campus of Stony Brook University. "In recent years, anglers targeting fluke or striped bass have been catching both adult and juvenile sand tiger sharks with greater frequency."

Recreational divers who have been diving North Carolina's wrecks for more than 25 years also report

The *Atlas* tanker's mazelike remains are a perfect backdrop for photographing sand tiger sharks.

seeing more sand tiger sharks now then ever before. "Shark numbers may be stabilizing, but to say they are increasing may be a stretch," Fessler countered. "There are more eyes in the water today looking for sharks than there were 25 years ago; in turn more sharks are being seen."

Based on what I have witnessed over the past 15 years, I believe shark numbers are slowly on the rise. I'm seeing sharks on wrecks where they were rarely seen before and with more regularity. Regardless of whether their numbers are increasing or not, sand tiger sharks, like all marine apex predators, require continued protection. The health of the ocean ecosystem, on which we are dependent for fish stocks, starts at the top of the food chain. Abundant sharks equates to abundant marine life. It's no coincidence that when we see the greatest numbers of sharks on wrecks we also see large gatherings of other fish such as Atlantic spadefish, grouper, jacks and flounder.

When I was a dive boat captain in North Carolina, each morning before departure I would ask the divers where they wanted to go. Most would say without hesitation, "We want sharks!" There was no need to twist my arm; a few minutes later we would be under way to wherever the hot spot for sand tigers was at the time. The wrecks of the *Caribsea, Proteus, Atlas, Aeolus,* USCGC *Spar* and *W.E. Hutton* (also known as the *Papoose)* are some of the famous sand tiger haunts that were often at the top of the hit list. As long as Mother Nature cooperated enough to allow us to venture offshore, we could pretty much count on outstanding shark diving.

As divers walked down the dock at the end of a successful day of shark encounters, I could tell I was going to see many of them again soon. It was apparent these divers had been bitten — not by a shark but by a bug: Sand tiger shark diving is highly contagious. AD

RESEARCH EDUCATION MEDICINE

The *Duane* is a former U.S. Coast Guard cutter sunk off the coast of Key Largo, Fla., in 1987. It is now lavishly decorated with sponge and orange cup corals and is home to abundant marine life.

STEPHEN ERINK

Touch and Go in Tonga

Text and photos by Douglas Hoffman

I started diving in 1985 and have been traveling the world to dive ever since. I have always had DAN® dive accident insurance in case I ever experienced a dive emergency, but thankfully I have not needed it. Another reason I've always been a DAN member is the evacuation benefit. I had the occasion to use that service just a few months ago, and it saved my life.

For the past 11 years I have guided expeditions dedicated to observing and photographing Southern Hemisphere humpback whales in Tonga, where swimming with the whales is permitted. Known as the friendly isles, this South Pacific nation is about a 90-minute flight from Fiji or a three-hour flight from New Zealand. It's remote, its infrastructure is lacking, and in many ways going there is like going back in time.

Because of this remoteness, I require everyone who goes one of my tours to be a DAN member and have DAN dive accident insurance. It is better, of course, to have it and not need it than to need it and not have it. Fortunately, I practice what I preach, because on Aug. 29, 2015, I needed it.

That afternoon we observed a relaxed mother and calf at the surface. After watching them for a while, we decided the time was right and slipped into the water. We swam about 100 feet and saw the whales, so we stopped and watched. We made no attempt to swim toward them and let them decide if they wanted to interact with us. As it happened, they did, and we floated side by side for more than an hour.

When the encounter began, the mother positioned the baby on her far side. As she became more comfortable with our presence, she made some subtle changes to her position, and the baby reacted by changing its position. The calf swam over the mother's back and alongside her, close to us. At one point the mother and I were floating just a few feet apart and looked into each other's eyes — it was magical.

During that swim I had some stomach discomfort, but I shrugged it off as indigestion. It persisted through

During a dive trip to the South Pacific, Douglas Hoffman became so ill he had to be evacuated for surgery to save his life.

the afternoon though and got worse in the evening. The next day was Sunday, and in Tonga nothing happens on Sundays. I lay in my room and could not find a comfortable position. The pain was severe. The next day rather than going to the boat I went to the doctor. After an ultrasound and a brief examination the doctor said I had a classic case of ruptured appendix and that I needed an operation or I would die.

Those are not words anybody wants to hear. I went to the hospital, where they put me on an IV and started talking about what to do with me. There was no surgeon in the area, and I would need to be evacuated. So I notified my sister, and she called DAN.

That was that. I just lay there, and DAN, along with my local friends Lisa and Amecia and my sister in California, took care of the details. Just prior to sunset an air ambulance landed in Vava'u to take me to New Zealand.

I remember lying on the gurney with an IV in my arm, being in pain and seeing a surreal sunset out the window. I thought to myself how lucky I was to have a private jet come and get me. Customs officials met the plane on the ground in New Zealand, and by the time the crew got me into the ambulance my paperwork was in order, and I was on the way into lifesaving surgery. I most certainly did not anticipate such a significant health crisis, but by being a DAN member I was prepared for it.

I am a week away from my next whale adventure, this one in Dominica, and you can be sure my DAN membership, dive accident insurance and trip insurance plans are all current. I don't plan to have another life-threatening emergency, but I take great comfort in knowing that if a problem arises I am covered. Having insurance not only protects you but also helps your loved ones feel at ease, and that is priceless. I strongly suggest that all divers, especially those who travel to remote locations, get covered. Thank you, DAN, and safe diving, everyone. AD

Always Ready

THE U.S. COAST GUARD DIVING PROGRAM

By David Helvarg

"My umbilical is stuck," MK1 Michael Pearsall reports.

"Primary banks going down," DV1 Geri Cabrera says from where she's monitoring her fellow diver's air, communications and depth on the XLDS (Extreme Lightweight Diving System).

We're on a Coast Guard pier in Alameda, Calif. It's a hot, clear day, and we can see his bubbles about 30 yards out.

"I'm having a hard time breathing. I need some air," Pearsall says.

"Tell the diver to go to EGS," directs team supervisor DV1 Adonis Kazouris, referring to the emergency gas system. Cabrera relays the message. Pearsall switches to the EGS scuba tank on his back instead of the rack

RYAN CARPENTER

of tanks on the pier that has been supplying him air through a quarter-inch umbilical.

"Can you get the umbilical untangled?" Kazouris asks Pearsall.

"No, negative," he replies.

The team's second diver proceeds over a muddy gray bottom through murky, 5-foot-visibility water and reports, "I've found a leak in the umbilical. Unfouling it now."

"Thanks, buddy," Pearsall responds into the mic of his MK-20 full-face mask, prompting some wry grins from his seven topside teammates.

Soon line handlers lift the two divers to the surface. "Divers on surface," Kazouris calls out.

"Divers on surface," a topside chorus repeats. The two divers climb up a swaying 15-foot rope-and-wood Jacob's ladder that's been secured to the pier a short distance behind the Coast Guard cutter *Stratton*.

I'm with a "fly-away team" from the U.S. Coast Guard's Regional Dive Locker West (RDLW), based in San Diego, and working out of a trailer full of tanks, weights, a compressor, safety lines and more.

Between maintenance dives underneath the 418-foot *Stratton*, they're doing what Coast Guard personnel always do between operations: train fiercely, in this case with various emergency scenarios such as loss of air supply, injury, entanglement and decompression sickness (DCS). They're working to qualify a couple of dive supervisors on the new XLDS. These drills are based on their primary missions: aids to navigation, polar operations and PWCS (ports, waterways and coastal security).

Examples of this work include helping to rescue the 207-foot Australian fishing vessel *Antarctic Chieftain* after it got stuck in Antarctic ice last winter, securing Manhattan's rivers when Pope Francis visited New York in September and helping recover debris and bodies from a Coast Guard helicopter crash that killed four of their fellow service members off Mobile, Ala., in 2012. In March 2016 they will head to the Arctic Ocean to train with Navy divers on an ice floe off Prudhoe Bay, Alaska, where a growing range of threats and challenges are emerging from the declining sea ice.

As part of their polar mission training, they do a lot of ship inspections and repairs for the fleet. Yesterday they inspected the *Stratton*'s hull, props and bow thruster (using a hand-held Outland video system so the ship's engineer could see what they saw), and they plugged a discharge port so a leak in the engine room could be worked on. This afternoon they'll put another patch over a sea chest (intake reservoir) so additional maintenance can be carried out inside the hull.

One of the dives lasted for an hour and 55 minutes, which is why they're using a surface-supplied air

system — so they don't have to pull divers out of the water to switch tanks.

"These guys are beautiful for us," notes the *Stratton*'s commanding officer Captain Nathan Moore. "If we'd called in a commercial dive team we'd be at their mercy."

The two unplanned patches probably would have cost about $10,000. In August 2015 the RDLW sent eight divers to Juneau, Alaska, to work on eight ships gathered for the annual buoy tender roundup. (Along with law enforcement and search and rescue, the Coast Guard also maintains the nation's navigational lights and buoys).

When I began writing my book *Rescue Warriors: The U.S. Coast Guard, America's Forgotten Heroes*, I was surprised that these service personnel seemed more comfortable on and above the water than below it. They had a rescue swimmer program that grew out of a helicopter rescue tragedy in 1983, but no dive program.

The service has had hardhat and scuba divers since World War II, but until recently diving was considered volunteer or collateral duty and comprised shallow-water repair work from three Pacific buoy tenders and hull inspections of polar icebreakers. After 9/11 the number of Coast Guard armed responders skyrocketed. The Maritime Transportation Security Act of 2002 created Maritime Safety and Security Teams (MSSTs) in major ports, and these teams included scuba divers doing underwater security sweeps. Still, even as it expanded from four to 12 units, diving remained a collateral duty, with most divers selecting and maintaining their own gear. Then on Aug. 17, 2006, a tragic safety failure occurred.

That day Lt. Jessica Hill and Boatswain's Mate Steven Duque died on a training dive below arctic ice during an "ice liberty" on the Coast Guard cutter *Healy* about 500 miles north of Barrow, Alaska. They were undertrained and overweighted, each carrying 60 pounds of weight in the pockets of their BCDs — about twice the recommended amount. Their low-pressure inflator hoses were not connected to their BCDs. They rapidly dropped down nearly 220 feet, where they ran out of air and asphyxiated. Their line handlers were nondiver volunteers who had no idea what was going on. The internal Coast Guard investigation that followed revealed a cascade of safety breaches, including that their gear had not been inspected in more than four years.

"The *Healy* incident flipped our entire leadership on its ear," says Ken Andersen, now chief of subsurface capabilities for the Coast Guard. Recognizing that diving had to be "elevated on par with other high-risk, training-intensive operations such as aviation," the service decided to professionalize it, establishing

DAVID HELVARG

permanent dive lockers in California (RDLW) and Virginia (Regional Dive Locker East) in 2008 and a third more recently in Hawaii (Regional Dive Locker Pacific). Training, gear and inspections were standardized. The lockers will soon have 71 rated members. The Coast Guard officially established a diver rating, and the first class of certified Coast Guard divers was recognized in April 2015.

Those already on duty spend more than 200 days a year deployed on missions. To carry these out they've acquired and trained on remotely operated VideoRay subs; metal detectors; hand-held, mask-mounted and towed side-scan sonar systems; and hydraulic tools, including underwater chainsaws. They use surface-supplied systems, Kirby Morgan helmets and scuba units. They hope to have their own hyperbaric chamber within five years; for now they deploy to sea with Navy medical crews and chambers or else depend on shore-based facilities.

New recruits go through a one-week screening at the enlisted training center in Cape May, N.J., where they put in a lot of pool time. Next they get acquainted with the lockers and are then sent to the Naval Diving and Salvage Training Center (NDSTC) in Panama City, Fla. There they undergo the Navy's five-month Second Class Diver Course (see "Year of the Military Diver," *Alert Diver*, Summer 2015). Some will later return for the three-month First Class Diver Course, which focuses on dive medicine and mission planning. Toward the end of the Second Class course, instead of Navy underwater explosives training, the Coast Guard divers undergo specialized training in light salvage, drysuit operations and polar diving.

The Coast Guard runs the armed services' only ice-diving school for two weeks each winter at a National Oceanic and Atmospheric Administration (NOAA) facility in Seattle, Wash. After some emergency ascent training in a tower tank, the trainees head 370 miles north to Lac des Roches, British Columbia, where they chop a hole in the lake ice and head below each morning. They lay out wagon-wheel designs in the snow around the hole in case a diver loses an umbilical and needs surface markers to find his or her way back.

DAVID HELVARG

DV1 Geri Cabrera and Chief Petty Officer Lucas Spencer monitor a diver using the XLDS.

Opposite: **MK1 Michael Pearsall enters the water for a training dive in Alameda, Calif., using the extreme lightweight diving system (XLDS).**

The patterns stand out dramatically on the ice as long as it's a sunny day.

As part of its training agreement with the Navy, the Coast Guard assigns six full-time trainers to NDSTC. Another seven work at the "dunker" at the Rescue Swimmer school in Elizabeth City, N.C. Dunkers are mock-ups of helicopter or small-boat interiors that drop and capsize in a pool (often in simulated darkness and storm waves) to train aviators and sailors to escape from a water crash.

Other interesting jobs done by Coast Guard divers include habitat surveys of endangered sea grasses and corals off Florida to see if navigation buoys need to be moved and post-Hurricane Sandy underwater inspections of newly created hazards to navigation. Poststorm assessments such as that, along with oil and chemical spills, have gotten program managers focused on developing contaminated-water diving capability for the lockers.

Back in Alameda, Pearsall complains to Geri Cabrera and the others, "This gray muck really clouds up," as he scrapes the mud off his dive boots, which he used to walk across the not really contaminated but certainly not pristine bottom of Alameda Bay.

One of only two women in the program, Cabrera, who grew up in Guam, is a pretty typical Coast Guard diver. "In 2007 I was asked, 'Can you do pull-ups?' 'Yeah, I can do pull-ups,' I said; I guess that's the issue they had with women," Cabrera says. "So I qualified and began diving with MSST Honolulu while also driving a 25-foot tactical boat because diving was still collateral duty. Later I dived the Pacific off the buoy tender *Sequoia* and then came to San Diego before moving on to Operation Deep Freeze [aboard the Coast Guard icebreaker *Polar Star*] for five months to McMurdo Station. So I've dived on untouched corals in the Pacific and in cold Antarctic waters. I have had the best of both worlds while getting to help people. I'd say my career's been blessed."

Now the recreational diving community stands to benefit from the Coast Guard's growing interest in diving. Since the Coast Guard investigates all maritime accidents, the dive program recently wrote a guide to help nondiving investigators better understand the factors that contribute to diver injuries and fatalities. Having themselves emerged out of a deadly incident, the dive lockers are seriously committed to putting safety first while also living their service's motto: *Semper paratus* — Always ready. AD

Genetic testing facilitates precision medicine, which has improved breast cancer treatment. Decompression sickness, like breast cancer, may be promoted by particular genetic or epigenetic variables, which if better understood could lead to precision medicine for divers.

The Future of Dive Medicine

HOW SCIENTIFIC RESEARCH WILL ENHANCE DIVER SAFETY

By Petar Denoble, M.D., D.S.C.

Medical advances in recent decades have led to targeted treatments for some cancers. This has raised hopes for similar breakthroughs in the fights against other diseases. Politicians are getting involved, calling for further work in "precision medicine" and individualized approaches to patients. Medicine in the 20th century identified specific causes and treatments for many diseases, but treatment outcomes remain highly variable. We have learned that most diseases and injuries are caused by multiple factors, meaning that a specific event, condition or individual characteristic by itself is not generally sufficient to produce the disease. When our knowledge of any of the integral factors of a given disease is incomplete, we remain puzzled by varying outcomes, and our preventive and treatment interventions lack desirable precision and efficacy.

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Sometimes unbeknownst to us there are several different sets of causal mechanisms that can lead to a specific disease. Other times individuals' responses to a known set of causal factors remain variable for unknown reasons. Advances in genomic studies open new possibilities for identifying causes of variability — both in responses to harmful factors and in the efficacy of specific treatments. This has advanced modern oncology, and a similar approach could benefit other areas of medicine, too. First we will examine how genetic testing enables precision medicine in two common cancers, breast cancer and lung cancer, then we will discuss how precision medicine pertains to dive medicine.

Breast cancer provides a good example of how genetic testing contributes to precision medicine. In the general population, breast cancer is caused by multiple factors. About 5 to 10 percent of breast cancer is caused by inherited genetic mutations. The two most important mutations related to breast cancer, BRCA1 and BRCA2, are present in 0.1-0.2 percent of the general population and in a much higher percentage in some minorities. The overall risk to women in the general population of developing cancer by age 70 is 12 percent. However, the average risk is much higher for carriers of BRCA1 (55-65 percent) and BRCA2 (45 percent).

While not all women with hereditary risk factors develop breast cancer, the risk for some women may be greater due to other known or unknown factors. Breast cancer is less common in men (0.1 percent), but in men who have the BRCA2 mutation the risk of breast cancer is about 7 percent — 70 times that of noncarriers. In addition to genetic testing of the individual, which provides information about the risk of acquiring the breast cancer, genetic testing of the cancer helps medical professionals establish a prognosis, choose effective therapies and avoid therapies to which the cancer is resistant.

In lung cancer today, genetic testing is unfortunately of less benefit, despite much work. Lung cancer is the leading cause of cancer death in men and women, and an external factor, cigarette smoking, is its number

one cause — 90 percent of lung cancer is associated with cigarette smoking. However, only 10-15 percent of smokers develop lung cancer in their lifetime, suggesting that there may be a host of differences in susceptibility. A family history of lung cancer doubles the risk of developing lung cancer, but a specific inherited factor has not been identified. Genetic studies of lung cancers continue, not because we want to learn who can smoke risk-free (smoking causes many other cancers and serious diseases) but to find possible genetic drivers of cancer growth that could be targeted by therapy. At present, genetic testing may help guide the therapy in a small fraction of lung cancer cases. The most significant target for the prevention of lung cancer, however, is cessation of smoking, and preventive efforts need not wait for advances in medicine to eliminate 90 percent of lung cancer cases.

PROBLEMS WITH PRECISION IN DCS

In decompression sickness (DCS), the magnitude and duration of exposure to pressure, the rate of decompression and some external factors determine the outcome of a dive. The role of tissue supersaturation with inert gas is notorious. The deeper and longer the dive and the faster the decompression, the greater the likelihood of supersaturation during ascent and of venous gas emboli (VGE), popularly called bubbles, which may result in DCS. In severe decompression accidents the consequences are generally grave without much variation among individuals due to the overwhelming significance of the external factors. However, in relatively mild dive exposures when the pressure and pressure change are limited, occurrence of VGE is variable but common, while occurrence of DCS is very rare but never zero.

The variability in both of these outcomes still escapes our comprehension. After the same dive, some divers may develop a lot of VGE, while others will not develop bubbles at all. In most divers who develop bubbles, the VGE are filtered out by the lungs and cause no harm. In a fraction of divers, however, VGE will pass through the right-to-left shunt from the veins into the arterial circulation, potentially blocking terminal arteries, damaging organs and causing symptoms of DCS. Even when this arterialization of bubbles occurs, few affected divers develop DCS. The only constant is that with more severe dive profiles (greater pressure, longer exposure duration and faster decompression) the average probability of DCS increases.

Contemporary dive-computer models measure exposure to an external factor — pressure — over time, but they cannot measure internal factors that modify the saturation and desaturation of the body. These include the amount of blood that perfuses tissues per unit of time, percent and distribution of body fat and other known and unknown factors. Algorithms used in dive computers take into account just the dive profile (the depth, time, breathing gas and rate of pressure change), assume an average body build and metabolic state, and predict the probability of DCS. However, it is clear that the risk is not the same for all individuals, but specific individual factors are not known. Figure 1 shows three stages of individually differentiated risk.

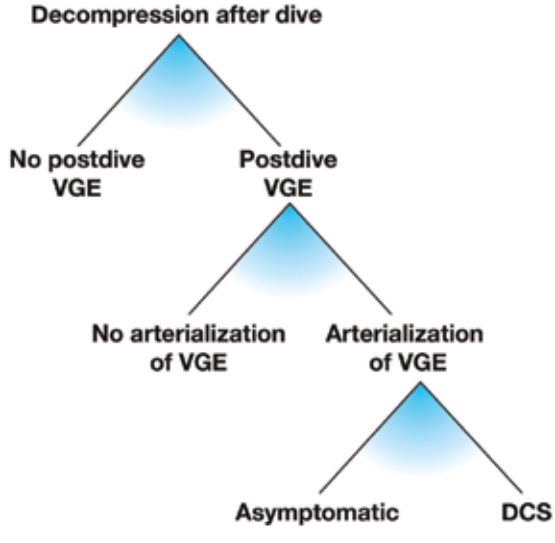
STEPHEN FRINK

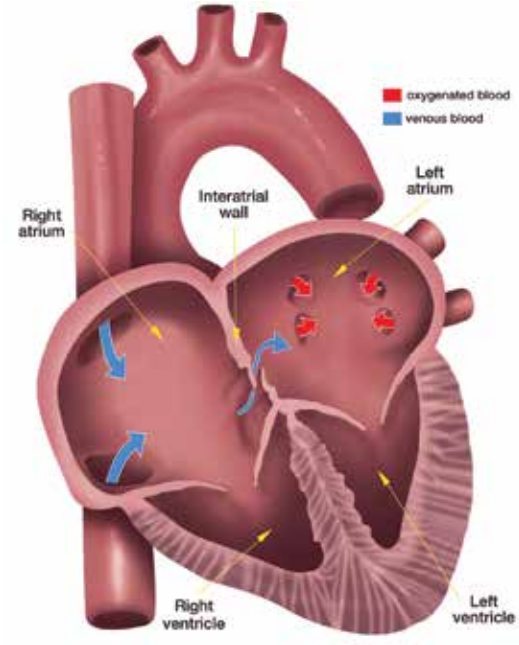
At each of these three stages there are factors that modify the effects and outcomes of exposure. In the absence of specific knowledge, the most common preventive strategy is to reduce supersaturation by limiting the depth/time exposure and ascent rate for all divers to avoid substantial bubbling — even though bubbles put only some divers (those with a right-to-left shunt [RLS]) at risk. Without bubbles (or with only a few), there will be no arterialization, even in divers with RLS, and there will be no DCS in those susceptible to arterial embolization.

Several approaches to mitigating postdive bubble occurrence have been studied; these include predive removal of hypothetical bubble nuclei by whole-body vibration, attempts to influence oxygen radicals or nitric oxide suspected of contributing to bubble generation, stimulation of heat-shock protein production and various other methods, including predive chocolate treats. Although some of these factors may reduce the amount of bubbles, the effects vary and may be of less importance than the individual variation in response to decompression.

If every diver had a consistent individual propensity for VGE production and could be classified as a "bubbler" or "nonbubbler" across a broad spectrum of reasonable dive exposures, safe exposure limits could be tailored individually. We would achieve greater precision if we could identify those divers who have persistent or occasional RLS and then customize a dive exposure for them. At present we already know that a large patent foramen ovale (PFO) enables arterialization and

Figure 1.





apparently increases the risk of DCS. A test for PFO is available. We can identify divers with a large PFO and close it, but this does not solve the problem for all divers because RLS may occur in lungs regardless of PFO. Risk of DCS due to pulmonary RLS may be more difficult to tackle because pulmonary RLS seems to be part of the normal physiological response to exercise and far more prevalent in the population than large PFOs.

It is important to note that even if we could prevent the occurrence of VGE, DCS could still occur. VGE do not play a role in pain-only DCS. Some cases of spinal DCS may be caused by bubbles occurring locally in tissue, without bubbles in venous blood. Similarly, some cases of inner-ear DCS may be caused by local bubbles rather than by arterialized gas emboli. Cutaneous (skin) manifestations of DCS may be caused by various mechanisms, some involving embolization of arterialized VGE and others independent of VGE.

As in lung cancer, the definitive cause of DCS is an external physical factor that, unlike smoking, we cannot eliminate if we want to dive. But by controlling the magnitude of exposure, we can minimize the risk of DCS. There is still a lot of room to improve the precision of DCS prediction and develop individually tailored preventive exposure restrictions. This can be achieved by advancing VGE study methods and dive population studies to identify individuals who may easily produce VGE or are prone to arterialization.

Understanding why some divers easily produce VGE and why some are more prone to DCS in the case of

Below: **Studies have identified changes in gene expression and transcription following breath-hold and compressed-gas dives.**

Opposite, from top: **Venous gas emboli (VGE) may enter arterial circulation through a right-to-left shunt such as a patent foramen ovale (PFO). VGE do not occur after every dive, not all VGE enter the arterial circulation, and arterialized VGE do not always lead to DCS.**

VGE arterialization, however, will need a novel approach. One promising direction is the study of the innate immune system and inflammation, both of which are involved in the human body's response to stress. Diving involves exposure to environmental changes that challenge the entire body and elicit immune responses and inflammation controlled by genetic mechanisms. However, measurable changes are rarely present in asymptomatic divers, making it difficult to study the transition of physiological adaptive stress responses into maladaptive or pathological reactions that lead to impaired organ function.

SHUNYU FAN/ISTOCKPHOTO.COM

GENETIC STUDIES

The idea that DCS, like breast cancer, may be promoted by a particular genetic or epigenetic variation attracts more and more researchers.

Genes are the basic physical units of inheritance passed from parents to offspring; they contain the information needed to specify traits. Humans have approximately 20,000 genes, an impressive collection that constitutes an individual's genotype. Genes are grouped into 23 pairs of chromosomes, each pair containing approximately 3.1 billion distinct code elements. The information encoded in genes is expressed through

the creation of proteins that build body structures and control body functions — the individual's observable traits, called the phenotype.

This expression involves transcription of the code from genes to messenger molecules that leave the cell nuclei and enter the cell body, where they direct synthesis of a specific protein. Gene expression is affected by another layer of molecules (the epigenome), which varies from cell to cell. The relationship between genotype and phenotype is complicated further by gene interaction with the environment. Thus, studying genetics is complex and requires a lot of resources. So far, genetic studies in diving have just scratched the surface.

Changes in gene expression and transcription have been found in animals exposed to breath-hold and compressed-gas diving. Underwater diving exposes divers to hyperoxia and increased production of reactive oxygen species, which are involved with nearly every physiological process in cells, including programmed cell death (apoptosis). Response to this stress alone can alter gene expression and transcription. Similar stress may be caused by exercise in nondivers and by many other factors.

Some studies found that experienced divers, as compared with nondivers, showed persistent changes in pathways of apoptosis, inflammation and immune responses in blood transcriptomes, indicating a cellular state of sustained alertness toward exogenous stress. There were no measurable physiological differences, however, between the divers and nondivers. Changes found after scuba diving were typical of sublethal oxidative stress; they included suppression of lymphocyte activity and activation of the innate immune system. It was not possible to distinguish the effects of oxidative stress and of gas microbubbles. Changes were similar after additional dives, and they returned to normal in between the dives.

Whether there will be a dive analog of BRCA1 and BRCA2 is impossible to predict at this stage. But these are just the first steps in a long journey, and accelerating development in medicine and technology leaves little doubt that precision medicine for divers will be achieved. AD

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Based on a review of the past 10 years of freshwater dive fatalities in the U.S. and Canada, DAN recommends divers be familiar with their gear, pay attention to their gas supplies and avoid ascents without any visible reference.

Safe Diving in Fresh Water

Text by Peter Buzzacott, MPH, Ph.D.; photos by Andy Morrison

We were gearing up on a sunny spring day at our local dive quarry. I had not dived for some months, and I recalled last year's DAN *Annual Diving Report*, in which we had written a section about diving fatalities in quarries, lakes and dive parks. There are more than 150 such sites — also known as scuba parks — in the U.S. and Canada, most of them near large population centers.

In our review we looked at the past 10 years and found 47 deaths in dive parks (defined as any freshwater site that deliberately placed attractions to entice divers) and 63 diving deaths at other freshwater sites such as rivers and lakes. (We excluded caves because cave diving is highly specialized.) We compared these two groups to identify safety issues we might warn the diving community about.

Although we didn't know where all the divers got their gear, we did know that information in 47 cases. Of these, 36 percent were wearing rented or borrowed equipment. The percentage was the same for freshwater diving fatalities both inside and outside of dive parks, but it was a much higher rate than for diving deaths in the sea, where we found that just 26 percent of divers who died were wearing unfamiliar gear.

Fatalities in dive parks peaked in May, earlier in the year than those in other freshwater sites or in the sea. I wondered if this timing might be a result of many divers returning to diving after the winter with a day at their local quarry. Maximum depths where divers died were significantly deeper in dive parks (76 feet compared with 39 feet outside of dive parks), and technical diving was also more common in dive parks than at other freshwater sites (17 percent versus 6 percent), probably due to greater access to deeper depths. Training was the purpose of the dive in 28 of the 110 freshwater deaths (25 percent).

The top three causes of death were drowning, cardiac problems and arterial gas embolism (AGE), as is commonly found in the sea. One thing that stood out, though, was that all five AGE events occurred in dive parks.

It was important to DAN researchers to figure out how to use these data to assist the diving community, so our next step was to look at our database of diver-supplied reports to help us better understand the causes of injuries and incidents. This incident report from a dive park contains some common elements:

I accompanied a class of students on a dive in a quarry. We visited a helicopter in water deeper than 60 feet. Once the class had performed their exercises, my buddy led the way from the helicopter to an underwater boat. The instructor and students followed at a distance. When we arrived at the boat, which was at about 45 feet, we stopped and turned around.

Unknown to us, about 10 yards away a diver in the class began to experience difficulty breathing through his regulator, and he quickly became low on air. He looked at his pressure gauge and saw that the pressure dropped to zero with each difficult breath. I did not see him since he was coming down at an angle and I was facing away from him. My buddy handed the diver a spare air supply twice, and he let go of it. He looked panicked.

Fortunately, staying calm saved the day in this case, and both divers surfaced unharmed. However, this incident should remind us all to regularly check our gas supply, especially when we dive deeper than usual. This incident also includes common elements of incidents such as a diver in training, diving more deeply than usual and being at risk of a panicked ascent, which is a well-established factor in many AGE deaths.

SUMMARY

On average, 11 divers die each year in fresh water in the U.S. and Canada. Almost half of these deaths occur in dive parks, which are typically deeper than other freshwater dive sites. Technical diving was more common in dive-park deaths than in deaths outside of dive parks.

Training was the purpose of the dive in 25 percent of the fatalities. Unfamiliar gear is a hazard for all divers; it may be more common at freshwater sites where training is popular. DAN recommends that divers take a few minutes before diving to become familiar with any new, borrowed or rented equipment. Check it carefully before entering the water, and when possible try it in water shallow enough to stand up in before going deeper. In particular, familiarize yourself with buoyancy control and emergency weight-removal systems, which vary among manufacturers.

Given that buoyancy problems and rapid ascents are linked to the risk of AGE, DAN recommends that divers try to avoid blue-water ascents when possible. In dive parks this might mean following an old quarry road away from shore and then back again at the end of the dive or using an ascent line and buoy for reference. If you must surface in open water, consider deploying a surface marker buoy connected to a reel, locking the reel and using the line as a reference.

Based on the types of incidents most often submitted to DAN's online reporting system, divers should remember to regularly check their remaining gas. Remember DAN's top three tips for safe diving in fresh water: Dive with familiar gear, avoid blue-water ascents, and keep an eye on your gas gauge. AD

Can I Dive with My Medical Condition?

DAN MEDICS AND RESEARCHERS ANSWER YOUR QUESTIONS ABOUT DIVE MEDICINE.

Q: I have been diagnosed with a medical condition, and I cannot find any specific information about it at *DAN.org*. How can I find out more about my condition and diving?

STEPHEN FRINK

A: The International Classification of Diseases (ICD), published by the World Health Organization (WHO) and used by physicians around the world, lists 12,420 disease categories and more than 70,000 diagnostic codes. The DAN® website includes specific information about a wide range of health and medical issues relevant to divers and potential divers, but it is impossible to list every disease and medical condition.

Consider calling the DAN medical information line at +1-919-684-2948; DAN medics and physicians are available to discuss your diving-related health and safety questions Monday through Friday, 9 a.m. to 5 p.m. Eastern Time. DAN medics have a wealth of knowledge about fitness to dive and diving with various medical conditions. We also have close working relationships with several major university medical centers and a large global network of doctors of various specialties trained in dive medicine.

Next consider that questions about fitness for diving with many medical conditions can be answered based on general guiding principles. Several of the articles at *DAN.org/medical/articles*, such as "Cardiovascular Fitness and Diving," "Diving and the Body Systems" and "Psychological Issues in Diving," can give divers an understanding of the most important criteria for determining fitness to dive — even if their particular medical condition isn't mentioned specifically.

While each individual's health status must be considered on a case-by-case basis, divers with significant cardiovascular or respiratory disease, disabling musculoskeletal issues or limited exercise capacity are usually discouraged from participating in scuba diving. Diving requires a level of fitness that can accommodate sudden exertion: a long surface swim to the boat or shore, fighting a strong current, carrying gear, climbing a ladder, managing heavy surge or surf and rescuing oneself or one's buddy. Poor physical fitness is a hazard to the diver as well as to dive buddies and/or potential rescuers.

A diver with physical limitations may wish to find a program specifically designed for divers with disabilities. There are a variety of adaptive dive programs for disabled divers. Some of these are therapeutic or rehabilitative by design, and these programs were created with medical support for both the disabled diver and the dive buddy.

— Marty McCafferty, EMT-P, DMT

Q: My wife and I love to travel to exotic destinations, and my previous doctor used to give me antibiotics in case I got sick in a remote location. I have a new primary care physician who is hesitant to do this. What does DAN recommend?

STEPHEN FRINK

A: For some time now prescribing guidelines regarding antibiotic use for various conditions have favored a much more conservative approach due to increasing antibiotic resistance. Many illnesses are viral in nature, and antibiotics are of no benefit in these cases. If you get sick while traveling, a local physician is your best resource; he or she will be aware of the common pathogens that cause problems in the area you are visiting.

When traveling, your best defenses against illness are handwashing, careful sourcing of water and food, getting relevant travel immunizations and taking appropriate precautions in areas where mosquitoes and other living organisms can transmit infectious diseases to humans. Talk to your doctor or visit a travel medicine clinic if you will be going to a region in which medical care is lacking. The doctor can advise you about any medications you should take with you and when to use them.

— Scott Smith, EMT-P, DMT

Q: Lately I feel like I'm getting sunburned much more easily than I used to. I am taking a new medication; is there any chance that could be the cause?

STEPHEN FRINK

A: Sunshine is a welcome addition to just about any day spent outdoors. For many people, a hat, a T-shirt and some sunscreen are sufficient to limit the negative effects of sun exposure.

However, certain medications can make people more sensitive to the sun's ultraviolet (UV) rays; this is called photosensitivity. Both regularly and temporarily used medications can cause photosensitivity. Minor symptoms include skin reddening, itching or rash; more serious symptoms include a burn, blisters and discoloration or darkening of the skin. Report any significant or unusual reaction to a medication combined with sun exposure to your prescribing or primary care physician. Some reactions are serious.

There are more than 100 medications, both prescription and over-the-counter, that can cause increased susceptibility to UV rays, and these include both oral and topical medications. The best policy is to first read the label of any medication you take and then ask your physician and/or pharmacist about photosensitivity before exposure to the sun (or a tanning bed).

Drugs that may cause photosensitivity include antibiotics, antihistamines, cardiovascular medications (such as diuretics and blood pressure medications), nonsteroidal anti-inflammatory drugs (ibuprofen, indomethacin), some antidepressants and some antipsychotic medications.

Taking a medication that can cause photosensitivity doesn't mean you have to avoid outdoor activities, it just means you should take extra precautions to lessen your exposure to UV light. Consider wearing a wide-brimmed hat, long sleeves and long pants, and reapply your sunscreen more frequently. Stay indoors around mid-day if possible, and seek shade when you're outside.

— Joel Dovenbarger, BSN

Q: I have been diving for 15 years without problems, but on my last couple of trips I experienced pain in my upper left abdomen under my ribs about 15-30 minutes into a dive. It becomes increasingly painful over the rest of the dive. I am healthy, take no prescription medications and exercise regularly. I usually take antacids prior to diving. I do not have this pain any other time. It gets more uncomfortable during ascent but goes away shortly after I get out of the water. It is starting to take the fun out of diving. Any suggestions?

A: Please note that we cannot diagnose you; you really need to be evaluated by a physician. Because your abdominal pain seems to change with pressure, it may be due to the expansion of gas in your gastrointestinal system. The increased discomfort during ascent in particular suggests trapped gas as a possibility. It could be normal gas resulting from digestion, or it could be from drinking carbonated beverages. Avoiding gassy foods such as beans, broccoli, cabbage and other cruciferous vegetables may help. Many divers stay away from sodas prior to diving to limit the amount of gas in the gastrointestinal system.

This may be evidence of a hernia. During ascent an isolated segment of bowel containing excess or expanding gas can expand, which may cause pain or injury. People should not dive with an unrepaired hernia. Other sources of abdominal pain include reflux, an irritated ulcer and other causes, but pain caused by these factors would be expected to occur at other times as well.

Another possibility that you should consider is that this may be related to swallowing air while breathing from your regulator. Divers swallow a certain amount of air as a result of breathing compressed gas, and a second stage with very low breathing resistance or that is prone to free flowing can increase air swallowing. You might consider having your regulator serviced and discussing your issues with the service technician. A "tightening up" of the second stage may help you.

Remember this is all speculation and that an evaluation by a doctor is crucial.

— Frances Smith, EMT-P, DMT

CHRISTO/SHUTTERSTOCK

Q: What do I need to know about diving with a cold sore?

A: Here are a few issues you should consider:

1. *Risk of further injury* — Sun exposure or mechanical trauma from the mask and/or regulator may worsen the wound, creating a larger scab and lengthening the healing process.
2. *Infection* — If the sore is bleeding, oozing or otherwise open, the risk of infection by pathogens in the water is significant. Cold sores can become complicated by bacterial infections, so it is important to wash them thoroughly with soap and water and keep them as clean and as dry (in general) as possible.
3. *Impaired mask fit* — If a mask skirt will be placed over the sore in a way that rubs or irritates it, then diving should be postponed. The same is true of the regulator; if holding it would cause irritation, then diving would not be recommended.
4. *Transmission* — Dive buddies should review procedures for buddy breathing in an out-of-air situation in light of the fact that cold sores are contagious. If gear is rented, ensure proper decontamination procedures are followed. Although it's unlikely, there is always a chance that resuscitation may be needed. Thus, precautions should be taken to prevent disease transmission. This is normally not an issue because barrier devices are readily available in most first aid kits.

Treatments such as penciclovir (Denavir) and docosanol (Abreva) can soften the skin and promote healing. Topical numbing agents such as phenol and menthol may be used for comfort. See your doctor and begin using an over-the-counter product at the first sign of a cold sore; beginning antiviral therapy within the first 48 hours can speed recovery. AD

— Lana Sorrell, EMT, DMT

Prepared to Act

OXYGEN, A WILLINGNESS TO USE IT AND A FAST BOAT SAVE THE DAY

By Savannah Vasquez

The day started just like any other for Capt. Josh Livingston of the *DreadKnot*, a dive and fishing charter boat out of Destin, Fla. Livingston and three guests had set out into the waters of the Gulf of Mexico with one plan: to freedive and pole-spear some red snapper on day one of the snapper season in federal waters.

After the group had tried one artificial reef spot without success, Livingston moved to a new location 20 miles offshore, where he noticed another group of divers.

"We were over the *Belize Queen* tugboat about 1,000 feet away from where they were on the *Odyssey* paddlewheeler," Livingston said. "When we pulled up I saw their dive flag."

But before Livingston and his guests had the chance to submerge, a mayday call came over the radio.

"I turned up the volume and heard the exchange and the coordinates; I looked at my plotter and realized the diver in distress was from that boat," Livingston said. The radio chatter seemed to suggest decompression sickness (DCS).

As a divemaster and certified emergency first responder,

ERIC DOUGLAS

When a diver from another vessel began to experience serious symptoms, Capt. Josh Livingston did not hesitate to provide quick assistance using his oxygen unit and his boat.

SAVANNAH VASQUEZ

"There is always an element of risk in diving, and not having oxygen available for emergencies amounts to an additional hazard."

Livingston knew the distressed diver needed pure oxygen as soon as possible.

"I got on the radio and asked the crew of the other vessel if they were prepared to deal with this type emergency, and they said they did not have oxygen on board," he reported. "So I radioed that I did and would be right there."

In no time, the *DreadKnot* pulled up alongside the other boat, where its crew of three had positioned the diver in an open space on the deck atop some life jackets for cushioning.

"I hopped on the boat first, and I recognized the injured diver," Livingston said. He knew the man as an avid local diver in his 50s with 20 years of experience and more than 300 dives.

Because he had prior knowledge of the man's demeanor, Livingston was better able to assess his condition. "He was out of it, lethargic," Livingston said. "He is normally very talkative, but he was very quiet and worried. I was told that he had spit up some blood, but I didn't see that with my own eyes. When I saw him he really didn't look that bad, but he was definitely lethargic and wasn't talking much."

As Livingston began to administer oxygen, he asked the diver what happened.

It was the group's third dive of the day. They too were spearfishing. Near the end of the dive, the diver got entangled in the wreck when he shot a fish. The paddleboat lies 111 feet below the surface, and Livingston learned that the accident happened close to the time the diver intended to start his ascent.

"He got entangled and ran out of air," Livingston said, "and the only way he figured he could free himself was to take off his gear, leave it at the bottom and swim to the top."

Once the diver began breathing oxygen, the next step was to get him safely to shore so he could be given a proper medical evaluation. The boat was in communication with the local Coast Guard station, which was planning to send a boat to retrieve the diver.

"The Coast Guard was going to send a cutter to meet us halfway, so we got under way, but I mentioned to them that it would probably be better to move him to my boat because it was faster," Livingston explained.

The *DreadKnot* is an aluminum-chambered boat designed for harbor patrols and Coast Guard operations, so while the recreational dive boat could cruise along at 20 knots, once they moved to Livingston's boat they would be able to increase the speed to 45 knots.

"We doubled our speed," he said, adding that during the transition the weather had begun to change. "It was getting rough with two- to three-foot seas, and the rain was coming down."

As the *DreadKnot* approached East Pass, leading into Destin, the Coast Guard met them as an escort.

"We fell in behind the cutter under the bridge and then turned to go to the Coast Guard station," Livingston said.

Once on land, the group was met by the Coast Guard, the police and an ambulance. The injured diver was taken to a local hospital to be assessed and was released the same day with no lasting health problems.

As for Livingston, he said his takeaway from the ordeal is to always be prepared.

"The Coast Guard doesn't always carry oxygen on their boats; that's one thing I learned from this," he said. "There is always an element of risk in diving, and not having oxygen available for emergencies amounts to an additional hazard."

Today Livingston carries two oxygen units aboard the *DreadKnot* and has added a defibrillator as well. He said he has no regrets about having to cancel his fishing trip that day, and he chose to refund his clients, all of whom were grateful for the positive outcome.

"We were happy we were in the right place at the right time," Livingston said. "And we were blessed with great fishing in the days that followed." AD

Although uncommon, unprovoked sea lion bites can occur, and divers should be aware of the potential hazard.

BRANDON COLE

Sea Lion Bite

By Marty McCafferty, EMT-P, DMT

ED STETSON

THE DIVER

The diver was a 67-year-old male with 35 years of diving experience.

THE INCIDENT

Early one afternoon near La Paz, Mexico, at Los Islotes, a popular dive site and sea lion rookery, a sea lion bit the diver on the stomach. At the time of the attack he was scuba diving in less than 20 feet of seawater with approximately 50 other divers from several dive boats present. After the attack, fellow divers and the crew helped him back aboard the ship. They removed his 3mm wetsuit to assess the injury and control the bleeding. He was conscious and lucid the entire time.

The liveaboard arrived in the harbor approximately two hours later, just before 3 p.m., and the diver was transported ashore in a waiting panga boat. The crew had dressed and bandaged his wounds, and he was in good condition overall. The patient, trip leader and crew determined that waiting for an ambulance might delay transport (unfortunately ambulances in that area cannot always provide timely responses), and so the trip leader chose to drive the diver in his private vehicle.

During the drive, the diver's vital signs were normal, and he did not show any signs of distress despite his obvious wounds. Because he appeared stable and the bleeding was controlled, they chose to go to a nearby local clinic. Area hospitals are usually quite busy with patients, possibly causing a delay in treatment for this diver.

They arrived at the local clinic just before 4 p.m., and the attending physician assumed care of the patient. The wounds were two parallel lacerations approximately 2 inches long, a half-inch wide and more than an inch deep with some smaller adjacent puncture wounds.

The doctor and his staff thoroughly cleaned the wounds, injected a local anesthetic and sutured the wounds closed. Two internal sutures were used first in each wound as they required a multilayer closure. Before he completed the closure, the doctor placed a sterile wick to promote drainage. One of the small puncture wounds required a single suture to close.

At the doctor's direction, a nurse administered a tetanus booster. The diver was discharged around 6 p.m., and his traveling companions escorted him to his hotel.

ANALYSIS

This incident is an excellent reminder of why dive operators need to have a preexisting emergency action plan and not hesitate to implement it. It also serves to illustrate that any action plan needs to accommodate emergencies beyond those involving decompression illness. For dive crew, good first-aid skills for physical trauma are a must.

The dive operator contacted local personnel who were familiar with local resources and made a decision based on their input and knowledge. The operator decided to transport the injured patient with the assistance of an EMT who was on the trip as well as a local lifeguard who was also an EMT.

Medical evaluation and treatment are important with any injury in which the skin is penetrated in the marine environment. Seal and sea lion bites in particular have a very high probability of infection. The importance of proper cleaning and disinfection cannot be overstated, even with apparently small wounds. All such wounds should to be monitored for signs of infection for at least seven to 10 days. Those signs can include increased swelling, pain or tenderness at or around the wound, increased redness, foul-smelling discharge from the wound, red streaks extending away from the wound site, fever and nausea.

Although it is not entirely clear why the sea lion bit the diver, a witness saw two bull sea lions fighting aggressively followed by one turning to flee from the other. The diver was approximately 50 feet away from them, but he was in the path of the fleeing animal and was bitten. Regardless of how playful or docile a marine animal may appear, we must not forget we are visitors to their environment and should remain keenly aware of their behavior. Be sure to learn how to observe and approach animals, and always follow experts' recommendations. AD

SEAL AND SEA LION INJURY MANAGEMENT

Contact with seals or sea lions can result in a serious infection by the bacterium leptospirosis, commonly known as "seal finger." Avoid feeding seals, as this will significantly reduce the likelihood of seal/human contact. Prevent contact between dogs and seals; diseases can be transmitted between them.

Wash any wounds caused by seals or sea lions thoroughly with disinfectant, and dry them. Seek medical care for any injuries caused by these animals, as there is potential for serious long-term health implications. Be sure to tell the doctor you were bitten by a seal or sea lion. Watch carefully for unusual signs or symptoms for seven to 10 days, and go to the hospital if you feel unwell at any time.

ED STETSON

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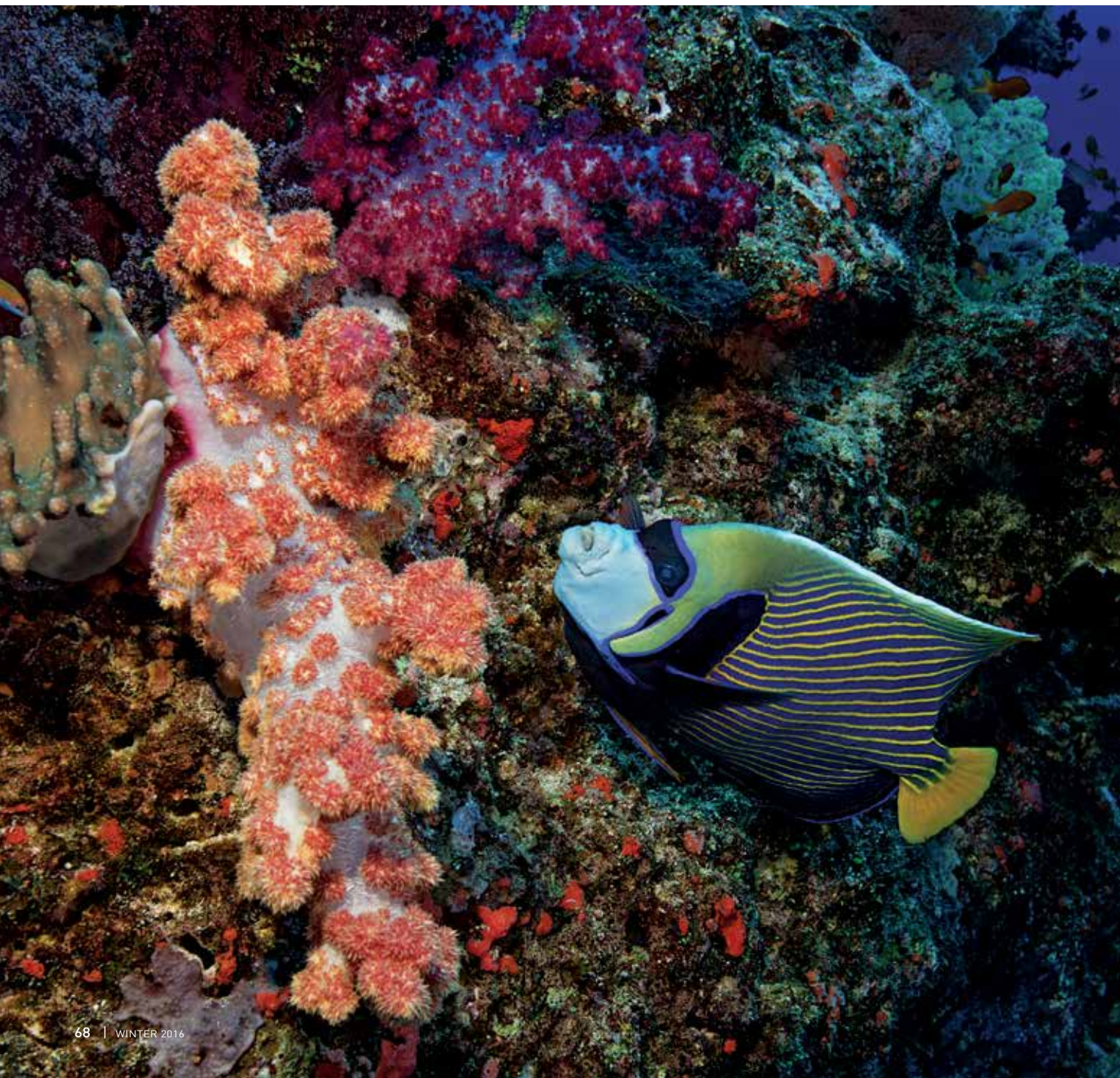




A LIVEABOARD TREK THROUGH THE BLIGH WATER

TEXT AND PHOTOS BY STEPHEN FRINK

When the divemaster announced we would start the day with a dawn dive at **Mellow Yellow**, I was thrilled. Recollections of dive sites tend to blend together over the years, but this one remains clearly defined by a previous dive in which we found a huge yellow frogfish nestled amid squat yellow sponges, surrounded by a field of saffron soft corals. I recall thinking at the time that they certainly nailed the name of the site. From my 2004 trip log:

> *At **Mellow Yellow** we were briefed on the possibility that we might find a large yellow frogfish, and sure enough it was right where we were told it would be. Larger and more vibrant than most of its Caribbean cousins, this frogfish was nicely situated amid some red and yellow encrusting sponges. However, as satisfying as this encounter was, the marquee attraction of this dive is the yellow soft corals that adorn the main pinnacle and the saddle that adjoins it to a smaller, deeper pinnacle nearby. This is the dive for which Velvia slide film was made: gold anthias, yellow soft corals, crimson sea fans and turquoise water. I was blown away on this dive — not literally, which is possible in the heavy current sometimes present here, but figuratively, in astonishment. We dived Mellow Yellow again later in the week at a time when the currents were not as propitious. There was no flow whatsoever, and the dive was therefore totally different — good, of course, but the right amount of current transforms the merely good into amazing in these waters.*

Now, more than a decade later, I wondered if this site would still deliver. After all, it is a pinnacle, and some of the pinnacles I'm seeing in other parts of the world are showing signs of wear. This degradation isn't necessarily from divers touching the coral, but as dozens of divers circumnavigate popular pinnacles every day, their exhaust bubbles percolate upward and scrub the soft corals above. We may aspire to take only pictures and leave only bubbles, but on sites with vertical walls, overhangs or pinnacles, the bubbles may cause damage.

With that in mind I expected to find this site diminished from my previous perceptions. Yet 11 years later, in a mild current (enough to supersize the soft corals but not so much as to make it difficult to stay in place to frame a photo) this remains a world-class dive.

Fiji is paradise for Indo-Pacific fishwatchers. *Above, from left:* Regal angelfish, painted frogfish, Diana's hogfish *Opposite:* Emperor angelfish

Photographers typically dive this site with a wide-angle lens; this day I concentrated on medium-sized fish portraits simply because the backgrounds were so rich, textured and colorful. While my yellow frogfish was unsurprisingly absent, the rest of the site was as pristine as ever. Revisiting the site was an epiphany, a testament to the healing waters that constantly flow through this place, the soft coral capital of the world. The fact that I was jumping into the water here so soon after leaving Los Angeles is insight into something notable about Fiji diving: It is so very good and so very near.

Unlike some exotic dive destinations, which can involve 40-hour treks and hotel stays en route, Fiji is blessedly accessible to North American travelers. From Los Angeles International Airport, Fiji's main island, Viti Levu, is a direct, 11-hour flight away. The port of departure for our liveaboard was just another two- to three-hour bus ride from the Nadi International Airport. Leaving LAX at midnight and gaining some hours by chewing through time zones along the way allowed us to settle into our cabins, prep our cameras and actually get into the water on the very first day of the charter.

CRUISING THE VATU-I-RA PASSAGE

The first dive on many cruise itineraries, the dreaded checkout dive, is quite often fairly marginal. These tend to be close to shore and offer a shallow bottom so guests can refresh rusty skills and dial in buoyancy on a reef sufficiently devoid of life that an errant bump won't matter. True to our expectations, this dive was the least impressive of those we did, but that was only because of the poor water clarity from days of rain pouring into the near-shore waters. The dive itself had potential for greatness.

At **Amazing Maze**, the amazing part was the series of tunnels rimmed by soft corals and a profusion of anthias, lionfish and clusters of anemones and clownfish. It would have been stunning but for the detritus and particulate matter that had washed onto the reef from nearby Viti Levu. With a 100mm macro lens mounted, I was perfectly happy to concentrate on reef minutiae. However, the songs of an obviously nearby humpback whale kept making me look up in expectation of the ultimate photographic frustration: a friendly whale, crappy visibility and a macro lens on my camera. I guess I was lucky I never saw a whale so I could avoid that angst.

Seeing what the near-shore reefs delivered made it all the more special to jump into the 150-foot visibility at Mellow Yellow the next morning after an overnight steam

to the Bligh Water in the Vatu-I-Ra Passage. We weren't in Kansas anymore (but we'd be going there later).

The Bligh Water is named for William Bligh, who in 1789 found himself exiled from command of the HMS *Bounty* by master's mate Fletcher Christian and a crew of 18 mutineers. Bligh and 18 loyal crewmembers were set adrift in a 23-foot launch to embark on a 3,600-mile journey to the Dutch port of Timor. Fear of cannibalism convinced Bligh not to dawdle in these waters, but dawdling here for the next 10 days was exactly what we had come to do.

After spending our first full day of the charter alternating among Mellow Yellow, **Black Magic Mountain** and **Coral Corner**, we steamed overnight to sample dive sites off the island of Makogai. My first dive was at a site known as **Half Pipe**. It would have been quite productive if for no other reason than the giant crimson gorgonians that adorn the face of the drop-off, all densely populated with small reef dwellers such as fusiliers and anthias. But I was fortunate to find an incredibly docile hawksbill turtle swimming along the wall, weaving beneath and between the abundant filter feeders. Of course there were the other usual reef suspects: titan and clown triggerfish, puffers, whitetip reef sharks, goatfish, clownfish and schooling Moorish idols. There were smaller creatures for the macro enthusiasts such as longnosed hawkfish, popcorn shrimp and leaf scorpionfish. This was a very fruitful dive that we would revisit by request later in the cruise.

After spending the day diving the nearby sites **Ratu Ridge** and **Dominoes**, we visited a village on the island of Makogai, a former leper colony. Before more humane treatment for leprosy became the norm, lepers sometimes were clubbed to death. When Fiji became a British colony, clubbing was outlawed, and the Leper Ordinance Act of 1899 addressed the contagious nature of the disease by preventing the infected from handling food for the public or bathing in public pools. In 1908 the government isolated the country's lepers at Makogai Island, and in 1911 nuns from the Missionary Sisters of the Society of Mary, along with a

From far left: **A hawksbill turtle swims through a crimson sea fan at Half Pipe; a resident ribbon eel at Jerry's Jelly; a shallow reef off Taveuni. Fiji is known for the density of colorful filter feeders that decorate the walls and overhangs.**

doctor who was the bishop in charge, arrived to care for the lepers. Other Pacific countries started sending their leprosy patients to Makogai, leading to a population of 675 patients on the island in 1947. The ratification of dapsone use at the International Conference on Leprosy in 1948 brought a steady decline in the number of leprosy cases, but not before more than 1,000 souls had been buried on Makogai.

A walk among the graves and remnants of the leprosarium was sobering, but afterward the village children put on a joyous dance for us. A convivial kava ceremony hosted by the village elder prior to the dance might have facilitated the happy atmosphere, although I've never actually acquired a buzz from drinking kava. The beverage is a grog made by grinding the root of the kava plant and straining it with water into a large communal bowl. The ceremony of drinking the muddy concoction from a coconut shell is an integral part of the Fiji experience, and one the village at Makogai shared with great hospitality.

TAVEUNI

Surprisingly, in six previous trips to Fiji I'd never been to one of its most iconic islands, Taveuni. The fourth largest island in Fiji, and connected to the outside world with its own international airport, the "Garden Island" offers a sophisticated infrastructure of dive resorts specializing in mythic dive sites. While we were diving from a liveaboard this trip, I look forward to a land-based dive trip here as well. The diving was exceptional, and we often saw the day dive boats from Taveuni cruising to their moorings. A friendly wave was about all the interaction we had with them though, for there are ample sites available to all.

Never having been to Taveuni, I'd not dived one of Fiji's most famous sites, the **Great White Wall**, an omission I was eager to rectify. According to the briefing, we would descend through a semilong tunnel and exit at about 80 feet before turning left and cruising along the reef wall. Almost immediately we encountered an area of the wall that could be described as both "great" and "white." When the current rips (which it clearly does at times, as evidenced by the density and diversity of soft corals) you might swim past the lushest portion of the dive without meaning to and won't be able to swim back against the current to see it again. You might also be surprised to see that the white soft corals aren't nearly as immense as the red, yellow or lavender soft coral trees you may have seen elsewhere. But the sheer multitude of them along this wall is most impressive. Don't despair if you are blown off the wall too soon, because the rest of the dive is likewise decorated by impressively vibrant soft-coral-festooned reefs.

One of the nice things about diving from a liveaboard that visits the same sites week after week is that the crew tends to know where to find creatures of significance. This is particularly true for territorial or sedentary species such as pygmy seahorses and blue ribbon eels, a subject I was interested in photographing.

I'm fortunate that many of my charter guests are repeat customers. A guest on this Fiji tour has an infallible memory, and whenever the subject of blue ribbon eels comes up she is sure to remind me, "My best shot of a blue ribbon eel never happened because when we were in Fiji in 2004 we saw one at 80 feet, and by the time you were done photographing it, it went back into its hole and never came out before my bottom time was up." On this trip I finally absolved myself of that long-lingering guilt by sharing with her a photo-op with a particularly bold blue ribbon eel in less than 30 feet of water at **Jerry's Jelly**, a rich and productive shallow dive site off Taveuni. While the eels, of which we found three on a small patch of reef, might have been the target species for that particular dive, the ship's log confirmed guest sightings of whitetip reef sharks, scorpionfish, garden eels, whip gobies, Maori wrasses and fire dartfish.

NAMENA MARINE RESERVE

The Namena Marine Reserve surrounds the tiny island of Namenalala and stretches between the two main islands

Opposite, clockwise from top left: **Many of the bommies in Fiji are decorated with pristine hard corals along the shallow plateau. Soft corals are abundant throughout the island chain. This coral window near Kansas is an iconic photo-op. The villagers in Fiji are gracious and welcoming, often inviting guests to a kava party or local dance.The Great White Wall off Taveuni is one of Fiji's most famous dive sites. Kansas received its name for the leather corals that must have reminded someone of wheat fields in the Midwest.**

of Fiji: Viti Levu and Vanua Levu. Established in 1997, it encompasses approximately 30 square miles and bans commercial fishing within its boundaries. Like so many marine protected areas, the Namena MPA pays massive dividends in terms of quality dives.

One of my consistently favorite dives in all of Fiji is found in **North Save-A-Tack Passage** at a dive site that encompasses both **The Arch** and a shallow plateau called **Kansas**. The latter site's tan leather corals must have reminded someone of Great Plains wheat fields. We dropped in at The Arch, a lovely wide-angle background worthy of a visit on its own, knowing there was a resident school of chevron barracuda (*see the front cover*) and jacks that cruise the edge of the drop-off. For whatever reason, whether current flow or propinquity, the barracuda were swimming in a tightly polarized formation that day. With a slow and measured approach, I was able to fill the frame with dozens of fish when zoomed tight and scores as I zoomed wide.

Jacks and barracuda are subtle variations of blue and silver; but swimming back to the reef I found color: An emperor angelfish, blissfully ignorant of my proximity, foraged amid the soft corals that decorated the base of The Arch. From there, a short swim along **Yellow Brick Road** culminated in the dense concentration of leather corals at Kansas. Adjacent to Kansas is the oft-photographed **Window of Dreams**, notable for the profusion of soft corals that surround a portal in the reef, just the right size for framing diver portraits.

Although so much is so good in the depths of the Namena Marine Reserve, you should save a little time at the end of the dive to explore the tops of the bommies.

HOW TO DIVE IT

GETTING THERE

Fiji lies in the southwestern Pacific, 1,750 miles northeast of Sydney, Australia. The 333 islands of the archipelago are spread over 80,000 square miles of ocean. The islands of Viti Levu, Vanua Levu and Taveuni make up 90 percent of the nation's landmass and are home to 85 percent of its 880,000 people. Several airlines offer flights from Los Angeles to Nadi, including American, Fiji Airways, Qantas and Air New Zealand.

LAND-BASED OR LIVEABOARD?

Our 2015 itinerary included some sites accessible only via liveaboard dive boat because of their distance from shore, but Fiji has dozens of extraordinary land-based dive resorts that offer high-quality diving with daily dive excursions and sophisticated scuba infrastructure.

WATER TEMPERATURE

Divers are sometimes surprised by how cold the water is in Fiji at certain times of year. It's certainly not frigid, but in September through November it might drop into the low- to mid-70s°F. Dress for it, and you'll have a wonderful time. In September 2015 the temperature was typically right around 75°F throughout our cruising range. I've been there in February and had 86°F water. In some months a 3mm wetsuit is plenty, but in others a 5mm to 7mm wetsuit might be advisable. With four dives per day the norm on liveaboards, be sure to pack sufficient thermal protection.

CURRENT

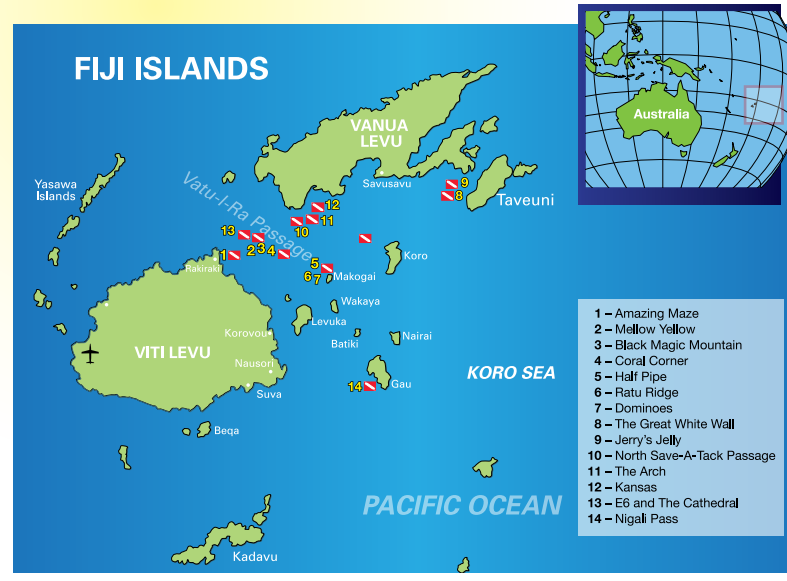
Many dive profiles bottom out around 80 feet and involve gradual ascents along consistently scenic walls or pinnacles. Though currents are not always present, ability to manage them is important. Depending on where you went and how your dive operator timed your drops, you could dive here for a week and never feel current, but you wouldn't see the best of Fiji that way. A bit of flow is necessary to get the soft corals in their optimal feeding finery, and much of the pelagic action from sharks and mantas is directly dependent on current. Familiarity with drift-diving protocols and the ability to deploy a safety sausage are essential.

VISIBILITY

Water clarity can be highly variable, depending on where in Fiji you dive. Proximity to rivers or other sources of freshwater runoff means reduced visibility. For the most part, assume good to great water clarity; 50 feet would be average for a near-shore reef, and this can climb to 150 feet on offshore reefs and pinnacles.

HYPERBARIC CHAMBER

There is a chamber in Fiji's capital city, Suva, on the main island, Viti Levu.

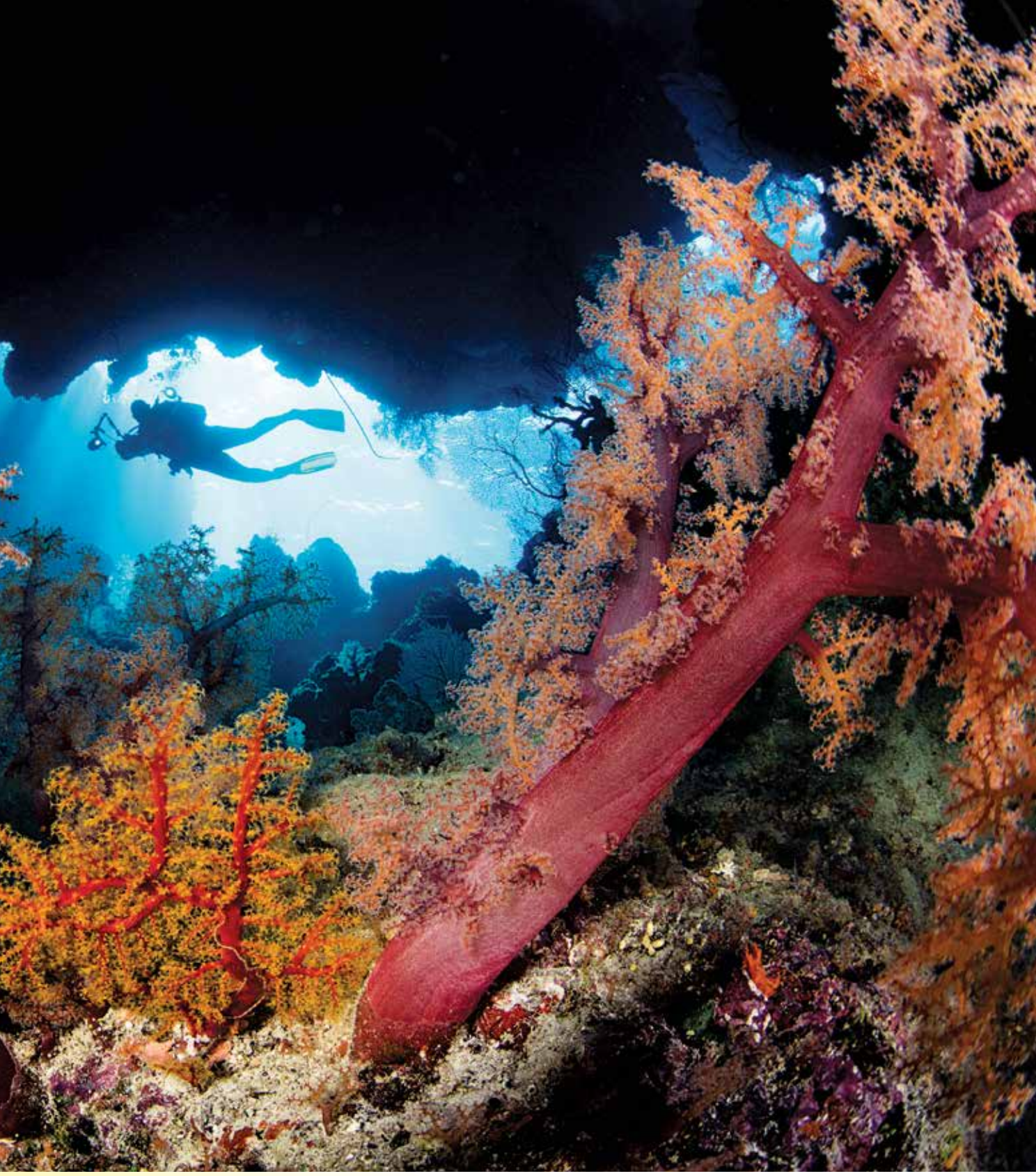


The hard-coral formations in the shallows are often quite extraordinary, as I experienced in a series of photos from a 2012 expedition there.

To spend a bit more time in Taveuni, we opted not to dive **Nigali Pass** on this trip. This was a very tough call, and it might have been the first time I've ever missed a shark dive on purpose. I revisited previous trip logs to recollect this iconic Fiji drift dive. The pass is a long channel that features almost certain encounters with horse-eye jacks and chevron barracuda. Once divers arrive, bait is strategically placed on the portion of the reef the crew calls "the bleachers." Red sea bass swarm the bait so eagerly that I think it makes the gray reef sharks hang back a bit. But the sharks come within camera range — 3 to 5 feet away, typically. The site features a large, scenic patch of lettuce coral in very shallow water, which provides an interesting place to offgass at the end of the dive.

The dive site known as E6 is rich with soft corals. These are all the more engaging with the beams of light that pierce through the perforations in the overhead environment at The Cathedral.

This 10-day expedition featured many other dives of significance, one of which I hadn't visited since the beginning of the digital era, which for me was 2001. I guess it is appropriate that the site is called **E6**, named for the chemical process used for developing certain transparency films, and last time I was there I was shooting Fujichrome Velvia in a Nikonos V. This time I was using a 50-megapixel Canon EOS 5DS, and happily I had far more exposures than the 36 that film had allotted. The ship's dive log indicated that those who were on a quest to photograph marine life on this dive saw schooling jacks, gray reef sharks, Moorish idols, clown triggerfish and the ubiquitous regal angelfish. With my fisheye lens better suited to large reef scenics, I ignored the reef dwellers and concentrated on the immense soft-coral-decorated foreground, while shafts of light pierced **The Cathedral**.



Here a narrow opening in the reef above allows sunlight to penetrate, giving an almost laserlike quality to the backgrounds.

It was particularly satisfying that a dive site I'd first experienced using the photo technology of the past is still so good when revisited with the latest imaging tools of 2015. That is somehow emblematic of the Fiji dive experience. The minimal visitation and the maximal nutrients that continuously drift along these reefs provide some insulation from the passage of time. AD

CENDERAWASIH BAY

A misty fog shrouds the Arfak mountain range. Silhouetted against an indigo sea, these mountains evoke the feeling of a place where time has stood still. An undulating landscape of waving palms, white sandy beaches, mangrove swamps and massive coral limestone cliffs embraces a peculiar wedge-shaped bay. Located in the eastern fringe of the Indonesian Archipelago, remote Cenderawasih Bay harbors secrets of the region's geological past and tectonic evolution.

The bay is easily recognizable on the map: It occupies the northeastern coastal area of West Papua and somewhat resembles the neck of a bird. Its huge assortment of marine life populates the various types of coral reefs found here: fringing reefs, barrier reefs, atolls, patch reefs and shallow-water reef mounds. The fringing reefs are the most abundant and have been scientifically documented as the last of the remaining pristine reefs in the world. Recognizing the bay's significance, in 2002 the provincial government and Conservation International established Taman Nasional Teluk Cenderawasih (Cenderawasih Bay National Park) as a marine protected area, the biggest in Indonesia.

The management plan for the park established 14 tourism zones. To date, human impact is minimal, as there are only few tourists per year and around 20,000 inhabitants. It's possible to travel the entire length and breadth of the park and see only a few locals. Modern developments are almost nonexistent; there is no water sports center, Four Seasons or Hilton. But on the geological time scale, massive changes have occurred over the millennia.

Between 3 million and 14 million years ago, slivers of land moved by unstable tectonic plates sealed the mouth of Cenderawasih Bay. These obstructions prevented the spread of oceanic larvae into and out of the bay. Thus the marine life in the bay evolved in isolation. Although the barriers eventually broke open, the shallow sill and sheer size of the bay limit oceanographic circulation, preventing planktonic larvae from reaching many reefs in the bay.

Through the ages the inhabitants of Cenderawasih Bay swam in varying sea levels; fishes and coral species vanished and reappeared again. During the Pleistocene epoch, sea level plunged to 400 feet below where it is today. Inhabitants of the shallow reefs perished, and animals of the deep found themselves near the surface of the bay. As sea levels rose again, flooding the dried reef zone, these deepwater animals followed the rising sea to depths in the 6- to 65-foot range. Here these inhabitants enjoyed little competition due to the bay's unique oceanographic properties, and deepwater species such as Burgess' butterflyfish (*Chaetodon burgessi*), which are normally associated with depths of 200 to 260 feet, are commonly found here as shallow as 33 feet.

Marine scientists have established that until recent times the bay was geologically isolated from the flow of the Pacific tides. This isolation consecrated Cenderawasih as an ancient sea with a high percentage of endemic fish and coral species found nowhere else on the planet. Ichthyologist Gerald Allen, Ph.D., a consultant for Conservation International, proclaimed the bay "the Galápagos of the East" based on documented findings of an "evolutionary cauldron" of new and unique corals, shrimps and fishes. Extensive surveys documented 995 species of fish and more than 500 species of corals — approximately 10 times as many as the entire Caribbean. Lured by the prospect of new discoveries, I made seven sojourns to this primordial sea in the last six years.

There is something decidedly adventurous and exciting about flying through five airports in three days, hopping from a ginormous Singapore Airlines double decker Airbus A380 to an Xpress Air 18-seat turboprop, arriving in Nabire and being promptly whisked away to a quaint harbor beside a raucous fish market. My first expedition was arranged by a local fixer and used police boats and Navy dive gear. In subsequent expeditions I traveled on a modern liveaboard.

Although my primary agenda was exploring sites that had not been seen before and capturing pictures

Clownfish and other Indo-Pacific reef tropicals are common in Cenderawasih Bay.

of deepwater animals in shallow water, the major attraction at Cenderawasih is the congregations of whale sharks *(Rhincodon typus)* in the southern part of the reserve. While there are a number places in the world where whale sharks congregate, such as the Galápagos, Belize, Western Australia's Ningaloo Reef and Donsol in the Philippines, the sharks are resident in those places for only one to three months before they move away. The fishermen in Cenderawasih say that the bay's whale sharks visit their fishing platforms throughout the year.

My exploration of this enchanting and unspoiled outpost of Indonesia began with navigational charts, a 2010 Rapid Marine Biological Assessment report by Mark Erdmann, Ph.D., and coordinates taken from *Diving Indonesia's Bird's Head Seascape* (Jones and Shimlock, 2011). Over the vastness of the atoll I explored layers upon layers of mighty plate corals in immaculate condition; the reef tops are adorned with some of healthiest hard-coral meadows I have ever seen. The outside reefs comprise dramatic vertical walls rich with sea whips and colorful sponges. We found pockets of severely damaged reef, which might have been casualties of dynamite fishing or coral-bleaching events. Many of these areas were in various stages of recovery, scattered with youthful colonies of staghorn corals.

Before we came we were told to expect low fish biomass. Fish density was indeed low at a few sites, but we repeatedly encountered massive schools along ridges, especially where tidal or ocean currents converged. One afternoon, while shooting a panorama of a field of hard corals, I looked up to see damselfishes congregating for an evening spawning session. There must have been a gazillion of them. Spellbound, I stayed until I'd nearly breathed my tank dry.

On the days we spent exploring the atoll and fringing reefs, we continued to find healthy coral; most of the sites we documented were populated by intact hard corals that stretched indefinitely along fringing reef slopes. Although we spotted only two sharks, we recorded several species of reef fish, including barracuda, eagle rays and several green and hawksbill turtles. A park ranger was on board telling us about past sightings of dugongs and saltwater crocodiles. I was delighted to capture images of a few endemic species: a Cenderawasih fairy wrasse, Cenderawasih fusiliers and a new species of longnosed butterflyfish. I found the usually deep-water Burgess' butterflyfish in just 33 feet of water.

Burt Jones, principal photographer for Conservation International's Cenderawasih Bay expedition, told us to not expect colorful soft-coral foliage like that of the Maldives or Raja Ampat, but one afternoon while in search of a site for a night dive near the Napen Peninsula we found a Solomon's mine of soft corals. It was a submerged ridge complex comprising two tiny islets and three rocky outcrops that barely broke the surface of the sea. Underwater, the terrain was a hodgepodge gallery of estranged artists: Works similar to Van Gogh, Monet and Picasso were on display. We found orange, red and yellow whip corals in hefty bushes, while bright tunicates blossomed like Chinese New Year plants. Lavish soft-coral coverage seemed to defy gravity. It was utterly out of proportion and out of place; the phantasmagoria was a scene straight out of a Lewis Carroll story. I named the site Dr. Seuss Reef.

Any exploration of Cenderawasih would not be complete without at least three days of interaction with the resident whale sharks. Only in recent years did we become aware of whale sharks frequenting the local fishing platforms (bagans). The fishermen told us that the sharks have been around their bagans since they began operating in the bay some 25 years ago.

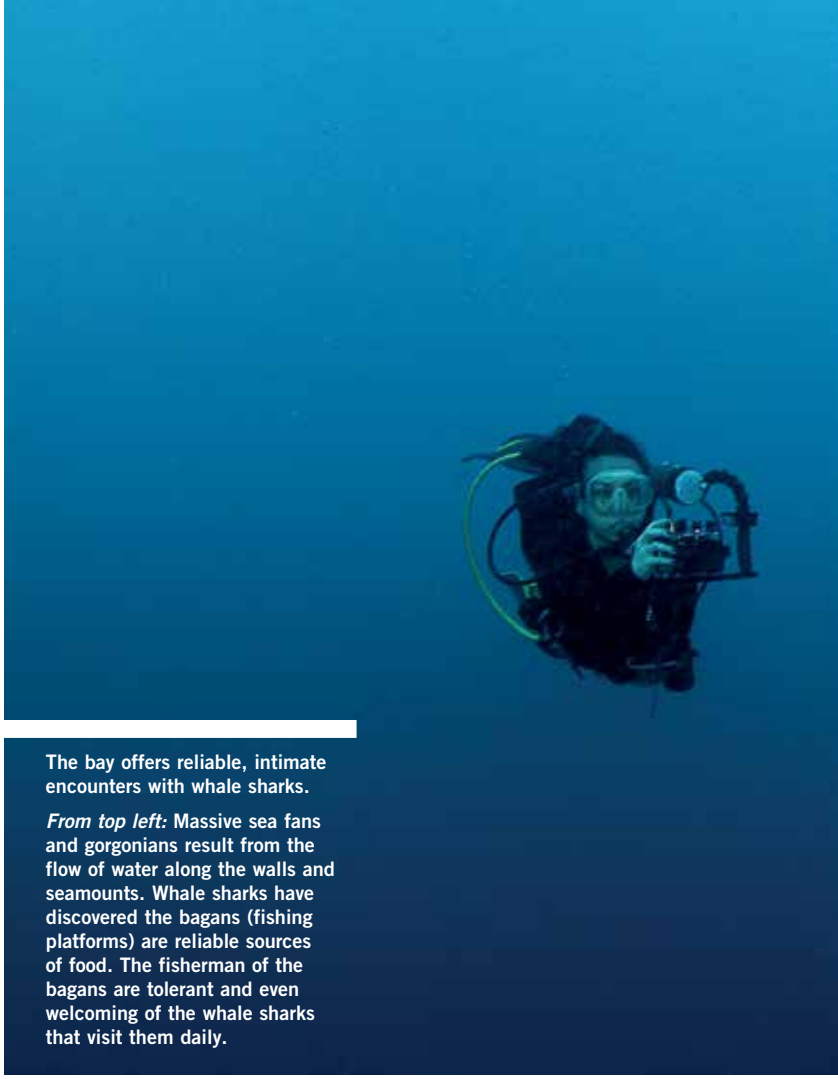
About 23 of these semimobile platforms are located around Kwatisore Bay at the southern end of the park. At dusk fishermen lower massive nets beneath the

Whale sharks are filter feeders, using suction to pull small fish and krill into their mouths.

Below, from left: **A hawksbill turtle poses for a picture. Michael Aw holds the fin of a whale shark, a tragic artifact of the shark-fin trade.**

platforms to about 60 feet deep. Floodlights on the surface illuminate the water to attract millions of ikan puri, three-inch-long baitfish. Fishermen raise the nets in the morning, bringing up tons of the fish, some of which will be collected and used as bait for bonito fishing. The rest of the baitfish remain in the net, hanging just beneath the platform. Whale sharks in the bay have learned to suck these small fishes from the nets. The fishermen feed bucketloads of ikan puri to the sharks, which we now know are opportunistic feeders that can associate humans with food. Cenderawasih Bay is the first location in the world in which such whale-shark behavior has been documented.

On our 2015 expedition we encountered 13 individual whale sharks beneath just one of the bagans. We started early each morning and seldom finished before dusk. Typical of sharks, lions and humans, prime feeding times were the in the morning and just before dusk. At 7 a.m. we usually saw two or three juveniles placidly sucking from the net, but by 10 a.m., eight animals, ranging from 7 feet to 40 feet, would congregate to feed from the nets or receive handouts from the fishermen. Noon was a lull period;



The bay offers reliable, intimate encounters with whale sharks.

From top left: **Massive sea fans and gorgonians result from the flow of water along the walls and seamounts. Whale sharks have discovered the bagans (fishing platforms) are reliable sources of food. The fisherman of the bagans are tolerant and even welcoming of the whale sharks that visit them daily.**

HOW TO DIVE IT

GETTING THERE

Established in 1993 by the Republic of Indonesia, the Cenderawasih Bay National Park covers 5,612 square miles in the southwest quarter of Cenderawasih Bay, West Papua. It can be accessed by sea from the towns of Manokwari and Nabire, which lie 60 miles north and 25 miles northeast, respectively. Flights are available to Manokwari, Biak and Nabire.

CONDITIONS

The weather is commonly rainy and stormy from February through May; the best time to dive is July through November. Whale sharks are resident year round. Air and water temperatures are commonly in the mid-80s°F, and most dives are between 80 and 130 feet. Tidal currents can be encountered on atoll and reef sites, but conditions are reliably mild where the whale sharks are found.

HYPERBARIC CHAMBER

The nearest hyperbaric facilities that treat divers are in Raja Ampat (West Papua, Indonesia), Manado (North Sulawesi, Indonesia) and Darwin, Australia.

For more information, contact the park's office at btnc@manokwari.wasantara.net.id.

only a couple of juveniles would still be hanging around for more handouts. At about 4 p.m. the crepuscular rays radiating through the water acted as a dinner bell. The sharks disregarded all table manners, frantically rushing in with mouths agape, climbing atop one another with great urgency, taking in as much food as possible before nightfall.

Throughout the four days we spent with these sharks, all members of our expedition were able to approach them closely and make eye contact on both snorkel and scuba. They were gentle and appeared to move their powerful tails so as to avoid hurting divers. Seemingly unopposed to our presence, some actually rose vertically alongside us to pose with the clumsy bubble-blowers.

At one point I was photographing three sharks as they confronted fishermen on the bagan for more food. Unbeknownst to me, two bigger sharks approached the bagan from behind me. I felt a push, and in the next moment I was like ham between bread, sandwiched between five animals, each of which weighed around 15 tons. It was a sloppy moment, with colossal fleshy mouths all around me, but the sharks were gentle, and I managed to escape from among them. I was flabbergasted, and my grin was as wide as a whale shark's mouth.

We know that whale sharks rise to the surface to feed on plankton and small fish, but there is much we don't know about them. The biggest fish in the ocean, they breathe with gills and are ectothermic (cold-blooded), preferring to swim in warm waters. We are unsure if the Cenderawasih population is local, but if the shark-fin merchants were to move in, all the animals in the bay could be harvested in just a couple of weeks. To better understand the migratory patterns of these sharks, Erdmann led Conservation International expeditions to tag some of them. (Learn more at *Conservation.org*.) The tags revealed that the sharks are not permanent residents of the bay, but some return each year.

The tagging exercise is an important effort to learn more about these awesome animals: where and how they mate, how they spend their early years and other mysteries. The tags may or may not provide some answers, but the primary concern is learning how to better protect them and their habitat for future generations.

We termed Cenderawasih Bay a global treasure. Ocean conservationist and diving legend Valerie Taylor has an even better description: the eighth natural wonder of our world. Cenderawasih is an embodiment of nature's beauty that fans our fervor to protect and preserve. AD

MY JOURNEY TO DIVE ALL 50 STATES

Text and photos by Jennifer Idol

The United States is home to extraordinary dive experiences. From reefs to caves, there are rich underwater adventures to be had all across America.

As a Texan I felt compelled to share our local underwater treasures when I flew over the Deepwater Horizon oil spill and saw the Gulf of Mexico burning in 2010. I felt an obligation to use my talent as a designer and underwater photographer to inspire others to learn about, care for and protect our natural places. So in 2011 I set out on a quest and became the first woman to dive all 50 states.


AARON BATES

LOGISTICS OF A CROSS-COUNTRY EXPEDITION

Embarking on an adventure across 3.8 million square miles took a great deal of time and resources. I personally funded the project while working a full-time job as a senior graphic designer. This meant I was short on both money and time at the outset. Breaking the large goal into smaller achievements helped me to successfully complete the mission.

I carefully planned my travel time by dividing my vacation days among 10 states per year. This allowed me to plan a five-year odyssey that included several trips each year over long weekends. By the end I had driven more than 72,000 miles and taken 80 flights.

Fellow Texan Ben Castro joined me for the first 27 states of this adventure. We both learned a lot about cold weather and long drives. The schedule I created meant driving as many as 16 hours per day, often for several days in a row, and typically returning to work the day after travel.

To make trips more affordable, we camped in state parks when possible. Since equipment for freezing temperatures was hard to come by in Texas, I ordered cold-weather clothing, a tent and a sleeping bag online (thank you, Internet reviewers!). Having the right tools is important for safe diving and camping.

I kept my project quiet until 2015 so I could create unbiased imagery and have an authentic experience. By self-funding, I could decide what story needed to be told. I successfully completed my expedition because I am passionate about sharing our underwater world. The journey led me on 419 dives with 73 buddies, who through their support and expertise contributed to my success.

NEW PLACES

I started my adventure with 15 years of dive experience, 22 certifications and a background as a photographer, so I already had begun to take people — through my imagery — to places they might never visit. But I was not (and am still not) an expert in every type of diving. I believe in diving within my training, so when I found myself wanting to reach new places, I trained more.

To showcase as many different environments as possible, I completed four more certifications during the journey. These enabled me to go deeper, enter small places, go farther and dive under ice.

Trimix training for depths up to 220 feet helped me reach the decks of the USS *Oriskany* and enter deep cave systems. Sidemount training not only helped me squeeze

"I SET OUT ON A QUEST AND BECAME THE FIRST WOMAN TO DIVE ALL 50 STATES."

A lion's mane jellyfish rises from the deep in Resurrection Bay, Alaska.

Opposite: Jennifer Idol in San Marcos, Texas

into a Texas cave, but it also was helpful for redundancy during ice dives and for carrying cylinders to entry points.

Diver propulsion vehicle (DPV) training helped me find the siliceous spires in Wyoming's Yellowstone Lake and to travel to lead-mine carts in Missouri's Mine La Motte. I like my "underwater motorcycle" and plan to do cave DPV training next year.

Some certifications, such as ice diving, are fairly location specific. I got certified for ice diving in Ohio and joined a class in Minnesota for more experience. The dive groups were welcoming and operated as teams with surface tenders. I found working with teams of divers who shared the same diving methods and procedures to be very rewarding.

As divers we experience a world hidden to most people. Some dive sites are even hidden to most divers. As a member of three official dive teams, I was able to capture images of dive sites that had restricted access. We come to love and protect only what we know and can see, so I enjoy revealing as much of the underwater world as possible.

GAINING EXPERIENCE

I know there's more to preparing for such diverse experiences than just certification and training. I built my skills progressively. When booking a charter in cold water I was often asked if I had drysuit experience. I found the question amusing because I had spent only one week the previous year diving in a wetsuit, but I know it's an important question. I am honest about my abilities because in diving such honesty helps keep you alive.

Diving across the country meant being flexible and open to changing conditions. Always training at the same dive site leads to a narrow experience. I dived with a variety of equipment configurations in many different climates, so when a boat captain told me a planned dive site wouldn't work, I was prepared for alternatives.

At one point I had planned to dive the German submarine *U-352* off the coast of North Carolina. Unfortunately a hurricane landed the weekend I was planning the dive. Since I had limited windows for diving, I changed course and headed to Lake Mead in Nevada. I was able to return to dive the *U-352* later on.

My certifications provided a foundation for my exploration. To safely reach my goal, I planned dives with not only my training in mind but also based on my experience in similar conditions. Often I needed to combine skills from my training courses to reach a goal or to manage task loading. I carry a large camera on nearly all my dives. I named my primary camera Goliath and my backup camera Big Beastie. Goliath died twice during my journey, so I renamed it David.

THE AMAZING SITES I SAW

I originally set out to show how my local waters are valuable. I want them to remain a place divers can enjoy, and I want to see them protected for future generations. I knew our marine environment was special, but I underestimated the diversity and richness of diving across America. Now transformed by my experience, I feel like I've taken only the first few steps of an even bigger journey.

In a way, diving all 50 states was a series of first experiences. Nothing is quite like a first impression. I remember my first dive 20 years ago in Cozumel, my first underwater photography dive and my first cave dives. By undertaking a quest of first experiences, I was able to love all that I saw.

My first few dives on this quest were in quarries and lakes. I enjoyed the statues, boats and other objects placed in dive parks around the country. Familiarity may make these sites seem less exciting to those who dive them often, but I was able to see them with fresh eyes. I remember fondly the statue of David in Martha's Quarry in Tennessee, a site I thoroughly enjoyed. Another special first on my journey was my first post-training cave dive in Jug Hole (also called Blue Hole) in Florida. Larry Hack invited me on that dive along with photographer Amanda Cotton. I'm still smiling.

As the quest progressed, so too did my first experiences. Not only did I meet the enthusiastic dive gear aficionados of the North East Diving Equipment Group in Dutch Springs, Pa., but I also got to dive in and photograph historic dive equipment. I'll always remember my first dive in a Mark V hardhat diving suit: It felt like diving in a person-shaped submarine. They also let me dive in a visually striking Russian military diving suit, which was definitely not for the claustrophobic. Pennsylvania is my favorite state for diving because of the people I met.

Opposite, left to right, top to bottom: **A spotted gar in Spring Lake, Texas; plumose anemones in Puget Sound, Wash.; a purposely sunk wreck in Philip's Quarry, Ind.; an opening in the ice in Square Lake, Minn.; the opening to Jackson Blue in Florida; a sea otter floats by in Seward, Alaska; a lead mine cart in Mine La Motte; American lobsters crawl along the bottom of Harts Cover in New Hampshire; blue angelfish swim through the USTS *Texas Clipper* in South Padre Island, Texas; David gazes up amidst vegetation at Loch Low-Minn in Athens, Tenn.; exiting White Star Quarry from beneath the ice in Ohio; a kelp rockfish hides in giant kelp off Catalina Island, Calif.; pink (humpy) salmon journey in an Alaskan tributary to spawn; diving a Mark V helmet and suit at Dutch Springs, Penn.; paddlewheel of the horse ferry in Lake Champlain, Vt.**









"THE JOURNEY LED ME ON 419 DIVES WITH 73 BUDDIES."






Larry Hack enters Jug Hole, Fla.

Opposite: Michael Underwood rises from 90 feet in Orange Grove Sink in Florida.

"BY THE END I HAD DRIVEN MORE THAN 72,000 MILES AND TAKEN 80 FLIGHTS."

UNEXPECTED DIVES

While freshwater sites can be perceived as mundane and lacking biodiversity, I have many vibrant photos of the aquatic life I saw on these sites. The blind crawfish in Florida's Peacock Springs were as strange as they sound. Spotted gar in Texas, salmon in Alaska and rainbow trout in Missouri likewise were fun to observe. The weirder the animal, the more excited I got.

The most surprising site I dived was Puget Sound in Washington. Cold water is home to some of the largest life I've seen. Big plumose anemones reach for nutrients in the green water, while crustaceans dominate the seafloor and lion's mane jellyfish rise from the deep.

The farther north I ventured, the vaster the landscape grew. Alaska is the USA's greatest wilderness. I spent a week above and below in Alaska, the longest trip on my quest. I left there reluctantly with a vow to return. In just one week I saw harbor seals, Steller sea lions, sea otters, puffins, bald eagles, wolves, grizzly bears, caribou, moose, starfish, lion's mane jellyfish, salmon and more.

A FEW LESSONS

America is still wild. Nature is unforgiving. Some of my dive sites were in national parks, and nearly all were in remote places with poor cell phone reception. Guides and park rangers taught me a lot about how to interact with wildlife. This was important for creating both ethical and high-quality images. I made every effort to leave no trace on dive sites and in wilderness areas.

I prepared for each trip by bringing supplies such as gallons of water, a spare battery to self-jump my car and kitty litter for tire traction in icy conditions. Some items I brought were life sustaining, while others were for comfort. I also brought a giant toolbox full of everything I would need to maintain and repair my gear while on the road.

Not every location includes a nearby dive shop, although I stopped at a few to save a dive. In Colorado I picked up a dive float since I had forgotten mine at home. Some sites require that you set or swim with a dive flag — be sure to familiarize yourself with relevant state laws and local regulations for diving at any site.

If I undertook this journey again I would allow for more travel time. Constant time constraints pushed my limits. By working tired, I broke or lost something in nearly every state.

WHAT'S NEXT?

I completed my quest in four years, six months and two days. When I finished, I had built up so much momentum preparing for dives and getting on the road that I didn't quite realize I had completed the journey. I was simultaneously tired, happy and eager for the next steps.

The adventures I had and divers I met on my journey are helping me define my future goals. I hope to work on Arctic expeditions and in cold-water environments. My ice-diving experience will help me reach goals beyond the 50-state adventure.

I am working this winter to finish my book for release in 2016. I'll start the year speaking at dive shows and conferences — I hope to see you at my Our World-Underwater presentations in either Chicago or Texas. I'll announce future speaking engagements on Facebook and on my website, *uwDesigner.com*.

GET OUT THERE AND DIVE

I seek to help others understand the underwater world through my photography and design and by sharing my exploration. My journey across the country was enriched by local divers who shared new and interesting places to dive. I encourage you to visit a local dive site and start your own adventure. AD

Dive computers generally work as designed, but the mathematical algorithms do not evaluate many of the factors that can alter the decompression risk of a given exposure.

Opposite: **Bubbles can be seen in a diver's heart on the screen of a portable ultrasound device. The right heart is shown on the left side, with the right ventricle above the right atrium. Many of the bright spots in the right heart are decompression-induced bubbles (in contrast with the bubble-free left heart). Bubbles are not found after all dives but are more likely after dives with greater decompression stress.**

DEFENSIVE DIVE PROFILE PLANNING

BY NEAL W. POLLOCK, PH.D.

Limited gas supply and less-than-stellar thermal protection once worked to cap decompression stress for the typical diver. Increased choices for gas supply and improved thermal protection have enabled divers to go further and longer. Dive computers have likewise expanded the freedom to explore. The square profiles of the past can be replaced by complex dive profiles that are easily tracked by these little boxes.

Decompression safety may be achieved by staying within dive computer or dive table limits, but decompression sickness (DCS) can develop even after dives that remain within prescribed limits. Dive computers generally work as designed, but the mathematical algorithms do not evaluate many of the factors that can alter the decompression risk of a given exposure. Building in modest buffers at every step of the diving process can help ensure good outcomes. This article will discuss concepts important for conservative practices, some of the pitfalls that must be overcome, and practical strategies for defensive dive-profile planning and implementation.

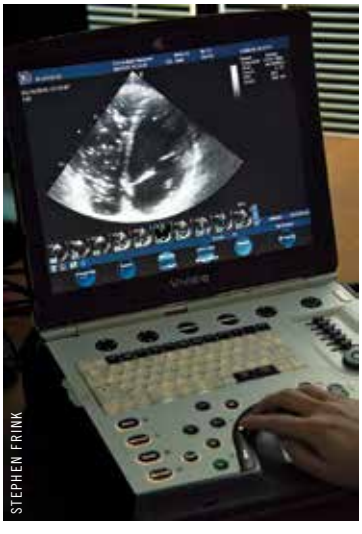
CONCEPTUAL CONTROL

Know the risks. Diving is used for both work and pleasure, and in the vast majority of cases it concludes without problems. The risks, though, should not be ignored. Understanding them is a critical step in preparedness. Early recognition of issues can resolve many before they become troublesome.

Take responsibility for your safety. Do not give any other person or any device complete authority over your activity. Some divers will follow a divemaster they just met without question; others will follow a computer without thinking about what it does not know or will expect it to get them out of trouble they may create. Any person or device can make mistakes. Make sure that you are actively and intentionally involved in every step of every dive, able to lead yourself when necessary.

STEPHEN FRINK

Understand the available tools. Reliance on dive computers is now the norm for many divers. While you do not have to be a decompression modeler to dive safely, it is important to have a clear conceptual understanding of how the decompression algorithms that you will rely on work. It is equally important to know what they do not consider and that they can be wrong. Ask questions, learn, and develop plans for the "just in case" events.



STEPHEN FRINK

Evaluate information critically. One of our human quirks is the abundance of faith we put in what appears on a screen or gauge, such as a gas gauge or dive computer screen. This can even spill over to what we read on the Internet, regardless of provenance. The tendency for blind faith must be kept in check. Maintain an open, critical mind to fully assess information and use it appropriately.

Know your risk tolerance. Risk is inherent to life; it cannot be fully avoided if one is to live, but it can be managed. Tolerance varies among individuals and situations. Generally, tolerance increases as the perceived benefit increases and decreases as the severity of the potential injury increases. Knowing your own comfort zones will help you plan and act to stay within them.

Maintain a safety-oriented mental state. When rules are broken or limits are violated with no obvious repercussions, there can be a gradual shift away from thinking of them as important. This can lead to "normalization of deviance," in which something once thought of as unacceptable becomes acceptable. The problem is that decompression stress is a relatively invisible hazard. We do not change color as we fill with inert gas, and decompression stress may not be perceived until a critical stage is reached. We can feel good right up to the point that we feel very bad. Vigilance is required to maintain good practice.

Reinforce safety messaging. Thinking or teaching "do this or get hurt" can be counterproductive to safety-oriented practice. As described above, the first time

the line is crossed without injury the rule will become less important. After it has been crossed a few times the rule may seem irrelevant, or the individual may perceive himself or herself as being endowed with special protection. Both of these viewpoints can lead to poor choices. Flipping the focus to "do this and be safer" can provide much healthier reinforcement. When nothing bad happens, the positive benefits of the practice are reinforced. Both peace of mind and good practice are promoted.

Choose dive partners whose risk tolerance, goals and attitudes align with your own.

STEPHEN FRINK

Avoid mission creep. Even the best intentions can be pushed aside by trouble-free diving and personal comfort. This can be exemplified on multiday dive trips. The intensity of diving frequently increases as the trip continues. It is not uncommon for a person developing DCS during a trip to describe their most conservative practice as their norm. Electronic dive logs, however, frequently show an erosion of safety buffers over successive days.

Pick your partners well. The mindset and practice of others in your group can radically affect your risk. Choosing those with complementary goals, objectives and attitudes can help ensure that the activity remains within your comfort zone. If someone you are diving with pushes you beyond your comfort zone, remember the first two rules: Know the risk, and take responsibility for your own safety.

Use tools to defend your practice. Selecting appropriate conservatism settings on your dive computer can reduce the need to argue over no-decompression limits or decompression profiles. Going back to the faith we often have in computers, differences in the selected settings may prompt discussions that help everyone gain insight. A critical mind is essential at this point to weigh the merits of the often heartfelt beliefs of those participating in the debate. Understanding the available tools is important for understanding the options and levels of conservatism. An article about gradient factors in the Fall 2015 issue of *Alert Diver* might be helpful to this end.[1]

PRACTICAL STRATEGIES

Solid knowledge, awareness, critical thinking and smart partner selection provide the foundation for good diving practice. Implementation requires further thought. Employing a number of small buffers can produce a web of protections that can mean giving up little in the way of opportunity while maintaining a high degree of conservatism.

The dive profile is the single most important determinant of the ultimate decompression risk of a dive. The shift from square profiles to multilevel profiles can produce powerful advantages.

Going deep increases the rate of inert gas uptake and the ultimate amount to be eliminated, but going to the extremes of one's training can be enticing. Multilevel diving offers a good way to scratch that itch while maintaining good decompression safety. Choosing sites appropriate for multilevel dives is a great way to start. In the simplest case, swimming outbound at one depth and back at a shallower depth can limit inert gas uptake and extend the controlled inert gas elimination period. Decompression stress is minimized, and the diver can experience different zones during a single dive.

Out and back is fine for many recreational exposures, but as maximum depths increase, it becomes increasingly important to spend progressively more time at progressively shallower depths. Dive sites that make this easy facilitate optimized dive profiles.

The popularization of the safety stop was probably the most significant evolution in decompression safety for recreational diving in the past 30 years.

STEPHEN FRINK

The high relative rate of pressure change in the shallowest zone makes it critical in determining the overall decompression stress. Next to backing off the intensity of a dive, the most important decompression safety buffer is time spent in the shallow regions during ascent. For much recreational diving this can be considered the depth range shallower than 25 feet. The popularization of the safety stop was probably the

most significant evolution in decompression safety for recreational diving in the past 30 years. The three-minute stop is good, but it is even better if it follows a progressive multilevel profile and is extended as gas supply and conditions allow.

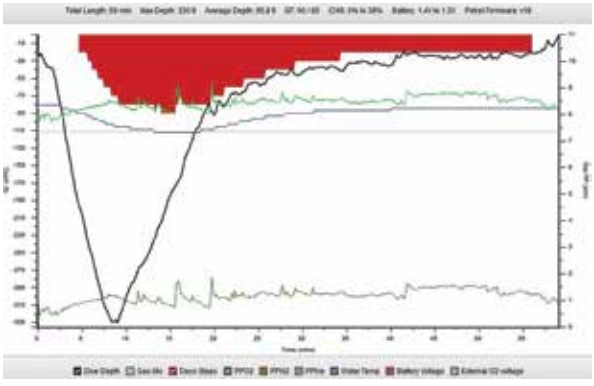


Figure 1.

Figure 1 shows the dive profile of a decompression dive in which the diver completed decompression 10 to 20 feet deeper than the dive computer algorithm required and then extended the time spent in the relatively shallow zone after the obligatory stop period before surfacing. This may be a more conservative ascent profile than was required, but the worry-free endpoint is reflected in the absence of bubbles seen in the heart during postdive monitoring.

There are times when over-applying well-intended rules can get in the way of safety. For example, divers are frequently taught to surface with a reserve of 500 psi in their tanks. If the concern for surfacing with this reserve becomes so compelling that safety stops are abbreviated, the rule becomes counterproductive. Dives should be planned to be finished with a reserve of air, but using some of that supply to extend a safety stop is probably a high-benefit compromise. Having said this, any deviations from established rules should be discussed postdive and actions should be taken to avoid unnecessary future violations.

Another area in which safety can be put at risk is reverse dive profiles. If all other things are equal, planning the deepest dive first makes sense in that it is consistent with good practice for multilevel diving. But all things are frequently not equal, and, as far as we know, the body does not actually register whether inert gas accumulates at pressure A or pressure B; the important thing is the total accumulation and the subsequent pressures achieved to eliminate it from the body. Practically speaking, the order of the maximum depth between two dives can be unimportant. Concerns arise when the "deepest dive first" rule is applied with such rigor that an unnecessarily deep dive is conducted for no other reason than to allow a second deep dive when it must be scheduled later (for example, to meet a suitable tide state). Mindless fixation on rules can create problems. Dive planning should be thoughtful.

Surface intervals also need to be considered. There is a trend toward progressive shortening, probably as a function of mission creep and perceived efficiency. Surface intervals are important for inert gas elimination. The minimum reasonable surface interval will vary with the exposure, but focusing on the minimum is not conservative practice. If short surface intervals are necessary, the severity of the dive profiles should be moderated.

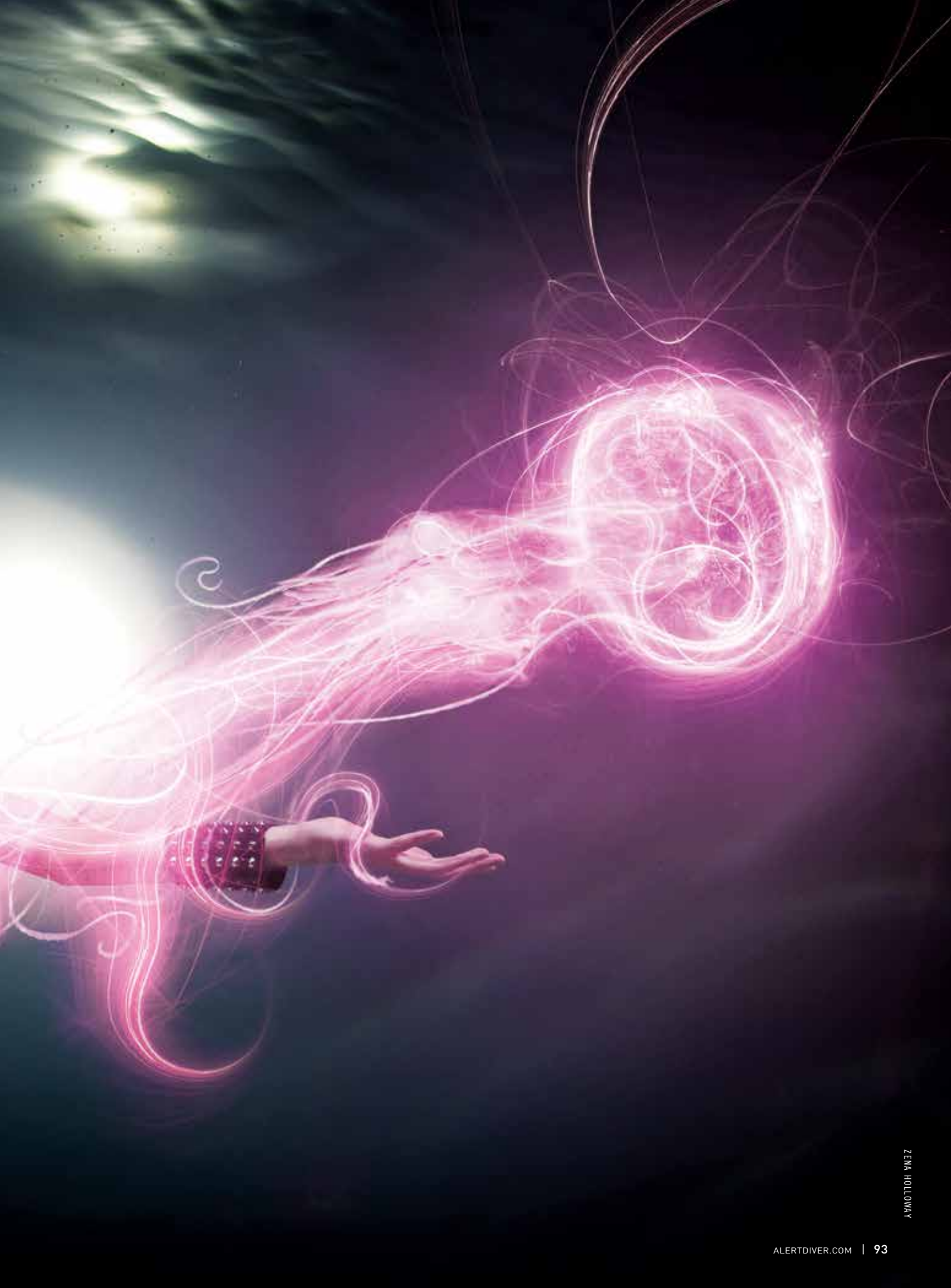
The ends of dive trips often require consideration of the final surface interval before flying. Flying-after-diving plans are often based on guidelines produced at a DAN workshop.[2] The recommended minimum preflight surface intervals were developed from the available data: 12 hours after single dives within no-decompression limits; 18 hours after multiple dives per day or multiple diving days; and "substantially longer than 18 hours" after decompression dives. An added challenge is that these guidelines apply only to aircraft cabin pressures equivalent to altitudes in the 2,000- to 8,000-foot range. Additional buffers are recommended since it cannot be known with certainty whether cabin altitudes might exceed this range. Planning a surface interval of at least 24 hours following diving is a good rule of thumb, and an extra safety buffer can be gained through more conservative exposures on the final day of diving. Driving to altitude postdive can similarly induce additional decompression stress; it also requires appropriate pre-travel surface intervals.

Ultimately, the best way to protect yourself and your partners is to build conservatism into all aspects of dive planning and execution. The net effect can be a high level of safety, often with relatively little compromise in your diving experience. When good habits are established and peace of mind maintained, the best diving in the world is possible. The thoughtful and well-informed diver remains the most important factor in producing safe outcomes. AD

REFERENCES

1. Pollock NW. Gradient Factors: A pathway for controlling decompression risk. Alert Diver 2015; 31(4): 46-9.
2. Sheffield PJ, Vann RD, eds. DAN Flying After Recreational Diving Workshop Proceedings; May 2, 2002. Durham, NC: Divers Alert Network, 2004.

IMAGING



ZENA HOLLOWAY

SHOOTER: **ZENA HOLLOWAY**

Photos by Zena Holloway; introduction by Stephen Frink


LINDA LAIRD

Zena Holloway has evolved into one of the world's top commercial underwater photographers in a circuitous and nontraditional fashion. She did not live by the sea as a child, and she does not point to Jacques Cousteau for her inspiration. She grew up in urban London until the age of eight, when she went off to boarding school in the countryside for the next eight years. Not much from those years suggested her future profession. However, there were the stories her mother told about her dad. Although he died when she was young, Holloway grew up hearing about how he loved scuba diving, and she decided she, too, should give it a try.

At 16 she enrolled in a diving course, and when she finished school at 18 she went on a dive holiday to the Red Sea. That's when her life's path took a plunge beneath the waves. Not ready to return to London at the end of her vacation, she got a job at a dive center and did odd jobs to make ends meet. She recalls being quite good at "cleaning the loo." One advantage she had was being English where most of the captains and instructors were Egyptian. This gave her the language and cultural knowledge to work as a hostess aboard the daily dive boats.

Holloway's time in Egypt provided some great dive experiences, but to make a career of it she needed to become an instructor. She enrolled in an Instructor Development Course in Sharm el Sheikh and upon graduating got a job on Grand Cayman, first at Red Sail Sports and then at Bob Soto's Diving, where she became one of three staff videographers filming the tourists as they dived.

After three years she decided there was more to life than producing tourist videos and in 1995 headed back to London, where the underwater production

scene there was just coming to life. Mike Portelly and others were shooting movies and stills in local pools, generating enough work to keep an assistant occupied. She found opportunity and inspiration to develop a portfolio of her own work, which led to a two-month gig shooting in Uruguay for National Geographic.

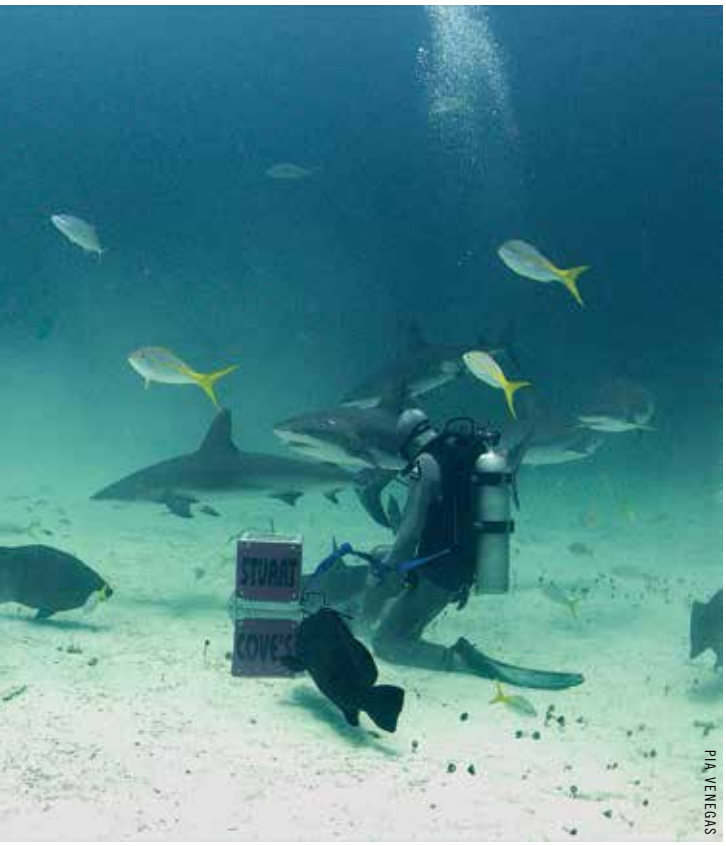
In 2002 Holloway traveled to Ibiza, Spain, to photograph the UK freedive team. During the shoot she found communication with the divers difficult and had to repeatedly swim to the surface to tell them what she was looking for. Although she was never deeper than 33 feet, it was a long day of zig-zag profiles and no safety stops. After the shoot she had some symptoms that made her very concerned about decompression sickness (DCS). She drank some water and took some aspirin (not what DAN® would recommend), and fortunately her symptoms subsided. But in the course of that health scare she discovered she was pregnant. Her panic and subsequent research about the potential effects on her unborn child led to the realization that DCS could be dangerous to a developing fetus. Happily, her daughter was a normal, healthy child, and Holloway continued on with a career that involved both open-ocean photography and many more pool photo sessions commissioned to bring to life art directors' visions.

Her expertise in the pool was refined in a rather humble way. From 2005 through 2009 she conducted annual "bread-and-butter" tours of the USA, visiting seven cities in two weeks, shooting underwater portraits of up to 50 babies a day. While business was good at the start, advancing digital technology and increasingly accessible underwater cameras took away the novelty of what she offered, and demand for her work diminished.

From there Holloway's career turned to a more stylized and commercial genre, involving work with art directors, stylists and talented models all working together to create vibrant underwater sets. Today she is one of the most creative and in-demand producers of underwater fantasy images in both stills and video. Her client list includes Nike, Speedo, Umbro, Sony, Jacuzzi as well as publications such as *GQ, Observer Magazine* and *How To Spend It*. Based in London, she lives with her husband and their three young children, Brooke, Willow and Woody.

In deference to her need to shoot both high-quality stills and 4K video, her primary underwater system is a Canon EOS-1D C in a Seacam housing. Her lighting systems include Ikelite strobes underwater and a variety of studio lights above the surface as dictated by the set and the concept. She does much of the postproduction work herself but often prefers to take images only as far as rough concepts before turning them over to a digital artist for the refinements necessary to make them finished pieces of art.

Read along as Holloway tells the stories behind some of her images.



PIA VENEGAS

Holloway at work in New Providence, Bahamas, with Stuart Cove's shark wranglers and safety divers

Previous spread: **"This image was shot in the underwater stage at Pinewood Studios in the UK, the same tank used to film the underwater stunts for *Mission: Impossible — Rogue Nation* as well as for several James Bond movies. I was lucky enough to get a commission to shoot there for *125* magazine, and the 3D Agency in London created this stunning jellyfish to go with the futuristic theme of the shoot. The orb behind the model is a powerful light in the background. The exquisite styling was by Harris Elliot (*harriselliott.com*), and this editorial shot led directly to a booking for a large campaign for Rosemount wines."**

See More
To see more of Holloway's work, visit *ZenaHolloway.com*.

"In 2007 I was commissioned to create the photo illustrations for a retelling of Charles Kingsley's classic 1863 book, *The Water-Babies: A Fairy Tale for a Land Baby.* The version I read as a child was illustrated with paintings, but this retelling combined my photos with artwork from illustrator Heidi Taylor to create the whimsical fantasies of the book.

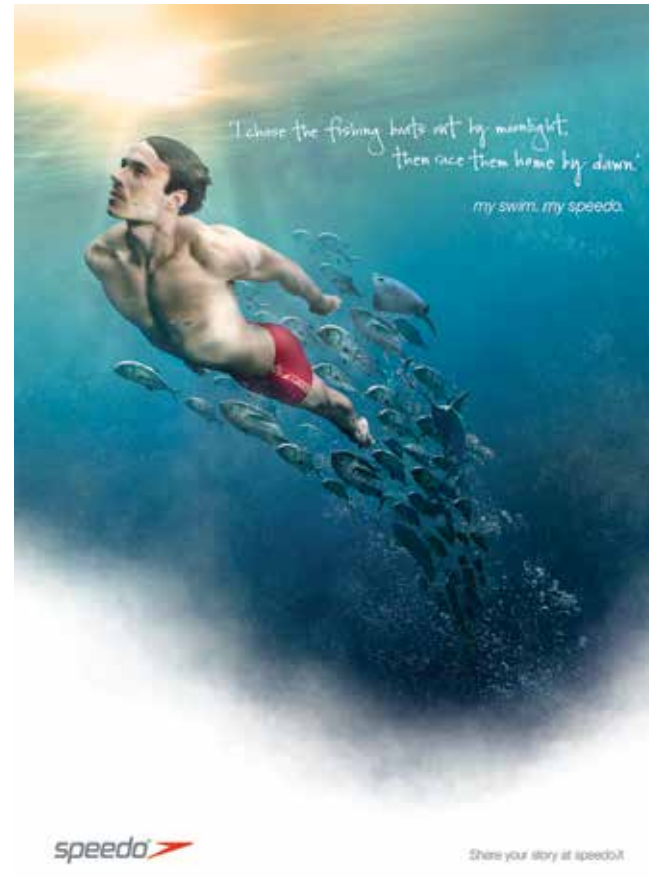
"I fell in love with Sue Flood's *Whale Calf* photograph and was delighted when she agreed to let me use it for the book. I had to get the child to fit the existing composition, so we shot him against a gray background underwater, which actually worked much better than expected. I love the child's wrinkly little feet and the white parasitic crabs on the whale from the original.

"The otter wasn't nearly as sweet as he looks. He spent the whole shoot trying to jump onto my head, and the stink of his musk was incredible. Really — they had to air out the swimming pool room for days after we left. Photographing both the child and the otter in a swimming pool was the only practical way to match the lighting.

"In the story the main character, Tom, meets all sorts of incredible underwater creatures; I thought the turbot image came together really nicely. I used a stock image of the fish, and the challenge was to get the light on the boy to match the lighting on the fish. Once this was achieved, it was a blessedly simple composition."

"In 2008 organizers of a freediving championship invited me to take pictures. The competition took place in 330 feet of blue water and was staged from a tanker moored off the coast of Cyprus. The visibility was sensational — a photographer's dream. Freedivers swarmed everywhere, diving up and down the lines from the boat. The freediver in this image in particular caught my attention as he looked like he was enjoying the freedom of the water. His pose says it all. Actually, I shot it the other way around, as a horizontal with the sun at the top, and it wasn't until I got it to the editing table and turned it that it became the image it is here. It has since been printed many times for art collectors' walls."

"Shot in 1998 in the Caribbean, this image launched my career. I won some awards for it, it appeared on several magazine covers, and it was sold as a fine art print. The good luck from this image is a droll twist: I hadn't anticipated that a horse could move so quickly in water and was very nearly killed by a hoof to the head while shooting."



"Speedo has been a loyal client for me over the years. They tend to run similar kinds of stylized advertisements each year, and I get a lot of repeat business from them. This model is Charlie Turner, who at the time was one of the fastest swimmers in the UK and made a great model for the image. All the retouching was completed by the advertising agency in London that took over that side of things after I had completed the shoot in the swimming pool. Sometimes I do my own retouching and postproduction work in Photoshop, but often the clients prefer to execute their own vision. That's one of the big differences between my personal work and commercial assignments."

"This image for Greenpeace was an exciting commission from the famous Saatchi & Saatchi advertising agency in London. They were pitching to Greenpeace for a marine conservation campaign, and I was lucky enough to land the job. Sadly, the image was never used, but we had great fun being in the water with the freedivers and making the shot. The shark was added in postproduction, but the cage and divers were all as shot. The cage was a specially commissioned aluminum construction that was very much full size. We used a crane to swing it into the sea from the deck of a large vessel. Last I heard the cage was being used in a Cyprus nightclub for a go-go girl to dance in."

"In 2005 I traveled to the Turks and Caicos to shoot a series of mermaid images for a commission for Toto bathroom fixtures. It was one of the most difficult shoots I've done. Digital technology was still in its infancy, and I was shooting with a Phase One digital camera back and a medium-format Mamiya RZ67 body in a very dodgy housing. It was hard work in open water and terrible weather. But we survived, the client was happy, and against the odds we got the image."

"Early in 2015 this UK model did a brief checkout dive in a shallow pool and soon afterward found himself in 30 feet of water, buddy breathing with a safety diver and surrounded by dozens of sharks in the Bahamas— and all without a mask. He had worked with me many times before on breath-hold shoots in pools, so I knew he was a superb underwater model. I wasn't sure how he'd handle the sharks or being on scuba. In the end he did me proud. As we were fizzing out before flying home after the job, I somehow managed to persuade him to get back in the water to do a test shot for me from the beach of the hotel. I wanted an action shot, and among a few variations was this running sequence, which came to life when I added the shark. I'll be returning to the Bahamas this summer to run an underwater photography workshop, where I look forward to making more images like this."

LED lighting works very well for close-focus, wide-angle images with small- to medium-sized foreground subjects such as this cabezon, as it is already necessary to get close to the subject.

A DIFFERENT LIGHT

USING LED LIGHTING FOR UNDERWATER STILL PHOTOGRAPHY

Text and photos by Andy and Allison Sallmon

Not long ago, underwater shooters were largely divided into two camps: still photographers and videographers. This factional division was based on practicality more than argument — cameras were dedicated to either still or video imaging, and, given the associated costs, it made sense to pick a side and stick with it.

In more recent years, however, the lines have blurred. Most cameras now feature both still and video capabilities. Many topside photographers and videographers have embraced this versatility, but adoption has been slow in marine photography because of the particular lighting needs of underwater shooters.

Historically, underwater still photographers have carried strobes, which use capacitors to provide a momentary burst of light when the camera's shutter is triggered. While some strobes have built-in continuous light functionality, these were more often used for aiming or assistance during night dives rather than emitting constant light bright enough to allow high-quality video imaging. At the same time, dedicated underwater video lights did not produce enough light to

allow consistent, high-quality still photography. And carrying both types of lighting meant lugging around an inordinately bulky rig.

Recently, however, developments in LED (light-emitting diode) technology have allowed high-output, compact lights to become mainstream. At last, underwater shooters have access to light systems that can support both still and video imagery.

FEATURES OF LED LIGHTS

Characteristics used to describe LED lights include lumen rating, burn time, beam angle, color-rendering index and color temperature. All must be considered from a practical standpoint when selecting a light for underwater still photography. Some units are tested according to the specification for flashlight performance issued by the American National Standards Institute and the National Electrical Manufacturers Association (ANSI/NEMA FL 1-2009 standard), which certifies that a light will perform as intended (e.g., an FL 1-compliant light is guaranteed to maintain its full lumen output throughout its burn time).

The **lumen rating** defines the amount of visible light emitted. In other words, this rating gives you the best indicator of an LED light's power. While a few options exist that provide an output similar to strobes (8,000 lumens or more), for now the price tags of LED lights with this level of performance will deter many photographers. A light's lumen rating represents its output at the highest power setting, so choosing a lower power setting decreases the light output proportionally. This may also affect a light's **burn time** (or run time), a characteristic that describes how long the light will last at a specific lumen output, usually the light's maximum, until it reaches 10 percent of the initial output measurement.

Beam angle is the angle at which the strength of the beam is half of the light's maximum strength (the maximum strength is generally at the center). This is also known as the full-width at half-maximum (FWHM) potential. This represents one of the key differences between high-end strobes and LED lights intended for video use. Strobes, which are used to capture a momentary portrait or behavior, generally have a wider beam angle (110–120 degrees is common) than do LED lights (typically less than 100 degrees) since video is commonly used to capture dynamic subjects. Complicating this issue is the refractive index of water. When lights with flat lenses are submerged, the beam angle is reduced by as much as 33 percent, but many manufacturers report only the topside beam angle, which can confuse potential purchasers. A few manufacturers have made an effort to simplify matters by measuring and reporting the underwater beam angle; others have designed lights with a domed lens to eliminate this complication altogether.

Color rating, also known as **color-rendering index** (CRI), defines a light source's ability to accurately depict the color spectrum compared to an ideal reference light of the same color temperature. CRI is expressed on a scale from 1-100; the higher the number, the more accurately colors will be reproduced. It is generally thought that a CRI of 90 or above is desirable for professional-level topside imaging. CRI is distinct from **color temperature**, expressed in degrees Kelvin, which characterizes light as warmer/yellower (lower values) or cooler/bluer (higher values). Most manufacturers

From top: **Using lights of differing strengths works well to achieve interesting shadows for macro subject matter such as this Spanish shawl nudibanch. Small, light-colored creatures such as this cowrie make good macro subject choices when shooting with LED lights. Wide-angle photography in bright, clear water might require shooting toward midwater as opposed to shooting upward toward the sun. This octopus shows that smaller subject size ensures that photographers are less limited by relatively narrow beam angles.**

of strobes and LED lights endeavor to achieve a color temperature near daylight balance (approximately 5500-6000K). In our experience, most brands of underwater LED lights tend to be slightly warmer than strobes, but minor temperature adjustments are easy to perform using basic postprocessing software.

CONSIDERATIONS AND TECHNIQUES

In recent years a variety of LED lights created specifically for underwater imaging have become available, and the technology is continually and rapidly improving. The dazzlingly bright 14,000-lumen lights we used in Bonaire in 2015 were a far cry from the 500-lumen lights we first used for still imaging less than five years ago. While currently available LED lights are easily capable of illuminating a subject for still photography, they still lack the pop of power offered by many strobes. As a result, one of the key tenets of underwater photography becomes especially important when substituting the former for the latter: Get close.

Decreasing the distance to your subject will help your LED lights produce excellent foreground exposure, even in wide-angle scenes. To this end, using photographic equipment that permits very close focus, such as short-focal-length macro lenses or fisheye wide-angle lenses, is critical. It is often necessary to use a wider aperture with LED lights than one might choose when using strobes, and depending upon the strength of your lights and their beam width, it might be necessary to choose a smaller subject (such as a single branch of soft coral) as opposed to a larger one (such as a large rock covered with soft coral).

The relative limits of currently available LED lights may also affect composition. Whereas when using strobes we generally endeavor to approach subjects from below and shoot toward the ocean's surface, LED lights do not always have the power to compensate for the faster shutter speeds sometimes required in bright conditions. For now, images featuring tight sunballs are far more likely to be achieved using strobes than a continuous light source.

Another consideration is your subject's comfort. We can attest through firsthand experience that certain subjects (especially models) might become annoyed quickly when asked to pose facing blindingly bright continuous lights. And while some marine life won't be bothered, there is simply no way to stealthily approach an animal with thousands of lumens of light continually emerging from your camera rig — and a shy species may not pose for even the briefest shot. Since burn time is a major limitation of currently available lights, you are unlikely to be swimming around with your lights constantly powered on, but even going through the motions of turning on your lights may disrupt some types of marine life. Although the compact size and light weight offered by some LED lights can be advantageous for travel, recent Federal Aviation Administration recommendations against packing lithium-ion batteries in checked luggage could mean adjusting your carry-on baggage plans to accommodate them.

ADVANTAGES

There are lots of advantages to using LED lights for still imaging. The ability to shift between video and still photography during a single dive without carrying multiple light sources (or worse yet, multiple dedicated camera systems) is the most obvious, and it's a biggie. Many, if not most, cameras are capable of both formats, and the flexibility offered by a strong continuous light source might handily outweigh any disadvantages.

In many cases, LED lights are smaller and/or lighter than strobes, providing a size/weight advantage that is particularly beneficial when diving from shore, in current or in confined spaces. LED lights also help optimize autofocus in dark conditions, allow visualization of colors at depth and permit real-time adjustments that decrease the need for in-water image review, which means more time to capture images. While bracketing remains a good idea, photographers can use the light meter during shot setup to detect any major exposure problems and correct any unwanted highlights or shadows before releasing the shutter.

The same goes for detection of backscatter or flare: Issues can be spotted easily through the viewfinder, which helps to diminish unpleasant surprises during image review (or worse yet, time-consuming processing obligations after download). Photographers using continuous light sources also have fewer shutter-speed limitations compared with strobe users, because they don't have to be concerned about synchronization or ghosting issues resulting from too-fast or too-slow shutter speeds, respectively.

CONCLUSION

Rapid, enormous advances in LED technology have given rise to a variety of compact, high-intensity lighting options for underwater image-makers. As a result, the use of LED lights in still imaging has become a useful illumination technique, allowing quick transition between videography and still photography and thus permitting shooters to choose how to document a subject during their dive. Certainly, there are differences between using strobes and LED lights for still imaging,

With the powerful LED lights now available to shooters, wide-angle imaging is easy with just a bit of trial and error, as seen in this image of a cuttlefish and diver in Indonesia.

but the gap has been substantially narrowed, and this trend will continue as improvements in batteries are made and more efficient LED technology is created.

Whether to hit the record button or shutter release is the new question. LED lighting is not meant to replace strobes for underwater still photography, but with some adaptation and compromise we now have the option for shooting stills and video with a single camera. Provided we have the bottom time, we can at last opt to capture a subject both ways during a single dive. AD

Unusually warm surface waters in California have made it easier to interact with uncommon creatures, such as smooth hammerhead sharks.

A PERFECT STORM OF WARM

Text by Allison Vitsky Sallmon, DVM; photos by Andy and Allison Sallmon

Every California diver I know has a recent story about when they first noticed things were changing at our local dive sites. Some recall their local kelp bed looking thin, while others mention the presence of yellowfin tuna on every shore dive, the range extension of a Mexican nudibranch or the appearance of a skinny baby sea lion on the swim step of their dive boat. For me it was when a 9-foot-long smooth hammerhead shark curiously bumped my camera rig. It was August 2014, and it was no secret that the surface waters were a few degrees warmer than normal.

On that day the swell and wind were formidable, but we were determined to get offshore. We hoped to get a good look at the hammerhead sharks — typically a subtropical species — that had been spotted at the surface by one or two multiday dive boats over the past few weeks. We couldn't believe our luck when one showed up and interacted closely (at times, very closely) with us for three hours.

Among divers the rumored cause for the oddities of the summer of 2014 was El Niño (the warm phase of the El Niño Southern Oscillation), an ocean-atmosphere interaction in the east-central equatorial Pacific that strongly influences ocean conditions and weather patterns. However, the U.S. National Oceanic and Atmospheric Administration (NOAA) had not confirmed the presence of El Niño conditions. Meanwhile, Washington state climatologist Nick Bond had already come up with an alternate name for the odd patch of warmer-than-usual ocean off the coast of the Pacific Northwest: "The Blob." This phenomenon, thought to be the result of locally persistent high pressure that inhibited normal wind-driven oceanic upwelling and cooling, had spread along the West Coast and encompassed multiple stretches of ocean from Alaska to Mexico.

In some places the ocean's surface was 5°F warmer than usual. Although the Blob quickly replaced El Niño as the established cause, 2014 diving and fishing reports in Southern California confirmed the effects, each more bizarre than the last. Tuna fishermen came back from a day offshore east of Catalina Island with images of a whale shark. The lush, iconic kelp of Catalina and San Clemente islands dwindled, and in some places this enabled prolific growth of *Sargassum horneri*, an invasive alga that better tolerates warmer water. A GoPro video of a manta ray,

gracefully flapping among sparse kelp stalks, created a fanatical rush on local dive charters.

By the time NOAA confirmed the arrival of El Niño conditions in March 2015, it was hard to believe that things could get any stranger, but they did. Sea bird and California sea lion populations began experiencing devastating die-offs. In April 2015, strong west-to-east surface winds blew masses of violet-blue *Velella velella*, open-ocean hydrozoans related to jellyfish, onto beaches in California, Oregon and Washington. And in June 2015 I watched in amazement as pelagic red tuna crabs (a squat lobster-like crustacean normally found near central Baja California) swarmed one of our few remaining local kelp beds and ultimately littered the coastline from San Diego to Los Angeles.

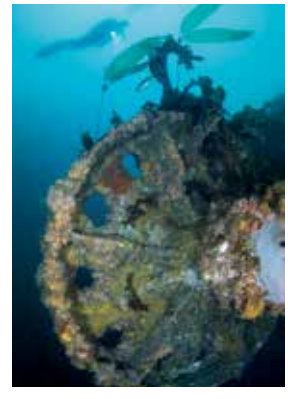
The peculiarities didn't stop there. In July and August 2015, smooth hammerhead sharks were bumping near-shore kayak fishermen so commonly and assertively that local beaches were closed on multiple occasions. On the docks, anglers posed proudly next to bluefin tuna, caught only 10 miles offshore, and local photographs of finescale triggerfish and Guadalupe cardinalfish became commonplace. In September 2015, I hovered in disbelief next to the barren propeller of the HMCS *Yukon*, a San Diego-area artificial reef that had been thickly encrusted with giant plumose anemones only 12 months prior. And only a month after that, a cluster of wahoo passed me at a Catalina Island dive site days before I photographed a pulsing Australian spotted jellyfish near the San Diego harbor. The world — at least, the underwater world I frequented on a regular basis — seemed to have gone stark raving mad.

Ed Parnell, Ph.D., research oceanographer at the Scripps Institution of Oceanography, wasn't terribly surprised to hear it. "The Blob was an unprecedented warm-water event that wasn't related to common oceanic indices," he explained. "Last year we had warmer surface conditions, but at depth things remained cold and nutrient-rich, so some deeper species were less affected than you might think. However, the water became very stratified and more resistant to mixing. Typically, an El Niño pattern results in advection of pulses of warm equatorial water northward, so that upwelled water is warmer than normal and less able to deliver nutrients to shallower structures. But this year, with things prestressed by the Blob, the seasonal thermocline is already deeper than normal, so upwelled water would likely be even warmer than we've seen with prior El Niños — in fact, this year upwelling might not deliver much cold, nutrient-rich water at all."

Parnell's key concern is further overgrowth of invasive *Sargassum horneri*. "Two years ago, we were seeing isolated pockets of it, but now it's popping up everywhere," he said. "If we lose the kelp in an area completely, sargassum can easily take over because it will no longer be suppressed by giant kelp shading."

Previous El Niño events have delivered mighty topside changes to the West Coast as well. In the past, the position of the jet stream has shifted south and east from the Gulf of Alaska so that storms track closer to the Southern California shoreline. The strong El Nino in 1982-83 brought crippling storm fronts, complete with waves that broke over the roofs of popular beachside restaurants. And in 1997-98, repeated deluges washed away roads and caused catastrophic mudslides. With California in the midst of a drought, it feels a little ungrateful to admit that stories of the past combined with ever-more-ominous nicknames bestowed upon the present El Niño ("Bruce Lee" is my current favorite) are more than a little frightening.

Parnell, however, says this may be one of the biggest reasons to remain optimistic. "Strong storms can revamp the bottom structure, remove urchin barrens and clear out the understory kelps, providing renewed areas for giant kelp to grow," he said. "El Niño may bring a series of storms, but we need to remember that those large storms act as a reset button for kelp forests in Southern California." AD

From left: **The propeller of the HCMS *Yukon* wreck in San Diego's Wreck Alley was thickly covered with giant plumose anemones in spring 2014. By the summer of 2015, the ocean had become warm enough to wipe them out, leaving nearly bare metal behind. A diver pauses over an Australian spotted jellyfish near the coast of San Diego. Pelagic red tuna crabs, a denizen of Baja, Mexico, swarmed a California kelp bed in June 2015.**

GOING PRO

By Heather Sinclair

When I decided to become a divemaster, I already knew I wanted to do my training on a small island in Indonesia. I'm a cold-water wimp, so it wasn't difficult to decide on clear, 86°F water that teemed with life. It was, however, difficult to pick one of the island's nearly 20 dive centers.

I wanted to enjoy my training, not just complete it. I took the time to talk to people at several dive centers and ask questions before deciding where to get trained. This helped me make the right choice, and it might help you, too.

First I considered which training agency I wanted to go with. I was happy with my recreational training, and I chose to continue with the organization I was familiar with. Next I asked questions by going door to door interviewing the dive centers. I did this in person, but many of these questions could have been answered by phone or email. I asked:

- What is the total cost of the course, including any fees or charges that aren't included in the basic course price?
- What are the boats like? Take a look, and see if they appear to be well maintained.
- What is the expected time commitment per day? Being a divemaster trainee is like being an employee: You're expected to help out at the dive center. Get an idea of when you'd be expected to start and finish each day.
- Will I be assigned a mentor for the duration of training, or will I be mentored by multiple instructors? If you have a preference, this question is important.
- How many divers are in a typical group? It may be more (or fewer) than you like, so it's worth asking if the center has a policy or a cap on the number.
- What makes the dive center unique? At each one I visited I asked what made it the best dive center on the island.
- What do you like best about working at this dive center?

STEPHEN FRINK

- How much should I expect to spend on gear? Compare the rental cost to the purchase price. If you plan to rent or borrow, find out whether you'll have consistent access to gear that fits you well.

This might sound superficial, but looks and size count. My first impression of a dive center influenced whether I wanted to train there or not. I noted each center's appearance, how busy it was and how much I liked the staff members I met. Rapport with the staff is particularly important because you'll be spending a fair amount of time with them.

At most dive centers I was greeted before I even entered, but at some I wasn't even acknowledged; this initial interaction (or lack thereof) made a difference. When asking the staff questions, I watched for signs of professionalism. I listened for clear answers, familiarity with the divemaster course and knowledge of dive center policies. Some of the staff members I talked to answered my questions easily, others rambled or gave unclear responses.

Becoming a divemaster is the first step toward a career in diving. Once you've decided where in the world you want to train, take the time to pick the right dive center. Visit, ask questions, and don't be afraid to rely on your first impression. It's *your* training, so be sure to choose the center that suits you best. AD

SHARE YOUR STORY

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DO YOU KNOW WHAT YOU'RE BREATHING?

CO_2 SENSING IN REBREATHER DIVING

By Michael Menduno

Unlike an open-circuit diver, who breathes a known, predetermined gas mixture (*You do analyze your gas before diving, don't you?*), a rebreather diver respires an artificial atmosphere that changes dynamically with depth over the course of a dive.

An electronic rebreather has two jobs: to measure and maintain a preset level of oxygen (partial pressure of oxygen, or PO_2) using oxygen (O_2) sensors and a controller, and to remove the diver's exhaled carbon dioxide (CO_2) by means of a chemical scrubber. Until recently there was no way to detect the presence of CO_2 in the breathing loop — that is, to know if the rebreather was working properly.

CO_2 detection has long vexed the U.S. Navy, which has spent millions of dollars over the past 50 years in search of a solution, and for good reason: Hypercapnia from elevated CO_2 levels in the loop is a major hazard in rebreather diving. It can lead to incapacitation, loss of consciousness and death in amounts greater than 0.01-0.02 atm.

Divers tend to be poor at detecting increased CO_2, especially when exerting themselves. By the time they detect it, the situation is usually perilous, requiring a rescue rather than a bailout. Appropriately dubbed the dark matter of rebreather diving, CO_2 may be responsible for or a contributing factor in as many as a third of sport rebreather fatalities.

In the past five years, as a result of a breakthrough in commercial technology, several sport rebreather manufacturers have introduced nondispersive infrared (NDIR) sensors that warn divers of elevated CO_2 levels, indicating a possible scrubber failure. Though the technology is still in its infancy, it holds promise for improving diver safety.

Meanwhile, the Navy Experimental Diving Unit (NEDU), which has tested dozens of NDIR devices with limited success due to problems with water vapor and pressure effects, is currently beta testing an innovative sensing film for use in oxygen rebreathers that could revolutionize CO_2 detection.

DARK MATTER IN THE LOOP

Divers produce about 0.9 liters of CO_2 for every liter of O_2 they consume. A properly functioning rebreather removes this gas from the breathing loop. Even so, CO_2 can accumulate in several ways. First, inspired CO_2 levels rise exponentially once the scrubber reaches depletion, which is known as "breakthrough."

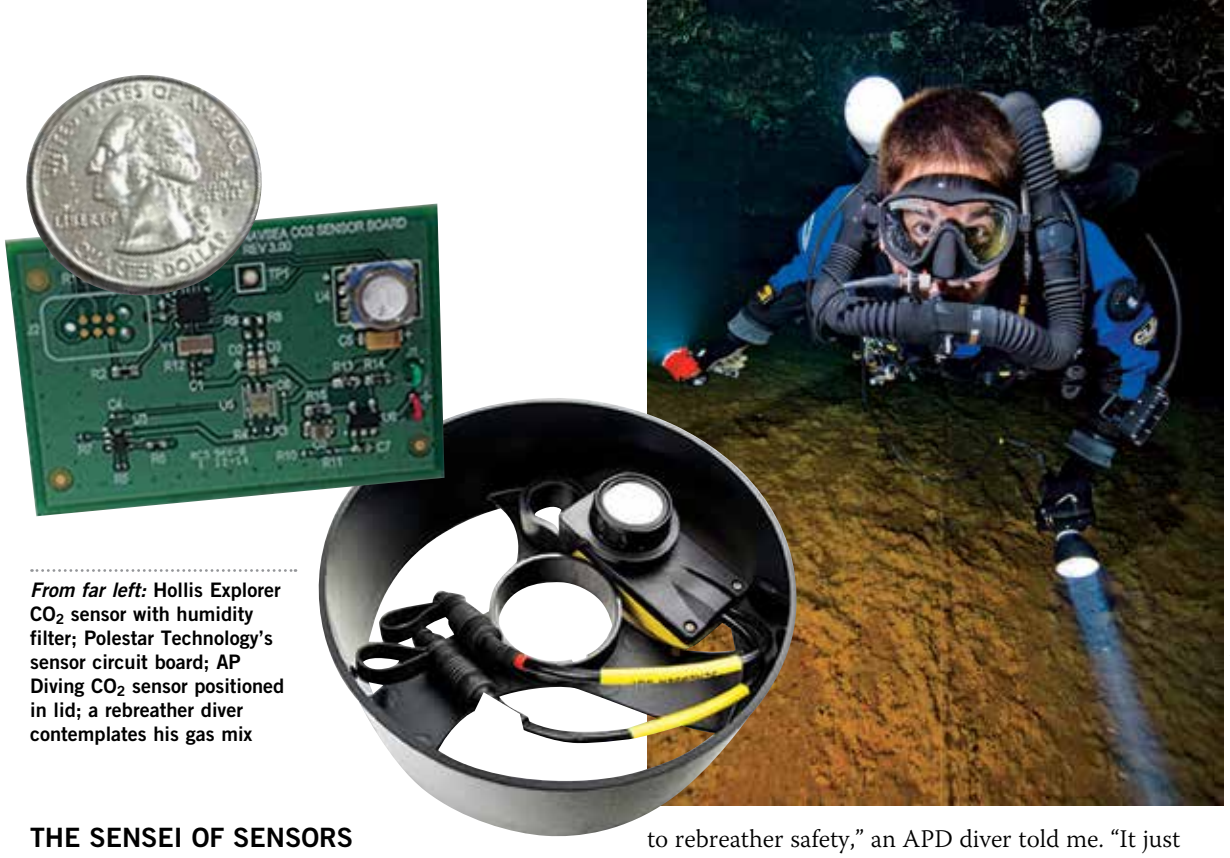
Feeling lucky? Although manufacturers publish a worst-case scrubber duration, actual duration can vary high or low by a factor of four times depending on a diver's profile and workload, the water temperature and even the brand of CO_2 absorbent used in the scrubber.

Improperly filling or installing the scrubber or forgetting to grease the scrubber O-ring can result in channeling or bypass, allowing CO_2 to be rebreathed. So can a dirty "mushroom valve," a one-way valve that directs the diver's exhalation to the scrubber.

Finally, divers eliminate CO_2 by breathing, and CO_2 levels in a rebreather diver's arterial blood can rise to dangerous levels as a result of insufficient breathing. In fact, the combined effects of immersion, static lung loading, increased gas density and having to push gas through the loop with the lungs can reduce a rebreather diver's capacity to ventilate by about 50 percent at 100 feet, and it continues to decrease with depth.

In the absence of a means to detect CO_2, military divers have relied on strict protocols for preparing their rebreathers, including a five-minute prebreathe to detect possible problems. However, a recent study[1] found that 90 percent of subjects failed to detect a partially faulty scrubber during the prebreathe. This illustrates the great need for reliable sensors.

In 2001, under pressure to reduce "scrubber crashes" in the fleet, NEDU released a patented scrubber thermal array that measures the heat of the chemical reaction as CO_2 moves through scrubber. AP Diving developed its own array, called a TempStik, in parallel. Though not foolproof, these devices function as a sort of gauge to estimate how much CO_2 absorbent has been used and how much remains, greatly reducing uncertainty about scrubber duration.



From far left: **Hollis Explorer CO_2 sensor with humidity filter; Polestar Technology's sensor circuit board; AP Diving CO_2 sensor positioned in lid; a rebreather diver contemplates his gas mix**

BECKY KAGAN SCHOTT, LIQUID PRODUCTIONS

THE SENSEI OF SENSORS

The Navy wants to improve safety by equipping rebreathers with both a scrubber gauge and one or more CO_2 sensors. Interestingly, sport rebreathers were first to incorporate the combined solution.

In 2008, rebreather pioneer Kevin Gurr of VR Technology Ltd. launched the Sentinel, which included a thermal array licensed from NEDU along with the then-groundbreaking low-power NDIR sensor from Gas Sensing Solutions (GSS). He later incorporated these into the Explorer, which was sold to Hollis Inc. AP Diving introduced its own version of the GSS sensor for its rebreathers in 2014. rEvo Rebreathers has also licensed NEDU's array.

The GSS sensor projects an infrared LED light through a sample of gas exiting the scrubber and calculates CO_2 levels based on the amount of light absorbed. Unfortunately water vapor also absorbs infrared light and thus reads as CO_2, so a barrier must be used to keep the sensor dry. This is no small task in a 100 percent humid environment, but it can usually be achieved with replaceable filters.

The software also requires extensive calibration data because light absorption changes with pressure in a noncomputable way. Because of its placement, the sensor is unable to detect a mushroom value failure or arterial CO_2 buildup.

Although the sensors have proved finicky and in some cases have had to be replaced, most users are supportive. "The current sensor is a fantastic addition to rebreather safety," an APD diver told me. "It just seems like it is still in development."

The game changer may be a new sensor technology developed by Polestar Technologies Inc. that NEDU is currently testing for use with oxygen rebreathers. At its core is a quarter-sized disc of polymer film that changes from blue to yellow in a reversible and predictable way when exposed to CO_2. Notably, moisture does not affect its operation.

A tiny white LED light illuminates the disc from a sealed pot below that houses the electronics. A digital meter reads the color, which is converted to the CO_2 level. The heads-up display gives a green light for good and flashes red when CO_2 levels reach a predetermined limit. It can easily be integrated into a mixed-gas rebreather.

In the future the device could be adapted to fit inside a rebreather mouthpiece and measure the end tidal CO_2 in the diver's exhalation — the holy grail of CO_2 sensing — to estimate arterial CO_2 levels. Future rebreathers may sport multiple sensors.

Although the technology exists, only six of the more than 20 rebreather manufacturers offer some form of CO_2 protection, and only two offer both an array and sensor. Many don't see the need. As one manufacturer told me, "Divers just need to learn to pack their scrubber properly."

Given that rebreather fatality rates have been estimated to be five to 10 times higher than open-circuit rates, perhaps the question is better put to the divers themselves: "Do you want to know what you're breathing, or not?" AD

REFERENCE: [1]**Deng C, Pollock NW, Gant N, Hannam JA, Dooley A, Mesley P, Mitchell SJ. The five-minute prebreathe in evaluating carbon dioxide absorption in a closed-circuit rebreather: a randomized single-blind study. Diving Hyperb Med. 2015; 45(1):16-24.**

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PARTING SHOT

By Bruce Shafer
scubashafer.com

I came upon this beautiful redline *Flabellina* (*Flabellina rubrolineata*) on a night dive in the Philippines. These tiny nudibranchs rarely reach an inch and half long, and this one was less than an inch. They are difficult to spot during the day, but when your light shines on one at night, it's time to stop and take a picture.

The extremely colorful *Flabellinas*, a genus in the suborder Aeolidina, are carnivorous. Our subject is laying eggs on the dead skeleton of a hydroid — the hydroid colony was presumably just eaten prior to being used as a foundation for the egg-sack cluster.

Nudibranchs abandon their eggs after laying them in spots that offer close food sources for their newly hatched young. Divers often see nudibranch egg clusters, but this elegant redline *Flabellina* actually laying eggs was a rare find. AD

EQUIPMENT: Nikon D300, 105mm lens, Subal housing, Ikelite strobes (2)
SETTINGS: 1/160 sec. @ f/22, ISO 100
LOCATION: Sunview, Anilao, Batangas, Philippines

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