Tech Diving Mag

Research - Development - Exploration

Deep Into Deco?!

A Primer for Nautical Terms & Maritime Trivia

Respiratory Loads During CCR Diving – Part II

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Issue 20 – September 2015

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Editorial

Welcome to the 20th issue of Tech Diving Mag.

Those who asked about DEMA, Best Publishing Co will be exhibiting this year and will have *Deep Into Deco: The Diver's Decompression Textbook* available there. Their booth is #1646, located in the Technical Diving Resource Center. Those who already got the book from Amazon, please put your reviews there. The frequently asked question: how does it compare to other deco-related titles? This one has all the basic topics covered, and is more into decompression simulation/modeling and up-to-date research.

The contributors for this issue are world renowned industry professional Bret Gilliam, commercial diving instructor Konstantinos Alexiou and technical diving enthusiast Flavio Fanelli. Take a look at their brief bio at www.techdivingmag.com/contributors.html.

Tech Diving Mag is based on article contribution, so you're always welcome to volunteer a piece and/or some photos. The guidelines could be found at www.techdivingmag.com/guidelines.html.

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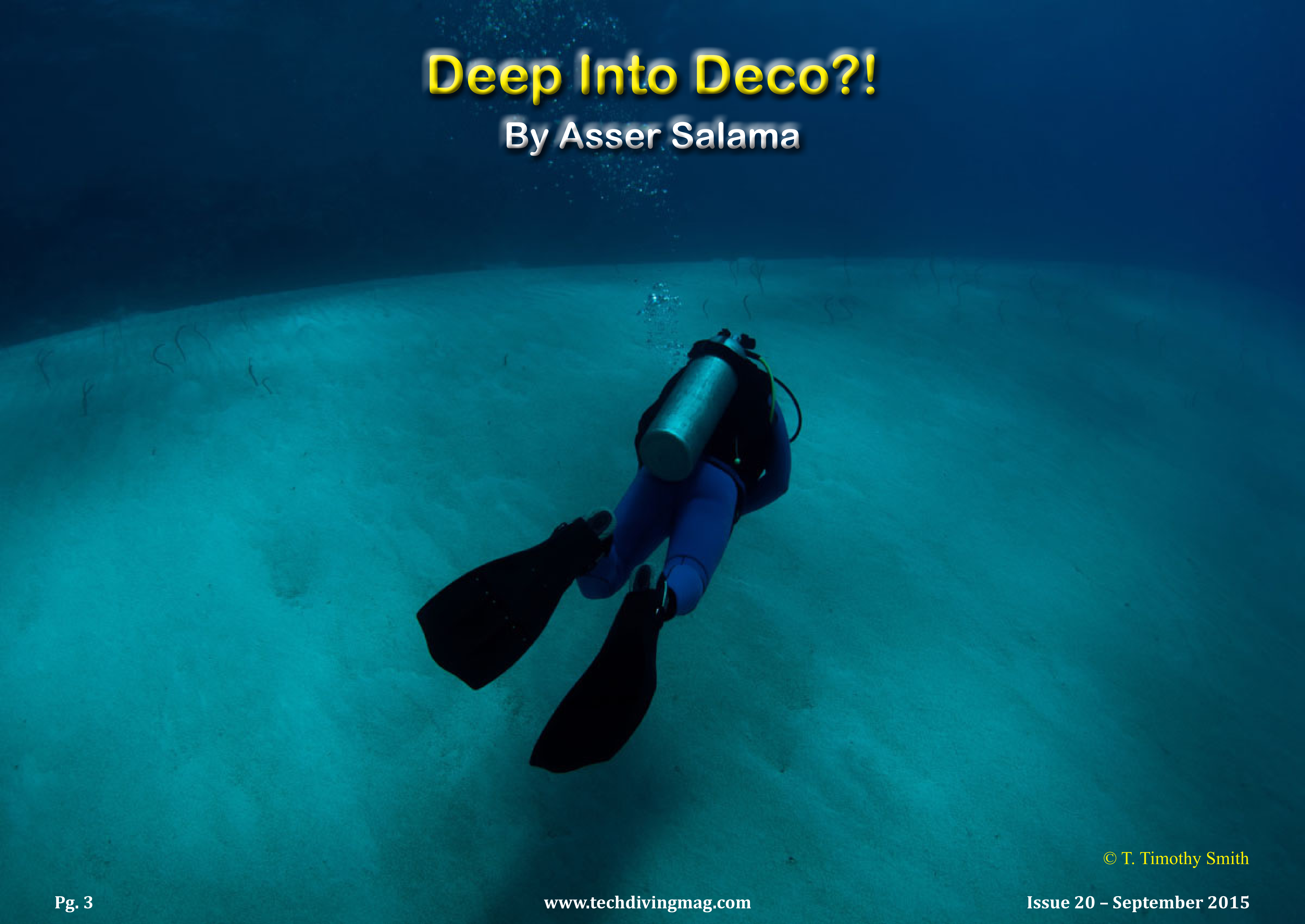
Asser Salama
Editor, Tech Diving Mag

Deep Into Deco?!

By Asser Salama



Date: Wednesday, October 31, 2007
Time: About noon
Place: Lighthouse, Dahab, South Sinai, Red Sea, Egypt

I went for a solo dive on a nonredundant single 80-cubic-foot (11- but wrongfully perceived as 12-liter) air tank and a Suunto dive computer adjusted to the most "aggressive" settings. My surface interval before the dive was more than 24 hours.

While in the water, I decided to get to the deepest part of the reef table. I know it's at 43 meters (140 feet). The reef here is not an exact wall; it's slopey with some scattered patches. I reached the deepest point in about four minutes. Then, and only then, I opted to go on with the gentle sand slope, away from the main reef. I've explored this place twice before. The first time I went to some 48 meters (160 feet); the second time I explored further, found two reef patches and had a look at the first one at 61 meters (200 feet). Now it felt like about the right time to take a glimpse at the second patch.

The second patch was at a depth of about 67 meters (220 feet) and far enough from the main reef. That's what I found out. It took me another four minutes to get there, and I had my time "smelling the roses." I kept exploring, and my Suunto kept moaning, blinking and amassing sky-rocketing decompression penalties. Jeez, I thought, it's too bad I don't have the good old Uwatec today; it usually doesn't bother me with this crap. I ignored the dive computer and continued enjoying the isolated reef patch I had for myself, until my pressure gauge read 70 bar (1,000 psi). That was certainly most unexpected. Now what?

I don't like surfacing in the blue, not to mention long surface swims. It was a shore dive, so there was no boat to pick me up. On my way back to the main reef, I decided not to be silly, so I didn't stick to the sand slope. I ascended to the 25-meter (80-foot) mark and continued swimming in midwater. Before reaching the reef table, I started a slow ascent and finally reached the 6-meter (20-foot) mark. I stopped there for a while then ascended to 3 meters (10 feet) and stopped there until my pressure gauge read some 10 bar (150 psi). The last thing my Suunto displayed before going into the error mode was 28 minutes of missed decompression "obligation."

I had oxygen onsite, but I didn't use it. I didn't think I needed it. On my way back to the dive center, I drank some water. After rinsing the gear, I took a cold shower (it was almost November and still uncomfortably hot) and then took a short nap. In about 16 hours I was driving my beloved Fiat Siena, heading to Sharm El Sheikh some 100 kilometers (60 miles) south of Dahab. The road's highest altitude is 640 meters (2,100 feet). I was going for a three-day boat trip; it was a very nice one indeed, in part because my Suunto was "bent" (running as a bottom timer not a dive computer), so it didn't bother me anymore.

Focusing only on the decompression part and discarding every other aspect of this dive, did I get lucky? Should I have been injured? How was this decompression penalty calculated? How could one twist the schedule in such an "irresponsible" manner and get away with it? More important, why did I whine about not having the Uwatec dive computer that day? Isn't the Suunto good enough?

On the other hand, if you follow the dive forums on the Internet, you frequently see the term "undeserved hit," meaning that a diver got "bent" — developed decompression sickness (DCS) — although he did everything possible to avoid this unfortunate event. I remember one time a vacation diver got bent while breathing what some operators incorrectly call air28 (28 percent oxygen, 72 percent nitrogen), although he used a dive computer (which was adjusted to normal air settings to offer a higher margin of safety) and did not violate the ascent rate or any no-decompression limits (NDL).

Is it not enough to stick to what your dive computer tells you? Even diving more conservatively doesn't guarantee you will avoid getting hit. At the same time, some people ignore the dive computer and do whatever they like without getting hit. This seems a bit illogical, doesn't it? What's the advantage then of getting a dive computer or even planning the dive using a decompression planning program or a set of dive tables?

The answer is: Decompression is still far from being an exact science. There is a severe lack of funding for decompression research, which means that whenever research on a particular aspect is done, it might not meet certain criteria in terms of the number of participants, the experimental conditions, etc. The result is many different theories on the very same aspect. These theories sometimes contradict each other, which means that they can't all be valid. Acceptance of what the scientific community tends to believe is another issue. Generally speaking, the diving community applies what works for them rather than what the scientific community subscribes to.

In conclusion, blindly subscribing to your favorite decompression planning tool, whatever it is, and following the most recent industry standards without understanding the underlying principles of decompression and without having enough knowledge on various aspects and theories could prove fatal. This does not mean you should not keep up with the latest standards. It simply means you should learn and understand.

In addition to being a technical diver and instructor, I am an engineer and a software developer. That's why I'm particularly interested in mathematical models. Since 2010 I've been studying decompression algorithms and contacting industry leaders and researchers in an attempt to enhance what we already have in hand. The output is Ultimate Planner, a decompression planning tool with some unique features. While reading this book, you'll see some examples of these features, how they were developed and how to use them. But I'm aware that neither differential equations nor source code probably interest you.

This book will touch on the basic principles of decompression theory and at the same time will shed light on the latest developments and controversial issues, as I tend to be technically up to date. You'll read some interesting interviews with researchers, accomplished divers, industry professionals, and software developers. I've also quoted experts on historical perspectives and other more specific issues, so you'll find the style a mix of strict no-nonsense writing and interesting storytelling. I didn't use footnotes, but references are numbered in the text and collected at the end of the book.

Excerpted from *Deep Into Deco: The Diver's Decompression Textbook*. The title is available in 3 forms: print book, eBook and package set (print book + eBook + 20% discount).

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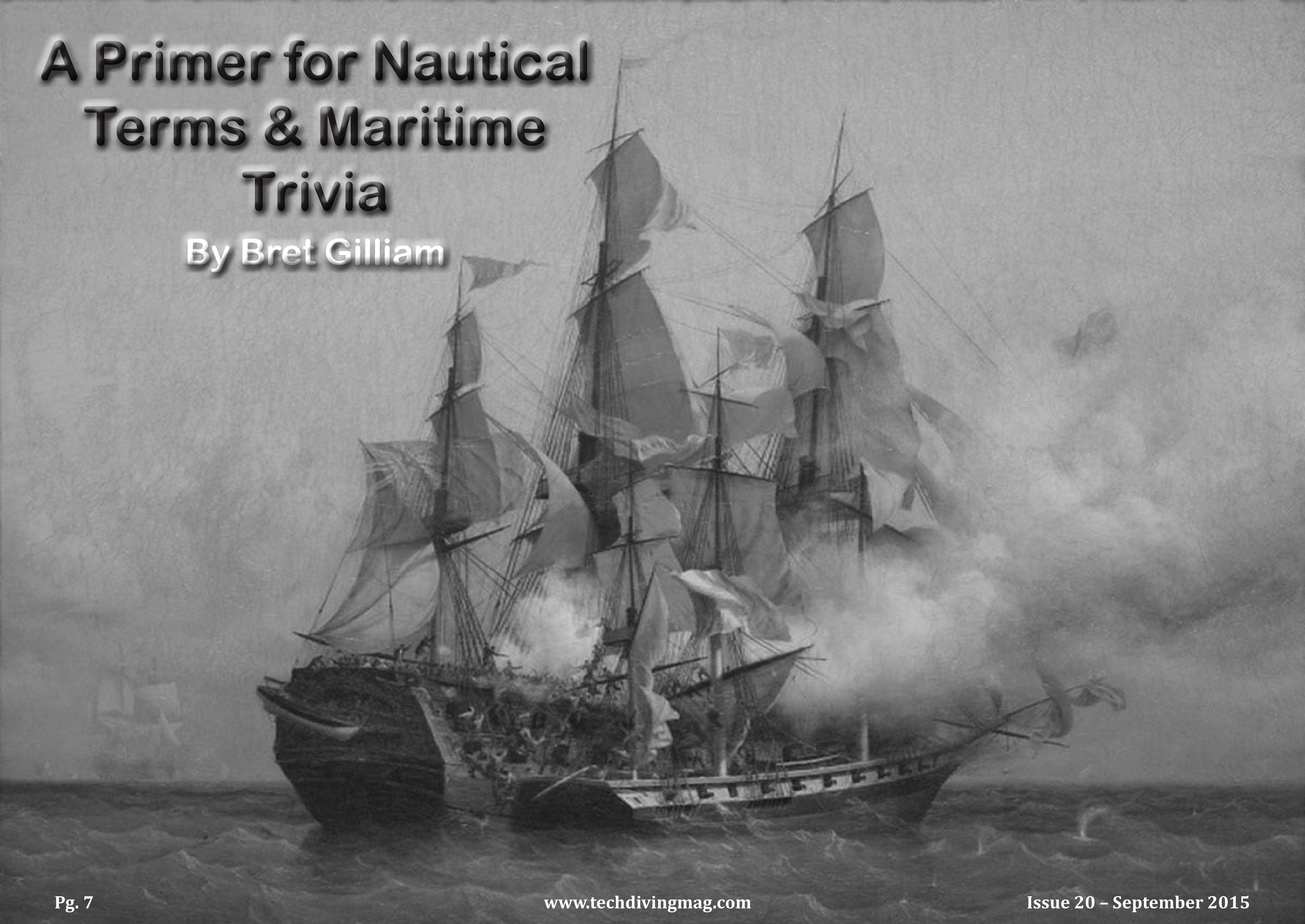
A Primer for Nautical Terms & Maritime Trivia

By Bret Gilliam



As a licensed professional master of vessels from motor yachts to cruise ships, I've lived with the esoteric lexicon of the mariner for over forty years. To the uninitiated, the language of the sea might as well be Pig Latin for most casual observers. But the lay person need not feel completely left out. The origins of some common nautical terms are steeped in maritime history and little known to most modern mariners.

Some terms are of historical interest, some are amusing, and some will manage to offend. But a look "behind the sextant" is probably worth the education and will dazzle your dinner partners at the next yacht club banquet.

The following selections from the sailor's lexicon are offered for your edification:

Starboard: The right side of a vessel. This traces its lineage all the way back to Viking ships and galleys propelled by sails and slave rowers. Ships of this era did not use conventional rudders affixed to the transom keel but employed a "sweep oar" or, literally, a "steering board" (star board) deployed from the right quarter (aft section). Starboard was derived from this since virtually all ships were constructed "right handed".

Port: The left side of a vessel. Since a ship outfitted with a "steering board" on its right side could not be brought alongside a pier without risking damage to this vital maneuvering equipment all docking was arranged to the "port" side, or city side. The starboard side was kept to seaward.

Head: A vessel's toilet. Early sailing craft had notoriously poor performance to windward due to sail designs featuring square-rigged rigging that encouraged the mariner of that day to use downwind or off-the-wind routes. Thus, when a crewman needed to relieve himself, he sought out the "head" of the ship where the downwind aspect of this vantage point favored his bodily functions.

Spanker: Small sails at the extreme aft section of a vessel. Popularized by Caribbean pirates as additions to complement the square rigged main sail plan. One buccaneer is said to have praised the performance of the fore & aft mizzens "for spanking her ass smartly". The obvious confusion for some over the use of this term is best summed up in this limerick:

There once was a lady from Bangor,
Who slept while the ship was at anchor,
She rose in dismay as she heard the mate say,
"Let's raise the top sheet and spank'er!"

Heave ho: What inevitably happens after eating too much "ho" in rough seas.

Before the mast: The crew's quarters or fo'c'sle. The ride in the forward section of the ship was subjected to an unholy pitching motion when sailing on the wind making the berthing section for ordinary seaman a wretched space. The most stable ride at sea was enjoyed aft of the main mast and was generally reserved for senior officers and the master.

Posh: The highest standard of luxury. The popular steamship route from England to the Mediterranean attracted all of Britain's upper crust for the extended cruises. Given the fashion of the time, it was much frowned upon to be cursed with a suntan since this implied that one might have to actually work for a living and go outdoors. In these latitudes the sun was cast on the southern side (right) of the ship en route to the Med and on the reverse on the return voyage. To ensure that one's cabin and deck lounge were on the shady side for both legs of the voyage, all gentlemen and ladies insisted on "port out, starboard home" accommodations. These "posh" cabins reflected the ultimate social status.

Horn pipe: A sailor's jig or dance. Enforced idleness on long passages aboard the whaling ships of the 1800s were the mother of invention. Creative seaman fashioned fine works of art from whale ivory known as "scrimshaw" and used the left over horns of livestock to carve musical instruments similar to penny whistles. The spirited tunes from these crude "horn pipes" sparked a wild dance performed with abandon that was a frequent relief from the tedium of the sea voyage. When ships met at sea, a sailor's "gam" frequently ensued with entire crews engaged in the furious all-male dancing rituals. "Ah, to be born again when truly appreciated," Liberace once reflected.

Holy stone: To clean the ship's decks by scrubbing with an abrasive stone. One of the more hated duties of the seaman during the golden age of sail. The expansive hardwood decks were cleaned of dirt, blood and other accumulations by the backbreaking labor of buffing by a flat stone with a "hole" drilled in the center for a mop handle. It is more likely that the "holy" in holy stone came from the sailor's true feelings for the "goddamn" practice.

Clean bill of health: This refers to a document issued to a ship that shows the port it sailed from has suffered no epidemic or infection.

As the crow flies: When lost or unsure of its position in coastal waters, a ship's crew would release a caged crow. The crow would fly toward the nearest land, giving the crew some sense of direction. The tallest lookout platform on a ship became known as the "crow's nest."

Son of a gun: When in port, and with the crew restricted to the ship, women were allowed to live aboard. Sometimes children were born on the ship and a convenient place was between the guns on the gun deck. If a child's father was unknown, as was often the case, the boy or girl was entered in the ship's log simply as "son of a gun."

The whole nine yards: Yards are the spars attached to the mast that support square sails. On a fully rigged, three-masted ship, there are three major square sails on each mast. If the nine major sails are employed, the whole nine yards are working.

Footloose: The bottom portion of a sail is called the foot. If it is not secured, it is footloose and dances randomly in the wind.

Overbearing: To sail downwind directly at another ship to "steal" or divert the wind from its sails.

Pooped: The poop is the stern section of a ship. To be pooped is to be swamped by a high following sea.

"If you harden up, I believe you can lay that nun to starboard:" Harbor pilot's advice to a schooner captain entering Boston harbor in 1830. (translation: sail closer to the wind and you can safely leave the red buoy to the right.) His directions were the cause of some consternation to the local Catholic priest brought aboard to bless the ship's safe return.

Dress for Success: A Swashbucklers Cautionary Tale

The captain of a British Man-of-War in the early 1700s, upon having his ship attacked by a boarding party of pirates, was heard to shout, "Bring me my red shirt!" as the skirmish began.

When one of his officers inquired as to the reason for his order, the captain explained, "In case I am wounded, I do not want my bloody wounds to deter the men's resolve."

Inspired by this selfless act of courage, his men fought on to victory that day. And so on throughout their tour of duty during every battle the captain would grandly order, "Bring me my red shirt!" and they would win the day vanquishing all enemies.

Later in the sea campaign facing overwhelming odds as ten boarding parties of cut throat pirates stormed his ship from port and starboard, the men awaited the captain's characteristic orders of inspiration, whereupon he shouted, "Bring me my brown trousers!"

The outcome of the battle, and his laundry, remains unknown.

After digesting this short tutorial you are now qualified to expound smugly on the esoteric lexicon of the mariner in all appropriate social circles while wearing red trousers, a blue blazer and a Greek fisherman's cap. For best results, avoid sharing your wisdom with actual marine professionals who might feel the need to give you a first-hand remedial lesson in "keelhauling."

Finally, it's worth noting that in 1989 my old crew aboard the 525-ft. cruise ship *Ocean Spirit* had a brass plaque placed outside my office that offered this warning: "The Floggings Will Continue Until Morale Improves."

Bret Gilliam is a licensed ship master and has commanded vessels up to 525-ft. in the cruise, yacht, commercial, scientific, and military shipping business over the last 40 years in the Pacific, Atlantic and Indian Oceans as well as the Caribbean and Red Sea.

Respiratory Loads During CCR Diving – Part II

By Konstantinos Alexiou

Introduction

We saw in the previous article, *Respiratory Loads During CCR Diving – Part I*, that the diver's respiratory function can be affected by external and internal loads.The primary effect of diving on resistance involves the breathing gas density, which is classified as an internal respiratory load. Density and viscosity are primary determinants of the resistance to gas flow through a pipe, the diver's airways in our case.The density of the breathing gas increases proportionally with the depth of immersion, as the breathing gas is provided to the diver at ambient pressure. In contrast, gas viscosity does not change at increased pressure within the limitsof human diving. Measurements in divers indicate that airway resistance is greater during expiration than inspiration, and increases approximately in proportion to the square root of the density (5, 6). This article deals with the limitations in the ventilatory capacity of the diver, occurring because of the impact of the breathing gas density on airways resistance.

Maximum Voluntary Ventilation (MVV)

In normobaric conditions, exercise performance is governed by the ability of the body's working muscles to utilize oxygen. The function of the cardiovascular system represents the primary limitation to someone's performance. However, at increased barometric pressure the individual's performance is limited by the ability to move gas in and out of the lungs. The Maximun Voluntary Ventilation (MVV) or peak expiratory flowat any gas densityρ can be approximated by the following formula (6):

$$A = A_o(\rho/\rho_o)^{-k}$$

where A: MVV or peak expiratory flow at a gas density ρ, A_o: MVV (or peak expiratory flow) at 1 ATA, ρ_o: gas density at 1 ATA, and k is a constant with the value 0.4-0.5. For example, if $\rho = 5\rho_o$ and k = 0.5, the MVV at a gas density ρ becomes $A = A_o(1/5)^{1/2}$.

Expiration

In normal subjects breathing air at 1 ATA, when a maximal effort is exerted to exhale, this effort affects the flow rate at high lung volumes and not flow rate at lower lung volumes. During maximal expiratory efforts, flow rate at low lung volumes is independent of effort due to airflow limitation (effort independent flow) (7). Maximal expiratory flow is limited by effort only at lung volumes in excess of 75-80% of the vital capacity (VC) (2).The rise in the alveolar pressure, P_{alv}, is the driving force that causes gas to flow into the airways, and it is equivalent to the sum of intrapleural pressure (P_{pl}) and the elastic recoil pressure (T) of the chest wall.In a forced expiration, both intrapleural pressure and alveolar pressure will increase. Because of airflow resistance, the alveolar pressure will drop along the airways during expiration (friction loss), whereas intrapleural pressure will remain the same. Therefore, there will be a point where intrapleural pressure surrounding the airway is greater than the alveolar pressure. On that point, referred to as "equal pressure point (EPP)", the airway may compress or even collapse, causing limitation to airflow (Figure 1). The above dynamic situation is an effort independent exhalation and once it occurs, no amount of extra expiratory effort will increase the flow of gas out of the alveoli. Since the expiration is effort independent, ventilation is also affected by this phenomenon. If for some reason the arterial CO_2 increases, the diver attempts to breathe harder, but his/her impaired ventilation (and therefore respiration) causes further increase in the levels of the arterial CO_2. Actually, the extra ventilatory effort is just wasted work and only serves to produce more CO_2. This will probably lead to respiratory muscle fatigue, which will lead to carbon dioxide narcosis and ultimately unconsciousness at depth (3, 4).

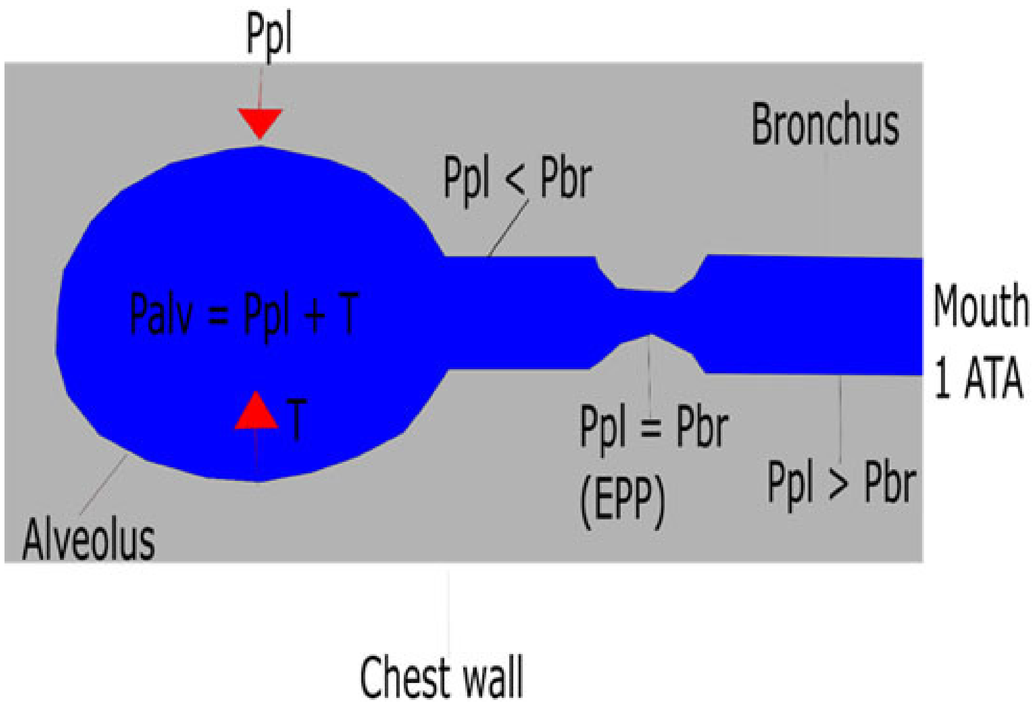


Figure 1. Schematic representation of the respiratory system, enclosed by the intrapleural cavity. Alveolar pressure (Palv) is generated as a result of elastic recoil due to wall tension (T) and intrapleural pressure (Ppl). The alveolar pressure will drop along the airways during expiration, whereas intrapleural pressure will remain the same. Therefore, there will be a point (EPP) where intrapleural pressure surrounding the airway is greater than the alveolar pressure. On that point, the airway will tend to collapse. (Alexiou, 2015)

A diver exposed at high ambient pressures is prone to experience effort independent flow during exhalation. This is due to an earlier onset of turbulent (density dependent) gas flow into the airways and the faster drop of the airway pressure where turbulent flow exists. Therefore, as the gas density increases, the EPP will be reached more quickly and effort independent flow will occurs (3, 4). Wood and Bryan (9) demonstrated that effort independent exhalation was almost encountered during normal tidal breathing when breathing air at 10 ATA. In simple and practical terms, if divers breathing air at 10 ATA tried to do much more than normal quiet breathing, they would have difficulty increasing their ventilation no matter how hard they tried (4).

Inspiration

Families of pressure-flow curves at different lung volumes were constructed for inspiration of gases at high densities varying from 1.29-10.1 g/l, corresponding to 1, 2, 4, 6 and 7.8 ATA breathing air. They showed that inspiratory flow is reduced as gas density increased and remained effort dependent. However, a degree of effort independent inspiration was observed in curves at below 40% VC especially at 7.8 ATA. This was attributed to the larynx acting as fixed dimensional flow restrictor especially at high ambient pressures (2). Vorosmarti et al. (8) noted that resistance during inspiration is typically lower than it is during expiration (Figure 2). Other studies (1) observed a significant reduction in gas flows during inspiration during maximal exercise at a gas density of 7.74 g/l. Based on them, this was caused because of the reduction of the inspiratory driving force at higher lung volumes.

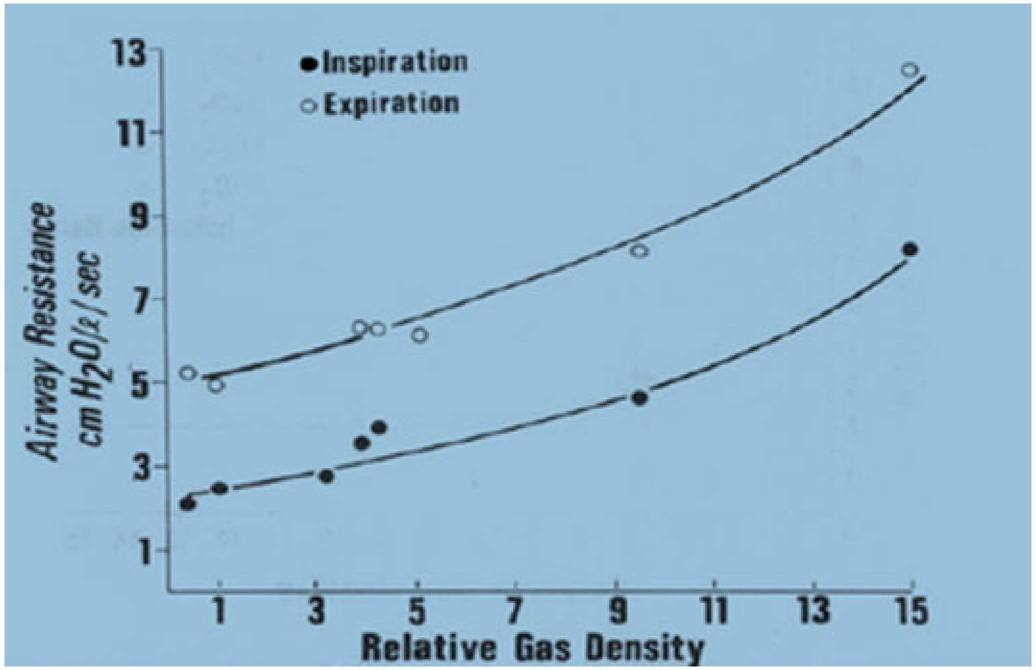


Figure 2. Mean values of inspiratory and expiratory airway resistance as a function of gas density during voluntary hyperventilation. (Data from Vorosmarti8)

Epilogue

The amount of physical work a diver can perform at increased barometric pressure depends on his/her ventilatory capability. The effects of increased breathing gas density have been studied extensively for many decades. The flow rates, both while inspiration and expiration, tend to decrease as gas density increases. The expiratory flows become effort independent and inspiratory flows and lung volumes are limited by inspiratory muscle strength and endurance. As the depth increases and exercise becomes more strenuous, the ventilatory response of the diver decreases. Dr. Mitchell notes (4), "*Increased gas density will increase the work associated with both inhalation and exhalation. However, arguably the most dramatic and limiting effects may relate to a phenomenon seen during expiration called effort independent exhalation*".

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Lab Rats

By Flavio Fanelli

On June 20, 2015 a small group of divers met at the Y40 facility (the deepest pool in the world, quite impressive; 40 meters in the deepest part) in Montegrotto Terme, Italy. They are part of a dive research.

Prof. Gerardo Bosco, head of the Hyperbaric Department of the University of Padova, is the leading researcher on decompression-induced bubble formation and platelet activation. He is an advocate of hyperbaric oxygen therapy. In 2010, he released a study concluding that prebreathing NBO and HBO significantly alleviated decompression-induced platelet activation. Data from this study showed that prebreathing oxygen, more effective with HBO than NBO, decreases air bubbles and platelet activation and, therefore, may be beneficial in reducing the development of decompression sickness. Our test was part of the ongoing research on this topic. At least that's what I understood!

The test was two 20 minute dives at 15 meter depth, pedaling on spinning-like bikes. Cadence was about 50 per minute. As soon as we completed the 20 minutes, we ascended at about 1m/min with the help of a rope, as we were not wearing fins. The surface interval between the dives was 2 hours, with no exercises and a light meal in between. Previous and post every dive, blood and urine samples were taken, along with the blood pressure readings. After the second dive, DAN scanned the divers for microbubbles. Water temp was around 30°C, meaning no insulation was needed, it was very comfortable down there.

Vittorio was the dive leader. Two divers (Marco and Flavio) were on JJ-CCR rebreather. Two other divers (Dan and Maurizio) were on Lungfish rebreather. Aldo was the videographer and safety diver (on Lungfish). The ppO2 set point was 1.4. The test was fun! I mean, we had a great day and hopefully this will help researchers to go ahead with new deco developments.

From left to right: Marco Care, prof. Gerardo Bosco, Vittorio Bianchini, Flavio Fanelli, Aldo Ferrucci, Maurizio Borella and Dan Reynolds


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Looking Back on Innovating Decompression Protocols

By Bret Gilliam

The era of dive tables as the only method of calculating dive plans is one that is largely forgotten by many in the "modern" world of electronic diving computers and the plethora of algorithms and deco models that now are available.

I have long been an advocate for embracing innovation and new technologies, including being a prominent spokesperson for transitioning to dive computers, nitrox, mixed gases for deep diving, and rebreathers beginning in the late 1980s. The controversy associated with trying to bring the arch-conservative segment of the diving industry into the "real world" back then was shrill, antagonistic, and grossly misinformed for the most part. But I, along with other informed experienced divers like Tom Mount, Sheck Exley, Rob Palmer, Jim Bowden, Randy Borher, Dr. Bill Hamilton, Dr. Morgan Wells, and Dick Rutkowski, battled for an even playing field to get the facts out for the diving public to objectively evaluate and finally all the practices became mainstream to the still befuddled dimwitted "experts" who so stupidly opposed any advances… including wet suits that weren't black!

Dick Rutkowski was the first target. When he retired as NOAA's Deputy Director of Diving, he decided to expand his cutting edge training programs in recompression treatments and chamber operations to include the first formalized nitrox training in sport diving. But you would have thought that he suddenly came out in favor of child molestation in the response fired at him from twits like DAN's then-Executive Director Peter Bennett who condemned him as an irresponsible reprobate who should be thrown out of the diving industry. *Skindiver* magazine's editor Bill Gleason ran a sensational editorial branding nitrox as the "Devil's Gas". PADI and SSI also denounced such practice.

Interestingly, both Bennett and Gleason ended up being ousted and fired in disgrace and all training agencies adopted nitrox and technical diving practice. But they and others, who were largely ignorant of the actual facts of these innovations and had their own personal agendas (including selling advertising), attacked those of us who spoke out with an unequaled vitriol that was simultaneously unfounded, unfair, and displayed their intellectual flaws in a public arena. Their bad behavior eventually made heroes out of us that dared to challenge their unbridled crap.

I have no apologies for my blunt criticism of their ilk. They tried to stifle safer diving practices, often with deliberately false information. I hope we don't see another era arise where a handful of self-appointed knucklehead critics try to screw things up again. Rutkowski always said, "Science overcomes bullshit." The man had the gift of clarity.

But my first involvement with deviations from standard practices was back in January of 1971 working on an experimental Navy deep diving project where we were assigned to film fast attack submarines in the open ocean at depths that eventually took us past 500 feet. At the time, all Navy diving was done on dive tables and there were very few choices.

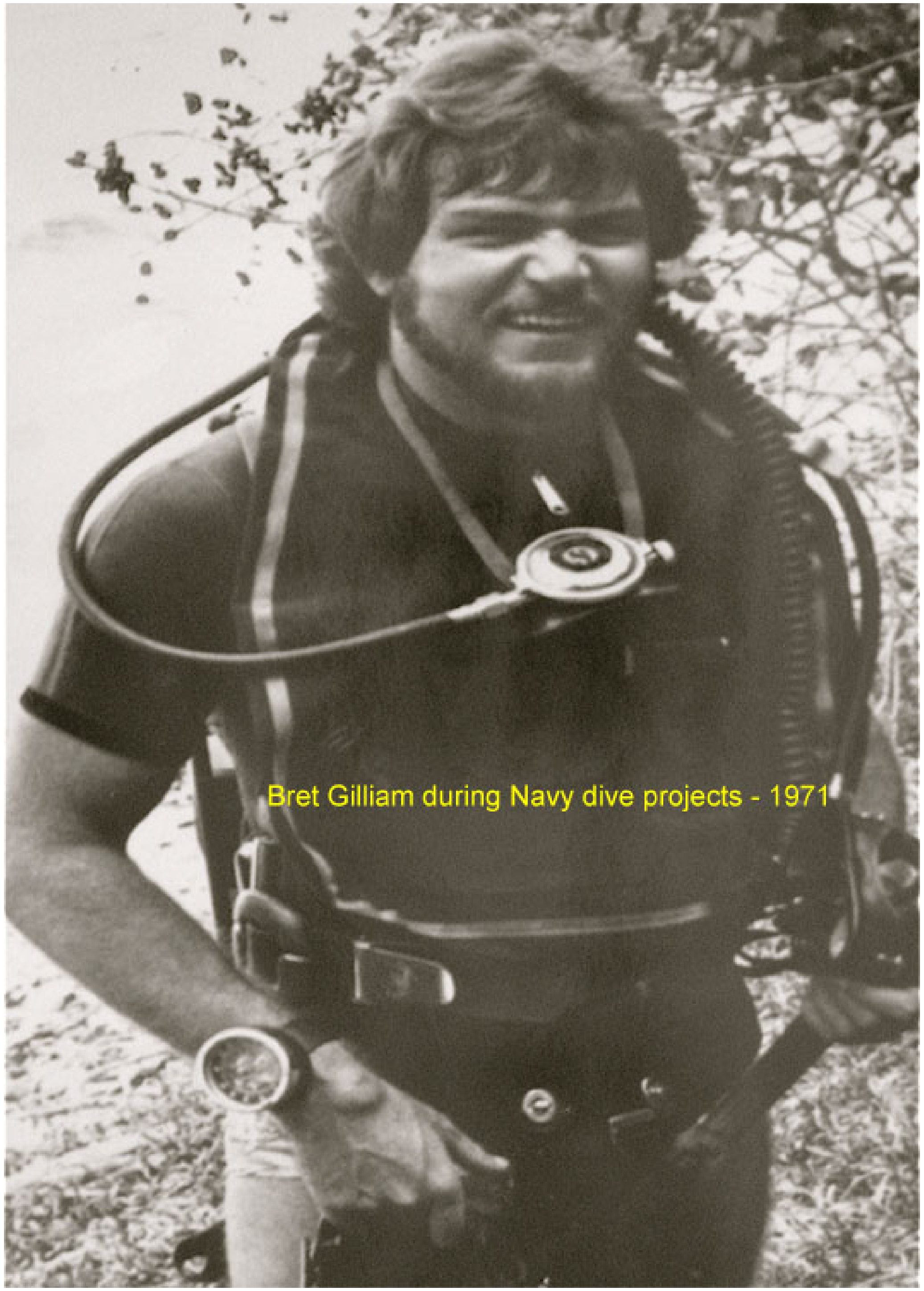
We had "standard" single dive exposure, "repetitive" multi-dive exposure, "exceptional" exposure, and "heliox" that employed helium with oxygen to manage both narcosis and O2 toxicity issues. Of course, there were also tables to default to in the event of omitted decompression due to contingencies. But it was a short menu.

For the most part, these tables served us pretty well. One thing that is interesting to note is that the standard maximum oxygen partial pressure then was a PO2 of 2.0ATA. This allowed air diving to 300 feet. Later the PO2 limits were reduced to 1.6ATA but that was derived from NOAA protocols that determined that some of the population could not tolerate higher PO2s.

In military diving when I came into the project, the governing protocols tended to be determined by the priority of the project as this was during the height of the Cold War era and making fast attack submarines as undetectable as possible was right at the top of the list. So we were encouraged to innovate as necessary to get the job done. In retrospect, it's also worth noting that our dive team was probably considered to be "expendable" in the pecking order of achieving the outcome and we were very much aware of that in short order.

Most Navy divers were tethered and on surface supply breathing gas then except for shallow scuba work and two ATA rebreather projects. We were some of the first teams that would work untethered, on self-contained multiple cylinder equipment packages and without the benefits of removal from the ocean for surface decompression. There is much to be learned from a variety of the departures from standard practice and some of the internal controversies that ensued, but the "bottom line" was the priority of the mission to get us below the deep scattering layer of ocean thermoclines (typically first encountered in the Caribbean below 500 fsw) and get the film work done for evaluation that would drive changes in nuclear submarine design to make them quieter and undetectable to the Soviets.

I was assigned to a team working in the Virgin Islands Trench, over 10,000 foot depths, while other teams were doing similar work off Andros Island in the Bahamas. Those teams included such pioneers as Jordan Klein who was also known for his Hollywood movie work on such films as "Thunderball" that featured Sean Connery's secret agent James Bond in diving adventures.


Bret Gilliam during Navy dive projects - 1971

When we learned that we would be deployed from surface vessels and would conduct our dives and subsequent long decompressions in the open ocean this initially did not raise any particular warning flags to our team. However, once we began operations we encountered a completely unexpected hazard that was off our "radar". Everyone is probably aware of the prolific population of oceanic white tip sharks, a pelagic species known for their aggressive behavior. What we didn't know then was that their aggressiveness was amplified by low frequency sound projections we introduced into the ocean caused by both the instruments used to calibrate various sonar devices and by the subs themselves with their own systems.

It wasn't until many years later that the relation of low frequency sound, and other stimuli such as the noise made by sinking ships as the hulls and compartments collapsed and aircraft that crashed into the ocean, tended to drive the sharks into far more excessive threats and virtually ended any ability to thwart their aggressive attack behavior. At times, we would enter the water for routine dive system drills and encounter 10-15 oceanics and have virtually no problems with them other than curious close approaches that could be dealt with by a bang on the snout or similar actions. However, once low frequency sound and other stimuliwere introduced, both their numbers and aggression tended to go off the scale.

Instead of a few sharks that generally behaved, we would now be faced with scores that could escalate into hundreds at a time. And all seemed hell-bent on biting anything they encountered. They bit the ship's props, the prop shafts, equipment that was lowered into the water, cables that were deployed, and just about anything that entered their ocean universe. From our rather selfish perspective, we were not particularly concerned about rushes to bite the boarding ladders. But we did care about their tendencies to want to bite us… fins, tanks, camera housings, and most importantly: body parts.

There were times when it was necessary for the deck crews to hang over the working dive decks on the vessel's sterns to push away the sharks with boat hooks just to make a "hole" in the ocean that we could jump into. It was not for the faint of heart. Once our descents were initiated, we found that the sharks would lose interest in the divers as we passed about 80-foot depths and return to abuse the vessel and its equipment. But when we came back up from deep exposures, we entered long decompression cycles that forced us into a constant war of evasive protective behavior that was more than a bit nuts.

So we began to experiment with anything that would get us out of the water faster without compromising our inherent risk and tolerance of inert breathing gas uptake that dictated our long decompression hangs to out-gas. The first thing we did was initiate contact with some civilian physiologists in Canada at a company called BioLab that were fascinated to have human subjects to beta-test some of their theories about the then largely unproven methods of changing decompression by innovations in usage of both pure oxygen and what they called "oxy-air". This gas would later become known as "nitrox" or "enriched air". Hell, they could have called it "magical mystery" gas as far as we were concerned if it got us out of the water faster and away from the munching predator sharks that never ceased trying to eat our equipment… and us… during the long hangs.

The first deviation from Navy protocol was to begin switching to oxygen as deep as 60 feet… a PO2 of 2.8 ATA. That exceeded the allowable maximum oxygen exposure for working divers but was exactly the same as what divers breathed if removed to the safety and comfort of a decompression chamber. We adopted a practice of as little physical exertion as possible to minimize carbon dioxide

Bret Gilliam on Navy ship during dive operations - 1971 production (CO_2) that was known to be a triggering influence for O_2 toxicity and seizures. Our methods worked and that cut our deco hangs by as much as 50%.

The next innovation was to switch to "oxy-air" or nitrox mixes in deeper depths while adjusting the PO_2 levels to our tolerance. This even more dramatically cut our deco times.

Also remember that this was January 1971, over 44 years ago. There were no cell phones, no Sat-Phones, barely any land phones on St. Croix and calling Toronto in Canada was absurdly expensive. There was no email or fax to quickly communicate the results of our daily dives and deco results so sometimes our dialogue was accomplished by "snail mail" and it could take weeks for our feedback and BioLab's suggestions to be exchanged.

On occasions when we could get access to phones, we'd call in following a new beta-test of a suggested aggressive deco schedule and when the phone would be answered on the other end we'd detect obvious surprise that we had somehow managed to survive. But that quickly moved on to a conversation about the next suggested evolution. It was an interesting process but ultimately effective. It laid the foundational groundwork for major changes in diving.

But most importantly to our dive teams, it got us out of the water faster and away from our antagonist shark partners that we shared the ocean with.

Later, NOAA picked up where we left off and when the first generation of computers allowed algorithmic experimentation on deco models using early electronic "real time" diving computers, the revolution really took off. Much credit is owed to the late Dr. Bill Hamilton in the U.S. and the late Dr. Albert Buhlmann in Switzerland for their pioneering work in underwater physiology and deco modeling. I was pleased and proud to have known both men as friends and professional colleagues. Their work forever changed how we dive today.

Looking back on how we arrived where diving technology is today is revealing. For our dive teams nearly 45 years ago, it was prompted by adaptions aimed at self-survival and the methods worked. That's a "bottom line" that increased our "bottom time" at depth while dramatically reducing our "hang time".

I'm sure the oceanic white tip sharks missed us. But we were not missing our prolonged time with them…

Bret Gilliam was the founder of TDI and the other agencies in the ITI conglomerate. He began diving in 1958 and his professional diving career in 1971 with the Navy project. Since then he has been involved in every segment of the diving industry including retail and resorts, military and commercial operations, filmmaking, publishing, manufacturing, diving ship and liveaboard design and operations, as well as legal consulting in litigation procedures. Along the way he has logged over 18,000 dives. He was inducted into Diving's Hall of Fame in 2012 by the AUAS as the Recipient of their NOGI Award for Diving Sports/Education. After nearly 25 years of living in the Caribbean and equatorial regions of the world, he now makes his home in Maine and travels internationally on diving projects.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