



Tech Diving Mag

Research - Development - Exploration

New Kids on the Block!
Waiting for the Light
Human Factors & Decision
Making in Diving
Deep Survival
Hyperbaric Oxygen Therapy

Issue 24 – September 2016

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Front cover image © Markus Rummel.

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A quick reminder: Best Publishing Co has updated their web site and now all three forms (print book, eBook and package set) of *Deep Into Deco: The Diver's Decompression Textbook* could be reached at a single web page. That's why some links in back issues might be broken. The print book is also available through Amazon.

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The contributors for this issue have brought together some unique, first-hand experiences. Our generous contributors are world renowned industry professional Bret Gilliam, technical diving instructor Albrecht Salm (PhD), instructor trainer and cave explorer Bruce Konefe and shipwreck researcher Erik Petkovic. Take a look at their brief bio at www.techdivingmag.com/contributors.html.

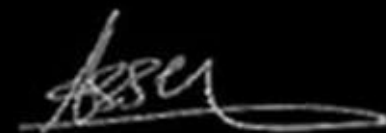
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Tech Diving Mag is based on article contribution, so you're always welcome to volunteer a piece and/or some photos. The guidelines could be found at www.techdivingmag.com/guidelines.html.

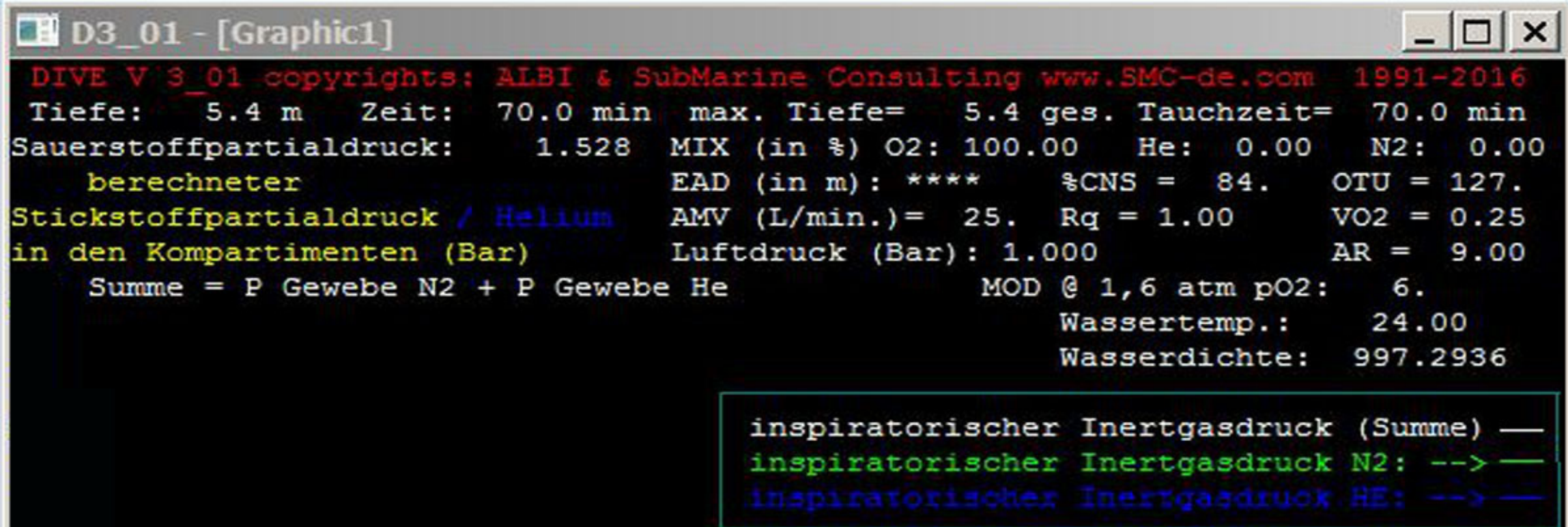
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This is very much your magazine, so if you want to share some views, just drop a line to asser@techdivingmag.com. And please subscribe to the newsletter at www.techdivingmag.com/communicate.html to be notified when new issues are available for download.

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Asser Salama
Editor, Tech Diving Mag



New Kids on the Block!

*A couple of very simple technical benchmarks
for an advanced mix gas dive computer*

By Albrecht Salm



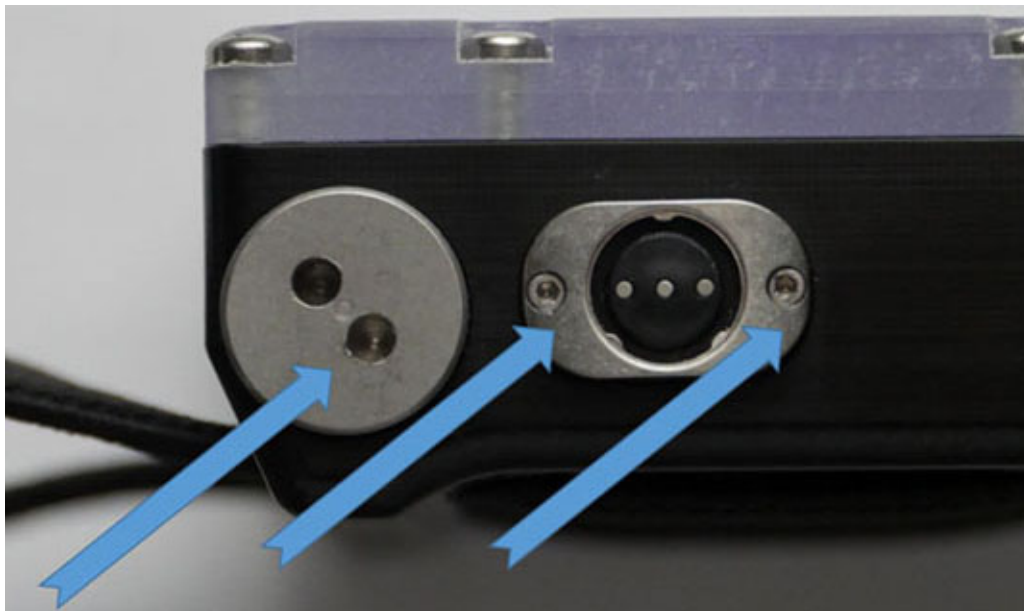
There is a bunch of new mix gas and wrist-watch type dive computers available; please have a look at: <http://www.ratio-computers.com/>

The real company behind this system is a well known Italian company: <http://www.divesystem.com/>

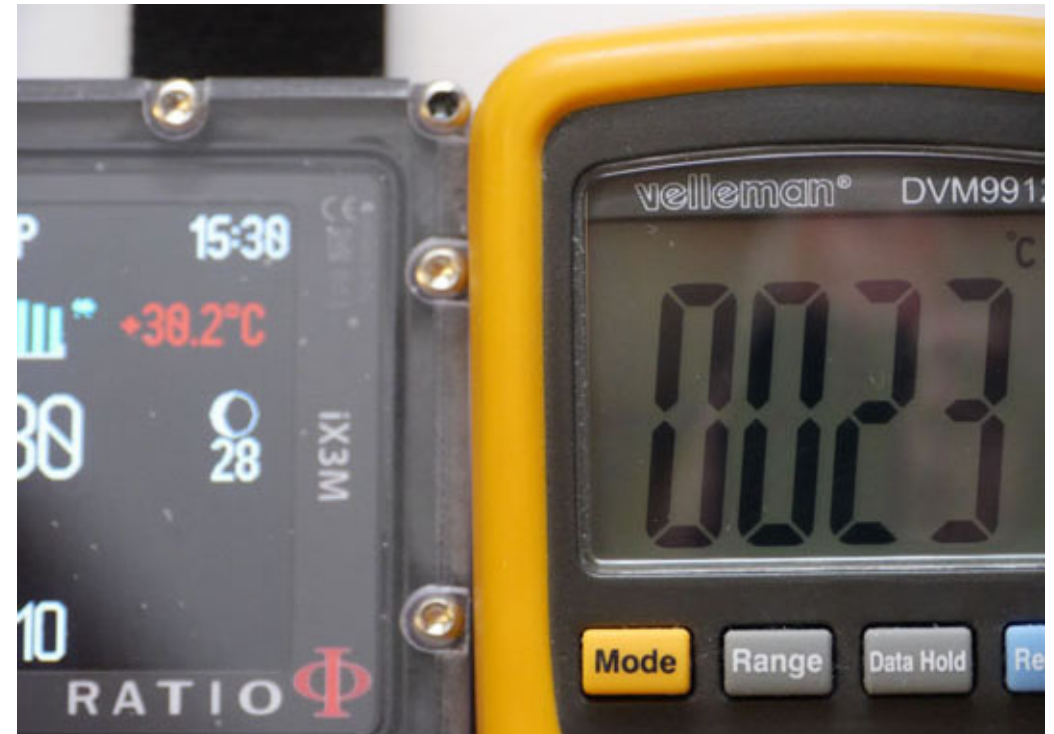
Thus we took one of these computers, the RATIO iX3M DEEP and played around with it a little bit in our laboratory. To be honest, our main focus (<http://www.smc-de.com/>) is a little bit different, pressure-wise, but we always have a lot of fun watching these little black boxes (or pieces of desktop deco-software) going nuts. Therefore here's the rationale for our benchmarks:

- ➔ helping manufacturers to make things better
- ➔ helping customers to reach an in-depth „informed decision“ more quickly

First we checked the hardware. You see the left side of the box with the USB plug (center):



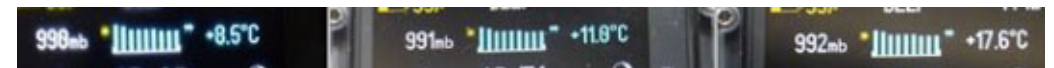
This seems not to be a real super-precision drilled piece. So we looked at the environmental parameters and realized a somewhat different approach to these: the temperature measured with a calibrated PT 100 showed up differently, 30.2 vs. 23.00:



And, as well the ambient pressure, 988 vs. 978:



And, after cooling down the whole system, the temperature compensation for the pressure reading did not meet our expectations:

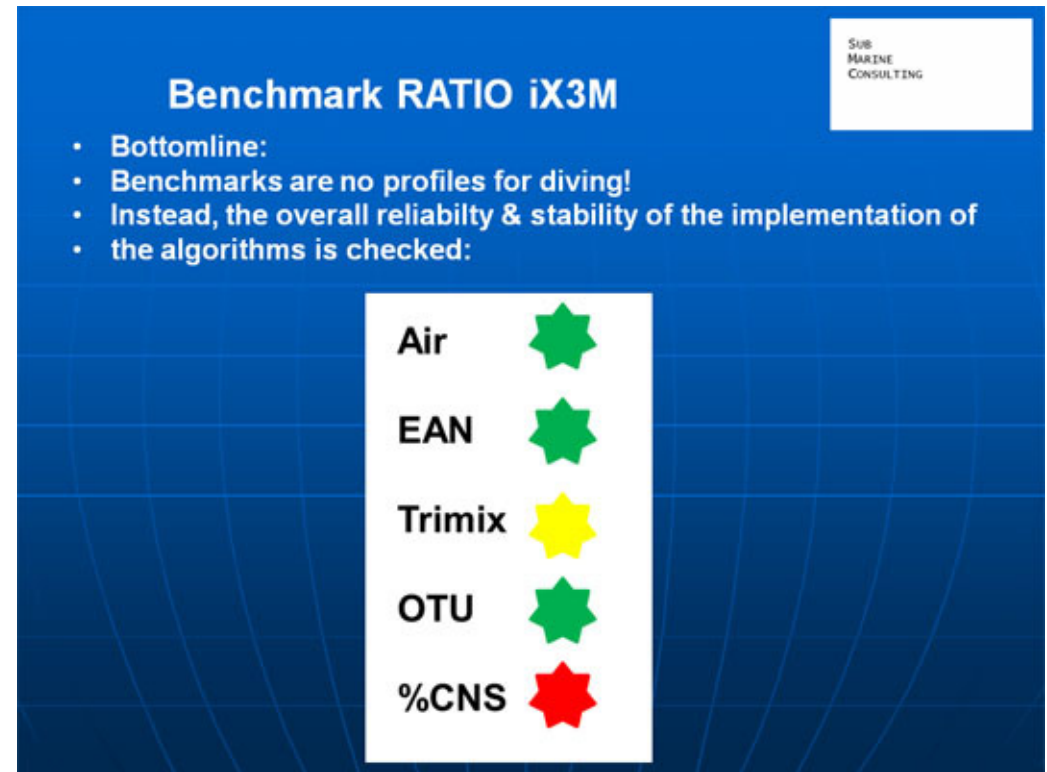


The „real“ values, assessed with calibrated laboratory equipment being: 993,0 mbar @ 22,0° C An average dive computer gets the depth reading via a pressure sensor. These usually work with the piezo effect on a little piece of silicon, bonded on one side into a vacuum chamber, thus able to measure the absolute pressure. Mechanical stress or strain on the silicon chip changes its electrical potential thus a voltage could be measured. A change in temperature brings for nearly all physical objects a change in volume. This is why a piezo sensor has to be „temperature drift compensated“ (among some other things, like drift due to its age, due to drift in the supply voltage and even more). An average piezo chip with media contact, that is for e.g. hot or cold water, signals on its own bus system (called „I²C“) or on a serial line first the bits for the measured voltage resp. the pressure and with the second data word comes the temperature. So it is up to the application software from the dive computer making good use of these values: the pressure has to be modified according to the temperature via a little polynom. If you are interested in the details of these operations, check the specifications of the sensors, as an example take ref [1].

After that, we checked a couple of theoretical diving schedules with the integrated „Dive Planner“ and found an agreeable agreement with a lot of other tables:

You could check these benchmarks at:

http://www.divetable.info/skripte/Benchmark_iX3M.pdf



The results being: for Air & EAN it looks quite OK, hence the green traffic light. The Trimix benchmarks are open to conjecture (yellow traffic light). As well part of the Ox-Tox figures, the %CNS values (red traffic light) were not according to the historically accepted parameters. So we had to make an in-depth test in our pool because this build-in „Dive Planner“ starts at 18 m depth and stops at a maximum dive-time of 60 min:

Ox-Tox Check (%ZNS, %CNS)

SUB
MARINE
CONSULTING

Diving Tower Esslingen / DE @ www.tauchturm.com,
Saturday, 06.08.2016

Dive Computer Test @ pure oxygen
from left to right:

NHeO3, RATIO iX3M, TEC 2G, Aladin [2]

START:



After ca. 70 minutes in the pool:

Ox-Tox Check (%ZNS, %CNS)

SUB
MARINE
CONSULTING

from left to right: NHeO3, RATIO iX3M, TEC 2G, Aladin [2]
after ca. 70 min, the END:

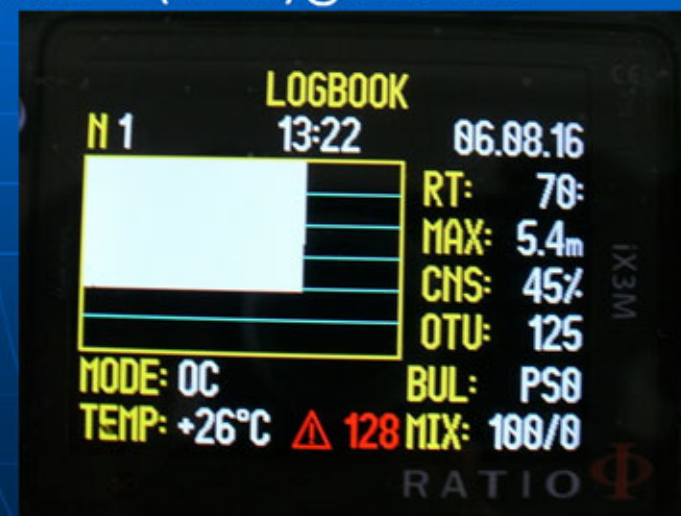


We reached at the following results:

Ox-Tox Check (%ZNS, %CNS)

SUB
MARINE
CONSULTING

fO₂: 1.00, dive time: 70 min, Air Pressure: ca. 998 +/- 2 mBar
geometrical depth: 5,4 (5,3 – 5,6),
Temp.: ca. 25 ° C (24 – 27) @ fresh water



And everything together with all the other computers in one table:

Ox-Tox Check (%ZNS, %CNS)

SUB
MARINE
CONSULTING

fO₂: 1.00, dive time: 70 min, Air Pressure: ca. 998 +/- 2 mBar
geometrical depth: 5,4 (5,3 – 5,6);
Temp.: ca. 25 ° C (24 – 27) @ fresh water; results:

Dive Computer	Depth [m]	%CNS (%ZNS)	OTU	NOAA Limits [100%]
NHeO3	5,3	62 (*)	129	
IX3M	5,4	45	125	
TEC 2 G	5,4	69	n. a.	
Aladin [2]	5,4 – 5,6	71	n. a.	
DIVE 3_01	5,3 (*)	58	126	120 min @ PO ₂ 1,6 atm 70 / 120 = 0,58
DIVE 3_01	5,4 (*)	84	127	
DIVE 3_01	5,6 (*)	84	129	83 min @ PO ₂ 1,65 atm 70 / 83 = 0,84

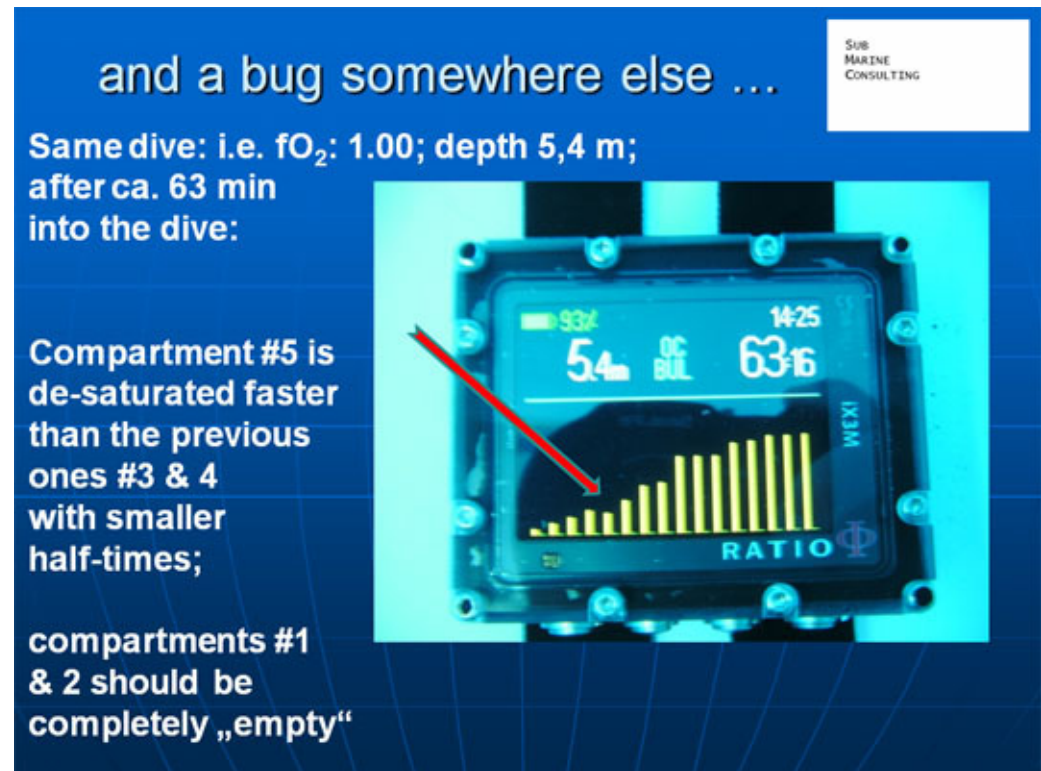
(*) compensated for Water Temperature & Air Pressure
(*) EAN 99: i.e.: fO₂ = 0,99

The official benchmark here is the NOAA value (5.th column), the table for the 100 % CNS dose [2]; Table 4.5, p. 4-28. We checked these values with the 64-Bit Version of DIVE (more info about DIVE at: http://www.divetable.info/DIVE_V3/index.htm) because there you have the possibility to compensate not only for the air pressure prior to the dive but as well for fresh/sea water and the density change due to water-temperature. (And, as well, we know for sure, that this little programme is aware of such subtleties that all the official Ox-Tox values are in atm and not in Bar).

The corresponding algorithm for the OTU, the Oxygen Tolerance Unit was developed by Hamilton et al. and published as the „REPEX“ papers [3]. You can find the appropriate table as well also in [2], Table 4.6, p. 4-29. The OTU seems to be quite ok, but is not really relevant to recreational TEC diving. For diving from a habitat or saturation diving it would be a completely different story ...

En passant, we found a little inconvenience: breathing 100 % O₂, the compartments loaded with N₂ should de-saturate slowly, slowly. That is, after more than 60 min into the dive, all compartments with a half-time less than 60/6 = 10 min should be „empty“ of N₂, completely. But this seemed not to be the case. As well the half-time of compartment #5 seems to be out of range: it should not de-saturated faster than the compartments on its left side.

If this is a problem of the implementation using $fO_2 = 1.0$, the half-times of the 16 compartments or just something with the view-port (the matching of real physical variables with the computer hardware, here with the display characteristics of the dive computer screen) we do presently not know.



One of the important features and a unique selling point in comparison to a lot of other dive loggers is the accompanying PC software (DiveLogger 3.2.3). It features the export of the logged dive profiles as DAN DL7 level 3 file (file extension: *.zxl).



Presently (09/2016) this does not work correctly with the topical DiveLogger version (3.2.3) or the topical version of the dive computer software (APOS 3.3.0):



As well you have to select and export each & every dive, one by one.

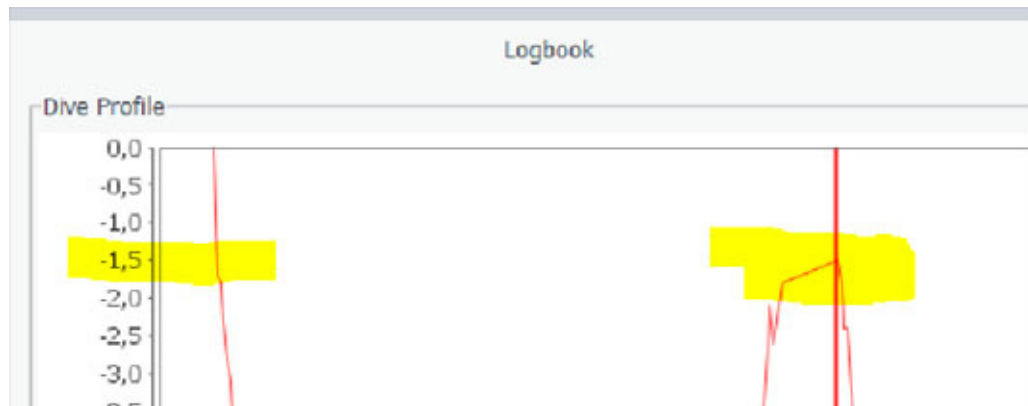
There is still another „feature“, or, IT-Security wise, we would call this a blunder of major proportions: you have to run the DiveLogger as Administrator.

Bottom Line: up to now no real big disappointments, a very nice, clear display and a very intuitive handling with the 4 knobs, even with thick gloves. For details pls. cf. the manuals: (<http://www.ratio-computers.com/support/manual.htm>).

Which, btw, are very good! There is as well a bunch of interesting „Apps“: that is little applications for the dive computer for compass and GPS, Stop Watch, Mix Analyzer, Moon Phase, Magnetometer, Lux Meter and the like.

Nevertheless there is always potential to grow:

- ➔ the energy consumption should certainly be reduced. Presently a 1-hour dive takes 5 to ca. 7% of the battery capacity. That is: the stamina in the manual is a little bit over-optimistic.
- ➔ this yields as well for the depth reading precision. A more realistic value would be appreciated. And, as well (pls. see below a screen shot from the DiveLogger): the indicated time-frame has never ever been spent on – 1.5 or so, but, instead, at the surface, i.e. 0.0!



➔ and, finally, as well the speed of the serial communication, i.e. the time it needs to transfer a dive from the RATIO to a PC, could be improved.

What we want to scrutinize, still, is the somewhat cryptic, because up to now not publicly documented, ASM, the „Adaptive Sigmoidal Model“ (*) for repetitive diving. We will check that in our recompression chamber facility with the following repetitive procedure: 50m, 10 min, Surface Interval(SI) 30 min, 35 m, 10 min.

We do that from time to time with various hardware (pls. cf. for e.g. <http://www.divetable.info/skripte/2.pdf>)

This schedule is, depending on the algorithm you use, something like 4 to 6 times more prone to DCS than a regular recreational scuba dive due to the very short SI: thus our tenders will get pure oxygen via the BIBS (Build-In-Breathing-System) starting from 15 or 12 m. This short SI is something we would not recommend.

If you are interested in the details on how to calculate this and the so-called P(DCS), the statistical probability on contracting a decompression sickness, pls. cf. [4], a past issue of this magazine and

all the references therein.

(*) Only in the manuals of the pre-decessor hardware, the ORCA and FURYO dive computers from DiveSystems there are a couple of even more cryptic remarks on this.

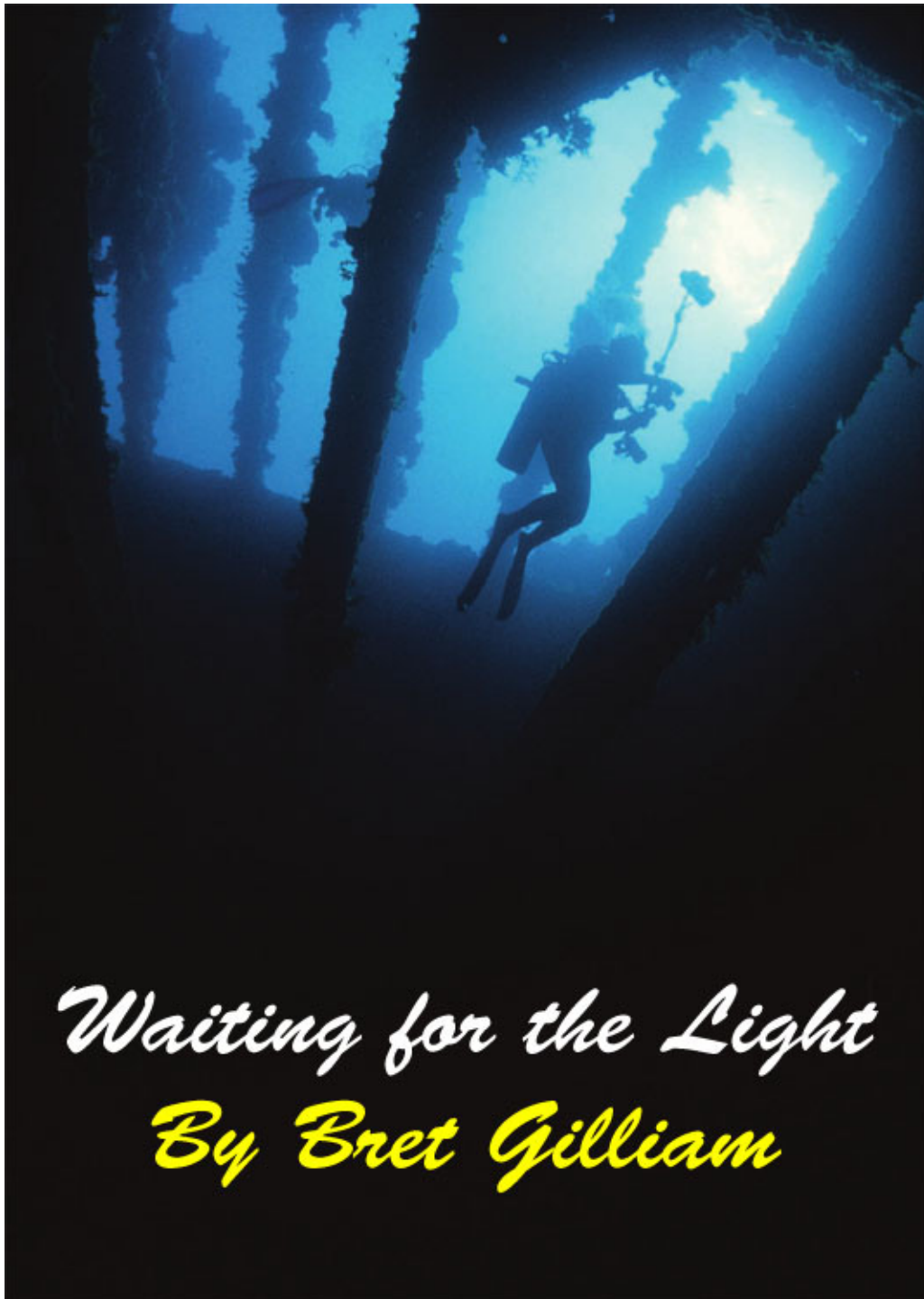
References

[1] www.meas-spec.com, you may look for eg. for: MS5541-30C.

[2] Dinsmore David A., Bozanic Jeffrey E. (2013) NOAA Diving Manual, Diving for Science and Technology, Fifth Edition, Best Publishing Company, Florida, ISBN 9781930536630
More infos there: <http://www.divetable.info/books/149.pdf>

[3] Hamilton, R.W., Kenyon, D.J., Peterson, R. E., Butler, G.J., Beers, D.M.(1988 May) Repex: Development of repetitive excursions, surfacing techniques, and oxygen procedures for habitat diving, NURP Technical Report 88-1A, Rockwell M.D., U.S. DoD)

[4] Tech Diving Mag, Issue 14 / 2014: Yet Another Benchmark, Part III: on the probability of getting decompression sickness (P(DCS)): <http://www.techdivingmag.com/download014.asp>



Learning life's lessons the hard way looms large in my legend. (Along with an avowed affinity for alliteration...) But one thing's for sure, I rarely make the same mistake twice. Well, there was that night in St. Barts back in 1977 when Jimmy Buffett told me that three Quaaludes and a couple of Heinekens would erase my hangover in a New York minute, but that's another story.

As has often been noted in my various writings over the years, there is much to be learned from mistakes... as long as you survive them. And sometimes little things have a way of adding up, much like your long-lost closest friends when you hit the lottery. In diving, a seemingly inconsequential series of slip-ups can lead to a far larger problem in the aggregate.

Maturity gained from various misadventures, both above and underwater, have a remarkable tendency to sober you up as you slip not-so-gracefully into middle age. Hopefully, we all can retain a bit of whimsy and a sense of humor lest we become, gasp, curmudgeonly in our dotage. About 25 years back on a trip to Truk to dive the wrecks, I had a brush with fate that I'd prefer to forget but perhaps is best shared. And the absurdity of it all is that I, of all people, knew better.

After a threesome of relatively inexperienced, but eager divers hurled themselves over the side of the dive boat with abandon, I was left to gear up in relative peace. Gathering my cameras, I slipped into the water and descended to the ship's main deck. However, the "Three Amigos" had innocently managed to stir up enough silt and grunge from the 50 year old hulk that photography around the superstructure and wheel house was out of the question.

My dive partner, Cathryn Castle, had already headed away from the dust bowl and was merrily firing away at soft coral formations that

adorned the bow gun. I hated to intrude on her scene and looked around for some subject matter to occupy myself. Sensing my chagrin at not being able to shoot the most dramatic area of the wreck, the local native guide gestured me to follow him.

We meandered along the deck until he found an old air vent from a hidden compartment. It wasn't even big enough to stick your head through, but he produced a light and directed its beam to a macabre pile of human skeletal remains that marked the entombment of the crew during that ferocious battle in February 1944. The eerie burial mound was just below the main deck level and appeared inaccessible through the few small access ports. I sighed in disappointment and should have known it just wasn't going to be my day.

But the guide had an ace in his sleeve. A jagged hole in the ship's side from the Allied bombing attack provided an artificial entrance to the bowels of the ship and directly into the "bone room". He gestured me to enter alone and swam off to intercept the novices now headed back in my direction. All right, I thought, this is more like it. Here's a major photo opportunity and I've even got the guide heading off the madding crowd for me.

I paused to consider my situation. I had entered the water planning to shoot photos on the main deck without any wreck penetration. I had neither a reel nor a light in my gear package. But my substantial professional camera gear was equipped with a high power wide angle strobe that could light a parking lot, albeit briefly. So I cautiously eased through the hull opening and assessed the interior that beckoned me. If I limited my exploration to a direct path from the bomb blast opening, I could stay within the ambient light range and should have no need for primary light or an exit line. Hey, no problem, right? Wrong.



Swimming carefully to avoid disturbing any silt on the room's floor, I fired my camera strobe twice to provide a guide path to the area and settled in without raising even a trace of sediment. I looked up and could see the tiny ray of light coming from the air vent above through to the main deck. I was only 53 feet deep according to my computer,

seven minutes into the dive, and had about 2500 psi left. This was perfect. Wrong again.

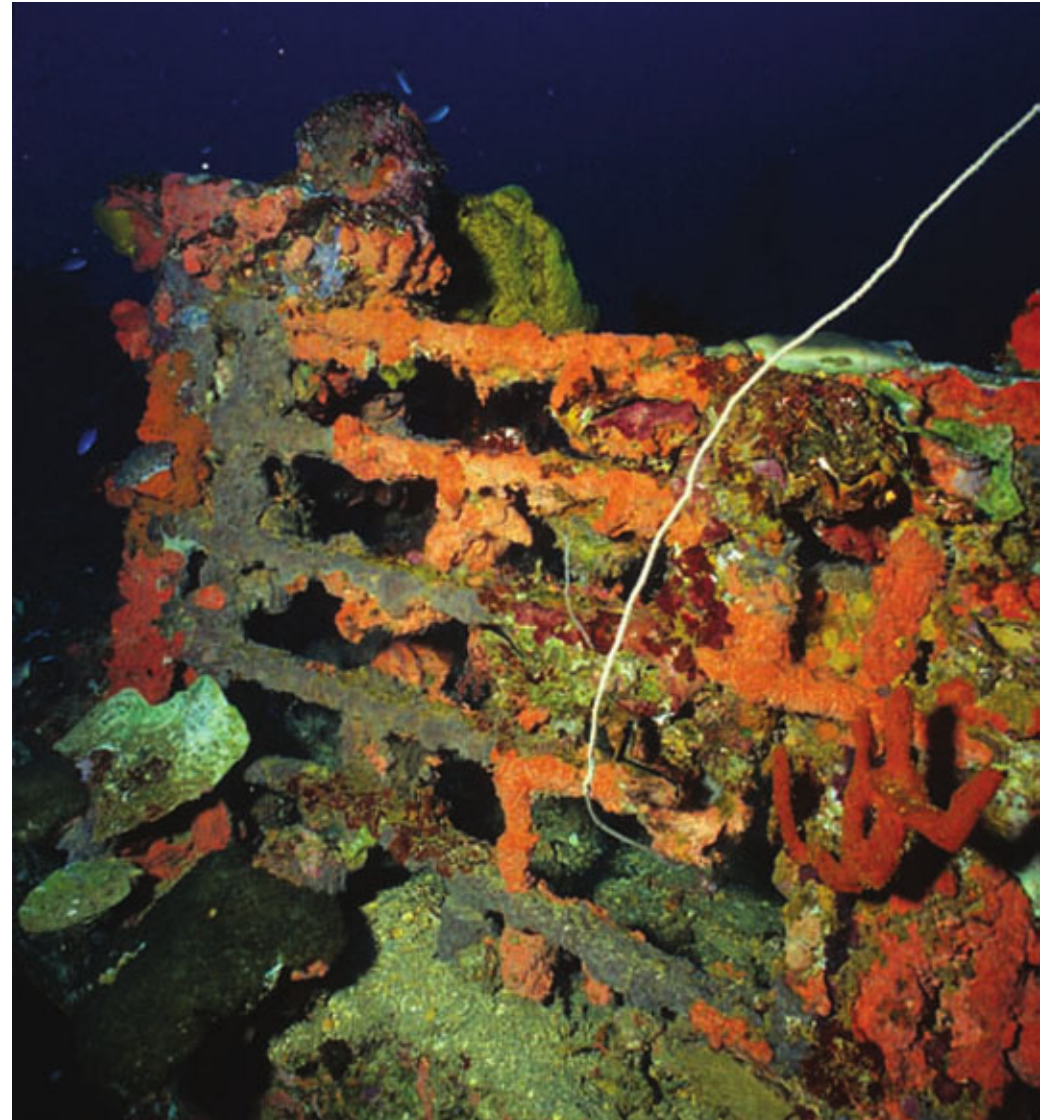
I took a lot of time composing the first couple of frames and the bright flash of the strobe illuminated the massive room for nearly a hundred feet. My back was to the entrance and the ambient light source that would provide my reference to get out. That was my near fatal mistake. A dozen or so more frames into my film, I suddenly was showered with a hailstorm of debris from the ceiling and a murky cloud that rose to obscure the skulls and bones that I was focused on. I could immediately hear the frenzied exhalations of several other divers who had entered the room behind me and were now thrashing around doing their utmost it seemed to replicate conditions you might find diving in a rain-filled muddy plow furrow in an Iowa cornfield.

They had been attracted by the flashing of my strobe and decided to check out what was so interesting. But their careless blundering quickly stirred things up so much that they did an about-face and inadvertently left me entombed with zero visibility. I quickly decided that allowing myself to get in this situation probably confirmed that my IQ was now roughly equivalent to pond scum.

Not wanting to make conditions any worse than they were, I slowly disengaged from my careful perch on a deck beam and turned for the exit... except the comforting glow of the only way out was gone. The wreck's interior was now completely obliterated by silt, sand, mud, ooze and other assortments of gunk accumulated after five decades on the sea floor. I quickly realized that I had no idea what direction to swim to get out. I was not, as they say, a happy camper.

The visibility was so bad that I couldn't even read my instruments where I was, so I gently ascended until I could feel the overhead of

the compartment. Here the visibility improved slightly. I could just read my gauges by flashing the strobe and squinting at the luminous faces of the computer and pressure gauge. Now I was at 42 feet with only about 2000 psi between me and a permanent spot next to the Japanese crew.



Turning a slow 360 afforded nothing but blinding backscatter from the dense silt. I was in deep yogurt and thoroughly pissed off at myself. A brief foray in four quadrants by feel yielded no avenue that I recognized for escape. Alone and nearly a hundred feet from the only way out, I would have to wait out the silt and let it settle.

Now came the hardest part: waiting. I felt around until I could find a small rupture in the overhead decking that I could try to channel my bubbles through so they didn't further exacerbate the crap raining down from the ceiling. If my air lasted long enough, the silt would settle and I could find my way out. I've nursed a few hundred pounds of air forever on decompression hangs before at 10 or 20 feet, but I was much deeper now and going absolutely nowhere until things cleared up.

I remembered that my computer read "7 minutes" dive time when I settled down next to the funeral pile. After what seemed like a period longer than my entire adolescence, I fired the strobe again and sneaked a peak at my console. It wasn't comforting, 51 minutes had gone by and I had 600 psi left. Fighting the panic urge to over-breathe or charge off blindly in hopes of stumbling on the way out, I pinned myself to the overhead deck plates and concentrated on making the air last as long as possible.

Far sooner than I hoped the regulator gave me the first slightly labored breath. Not good. Now my list of options was rapidly declining. Another inhalation was harder and I knew it was time to go... somewhere, anywhere but here. I dropped a few feet below the ceiling and let my eyes grope into the darkness. Nothing... blacker than a coal chute. Some internal navigation sense committed me to a direction I thought made sense.



Another breath came harder than the last and I knew I was down to seeds and stems. “Swim steady, but in control!” I muttered to myself. The next breath was like you’d expect from a garden hose to the surface from the bottom of a swimming pool. But then I could see the dim outline of ambient light in the distance. I kicked strongly to that reference point. The last gasp from the regulator came as I cleared the bomb opening in the hull’s side. Looking up, I could see the surface. I covered the thirty feet of distance across the deck to the anchor line in seconds, bolted up and wrenched the regulator on the safety tank at 20 feet out of the mouth of a diver who gaped at me like I was a Republican crashing the St. Patrick’s Day party at the Kennedy compound in Hyannisport on Cape Cod.

It must have taken fifteen minutes to regain control over my respiration and heartbeat. When I surfaced, no one seemed to have noticed my absence during most of the dive. One of the “Three Amigos” came over and sat beside me to rave about the wreck and his exploration. But he confided, “You really looked like you were stressing when you took that regulator away from that dude at the end. Man, you need to chill out a bit.”

He was right. I needed Buffett and his spiritual guidance right then more than anything in the world. I still had the taste of mortal fear in my mouth. And wouldn’t you know... it tasted like chicken.

POST SCRIPT: *The lesson to be learned comes down simply to carrying sufficient gear for all foreseeable contingencies. In wreck diving environments, that means a reel and a primary light. Yes, I would have been fine if I was the only diver on the wreck but I should have anticipated that less experienced divers might blunder into my area and upset the entire apple cart. As it was, I made apple sauce out of bad situation. Thinking through the situation after the room silted*

out provided the only real solution: patience. The silt did clear but it was a tense scenario. Waiting alone in the dark may work for bats but it’s not a place that most folks find hospitable. A hundred feet of line on a reel would have provided the guaranteed way out if I’d tied in from the hole in the hull before making my way in. It could have done double duty when I came out as well: I could have strangled the Three Amigos with it. Ah well, next time.



Your Decompression Planning Companion

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Human Factors & Decision Making in Diving
Freely Adapted from Aeronautical Decision Making
By Fabio Sardone

I am a diver since I was 14 and a pilot since I was 16. At time of writing I am 49 so I have gained a little bit of experience in a couple of fields in which people are faced with an unnatural environment for man and require good handling of stress, situational awareness and skills to successfully carry out activities.

I recently upgraded from Open Circuit hypoxic Trimix to a Closed Circuit Rebreather. I was already convinced that divers' training was too light on Human factors and Decision making, but, moving to CCR, the analysis of literature and accidents I carried out to try to understand the safety of operating a CCR, convinced me this area needed even more attention in CCR training than in Tech OC training. I have, in fact, learned (reference Rebreather Forum 3) that most of the accidents are due to human factors and especially due to a faulty decision making process. This strikes a stunning resemblance with aviation accidents where the human factors are the cause of the majority of preventable accidents. While in Aviation there is a lot of training and discussion about Decision Making in diving there is little to no training in Diving Decision Making (DDM). Here, I will attempt to mutate what I have learned in the aviation decision-making process to diving in an effort to improve rebreather diving safety.

GENERALITY

Divers who are involved in accidents generally know what went wrong (even more so those reading about the accident). Very often, the diver was aware of the possible hazards when the decision led to the wrong course of action was made. In the interest of expediency, cost savings, self-gratification, or other, often irrelevant factors, the incorrect course of action was chosen. This cycle of decisions began in the planning stage with decisions made on how much gas was necessary, how much bailout, the dive profile, the diving conditions, accepting the maintenance status of the equipment. This

cycle continues throughout the dive with decisions made on depth, penetration, adherence to plan and when to start ascent. Each dive is a sequence of choices with certain milestones in the sequence that require particular determination and discretion.

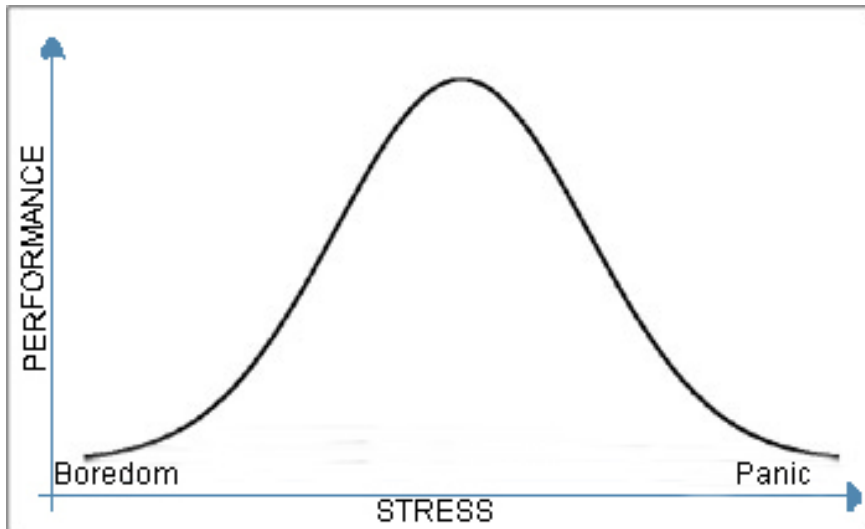
While the simple task of diving is mainly a physical one, learning to handle complex situation underwater, possibly, with failing equipment, lost deco gasses, or entrapment in overhead environment, requires experience and a solid thought process. DDM might help reduce the long and sometimes painful process of learning how to make good judgment decisions based upon experience alone. While it is true that simple errors of equipment operation are seldom serious, mistakes in judgment can be fatal, especially in CCR diving.

STRESS AND DIVING

What is stress? Stress is a term used to describe the body's nonspecific response to demands placed on it, whether these demands are pleasant or unpleasant in nature. The demands on a diver can range from entrapment on overhead environment to a lost wallet. Correctly executing required tasks (before and during dive) is diver's responsibility and it is necessary to survive the dive. Therefore, a healthy diver should perform at his/her optimum level and make decisions to the best of his/her ability. Numerous physical and psychological conditions in a diver's personal and professional life, as well as the nature of dive itself, can hamper this ability. Even though a diver might (while he/she should!) hold a medical '*fitness to dive*' certificate, the decision whether the diver is fit to dive is strictly his/hers.

HOW MUCH STRESS IS IN YOUR LIFE?

You may face major stressors such as a loss of income, serious illness, death of a family member, change in residence, or birth of a baby, plus a multitude of comparatively minor positive and negative stressors. These major and minor stressors have a cumulative effect that constitutes your total stress-adaption capability, which can vary from year to year. When we exceed this level, stress overload may lead to poor health or illness.



IS STRESS BAD?

Stress is a response to a set of circumstances that induces a change in a person's current physiological and/or psychological patterns of functioning forcing him to adapt to these changes. Stress is an inevitable and necessary part of life that adds motivation to life and heightens an individual's response to meet any challenge. In fact, performance of a task will generally improve with the onset of stress, but will peak and then begin to degrade rapidly as stress levels exceed an individual's adaptive abilities to handle the situation.

HANDLING STRESS IN DIVING

Accidents often occur when diving task requirements exceed a diver's capabilities. **A superior diver uses superior judgment to avoid situations, which might call for use of superior skills.** The difference between diver capabilities and task requirements is the margin of safety.

- a. Stress is insidious. Stress has a gradual and cumulative effect that develops slowly, so slowly that stress can be well established before becoming apparent. An individual may think that he/she is handling everything quite well, when in fact there are subtle signs that he/she is beyond his/her ability to respond appropriately.
- b. Stress is cumulative. A generalized stress reaction can develop as a result of accumulated stress. There is a limit to a diver's adaptive nature. This limit, the stress tolerance level, is based on a diver's ability to cope with the situation. If the number or intensity of the stressors becomes too great, the diver is susceptible to an environmental overload. At this point, a diver's performance begins to decline and judgment deteriorates.

PERSONAL CHECKLIST

One essential decision point before a dive is whether to go dive in the first place. Establishing a checklist of basic principles that cannot be compromised is one first and fundamental step in making this initial decision and avoiding then a dangerous path with decision leading to compromising safety later in the dive. This personal checklist should include the fundamental tenets applicable to every dive. Once a diver decides what not to do, the decision on what needs to be done becomes clearer. Consider the following "nevers" as factors that contribute significantly to unsafe dive:

a. **Dive while under the influence of alcohol or drugs, including applicable prescription drugs,** is a never. Several drinks of an alcoholic beverage will influence thought and reaction for approximately 24 hours, while heavy drinking will have lingering effects for up to 36 hours or longer with the addition of dehydration on decompression. Effects from the use of marijuana remain in the system for at least a week. The concept should be obvious that safety is measurably compromised within those time periods. The side effects and duration of all prescription drugs are well documented and available from a local pharmacist, the family physician, a drug addiction agency, or the Surgeon General. Most of the time recreational diving happens during time off, weekends, vacations where people like to relax and maybe drink a bit more, these activities do not match.

b. **Diving with a known medical deficiency.** This is never expedient, while it could be legal certainly could bring dire consequences in a non-permissive environment like underwater.

c. **Diving outside the certified equipment limits** (scrubber duration, sensor expiry dates, depth, gas density). Beyond that, you are in the wilderness and all discoveries could be unhappy experiences.

d. **Diving beyond diver certification/knowledge/experience.** Certification (properly done) means you have experienced the environment in a benign situation under supervision. Divers, before the whole certification paradigm had been put in place, used to build experience with other divers until they felt they had built the necessary experience. You do not know what you do not know. Instructors will provide the training for the diving you are certified to perform. Going beyond those limits or, in general the limits of your experience and knowledge, might bring you in unknown territory both in term of knowledge or motor skills/abilities, which in turn might have serious

consequences. Divers might not even understand what they are risking because they do not understand the demands a failure might put on them, do not know the proper response action to an issue or they are unknowingly lacking a piece of critical equipment. If no failures happen they might be able to enjoy great diving, but if they have to cope with a failure they might be beyond their capability to handle the required drill to safely return to surface unharmed. In this circumstances multiple dives with no mishap will reinforce the idea of being able to dive beyond recognized limits and inducing further increase in risk factors: time, depth or overhead penetration just to name a few. This is called normalization of deviance and it would require an article of its own. A very notorious case happened in summer 2015 of a diver (Doc Deep) that experienced several extreme dives (outside recognized limits) without consequences, which kept enforcing the idea that was ok to keep pushing until the fatal one (a world record attempt).

e. **Diving with less than the required minimum gas reserves** (bailout)/failing to plan gas consumption correctly/underestimate own SAC rate. Always have something suitable to breathe is key to survive a dive!

f. **Casual neglect of any applicable checklist** is never justified. A checklist may be larger or smaller; however, certain standards should be established for all dives so that the first decision point is whether or not to begin the dive. This can be the toughest decision. . Diving accident statistics show that divers should be conducting pre-dive checklists on themselves as well as their equipment (CCR).



The I'M SAFE checklist

1. **Illness.** Do I have any symptoms?
2. **Medication.** Have I been taking prescription or over-the-counter drugs?
3. **Stress.** Am I under psychological pressure from the job? Do I have money, health, or family problems?
4. **Alcohol.** Have I been drinking within 8 hours? Within 24 hours?
5. **Fatigue.** Am I tired and not adequately rested?
6. **Eating/Drinking.** Have I eaten and drank enough of the proper foods/water to keep adequately nourished/hydrated during the dive?

Diver impairment contributes to many more accidents than failures of equipment. This version of the "I'M SAFE" personal checklist (See box above) contains all of the most common categories of diver impairment and can easily be committed to memory.

THE DECIDE MODEL

A good tool to use in making good decisions is the Decide Model (see Box).

The Decide Model, comprised of a six step process, is intended to provide the diver with a logical way of approaching decision

making. The six elements of the Decide Model represent a continuous loop decision process which can be used to assist a diver in the decision making process when he/she is faced with a change in a situation that requires a judgment. This Decide Model is primarily focused on the intellectual component, but can have an impact on the motivational component of judgment as well. If an individual practices the Decide Model in all decision making, its use can become very natural and could result in better decisions being made under all types of situations.

The DECIDE model	DECIDE Model Example
1. Detect. The decision maker detects the fact that change has occurred.	1. Detect: I am using more gas than expected (this detection presupposes a plan and monitoring the discrepancy between this plan and the actual execution of the dive)
2. Estimate. The decision maker estimates the need to counter or react to the change.	2. Estimate: the excess gas I am using was in reserve in case I lost my first deco gas or for my buddy, therefore I need to act
3. Choose. The decision maker chooses a desirable outcome (in terms of success).	3. Choose options: I can go shallower on the wreck rather than visiting to lower parts or I need to end early my dive
4. Identify. The decision maker identifies actions that could successfully control the change.	4. Identify: Best course of action and signal decision to buddy
5. Do. The decision maker takes the necessary action.	5. Do: go shallower or abort the dive
6. Evaluate. The decision maker evaluates the effect(s) of his action countering the change.	6. Evaluate new gas consumption and repeat process



DIVERS' ATTITUDE

Let me repeat: Divers who are involved in accidents generally know what went wrong. Very often, the diver was aware of the possible hazards when he made the decision that led to the wrong course of action. Often in case of fatal accident the diving community recognizes the faulty decisions or the safety rules violation originating the accidents, nevertheless divers are committing the same mistakes over and over (diving sensors beyond dates, overusing scrubber, using non appropriate absorbing materials, wrongly assembling equipment by skipping checklists usage). The box illustrates some recognized dangerous attitude, which lead to faulty decision-making process resulting in less than optimal selection of a course of action. Also in diving, since the field is unregulated or loosely regulated, divers tend to believe that following rules is not really compulsory. While this might be true in term of legal compulsion to follow those, most of the time in dangerous activities, rules (or guidelines) are written in the blood of those who discovered the need of doing things in a certain way in the worst possible way: by loosing their life. Let's make a few points about rules and following them in the diving world.

- a. A diver does not have to be a phenomenal one to be prone to disregard the rules that would assure a safe dive. However, a diver should be an emotionally stable person who can accept the fact that he/she is not in possession of all facts or skills for all situations and be willing to accept the recommendations of those who specialize in evaluating, assessing, and defining diving procedures.
- b. Reaching a consensus on all matters within the diving community is difficult, if not impossible. The absence of a strong regulatory body makes rule adherence essentially voluntary. Even though the rules and procedures are designed to serve

most of the people most of the time, a diver can always argue for different ways of doing things. The immature, emotionally unbalanced diver has strong tendencies to satisfy a personal need regardless of the consequences.

Dangerous Attitudes

- a. **Antiauthority** (don't tell me!). This attitude is found in people who do not like anyone telling them what to do. In a sense they are saying no one can tell me what to do. They may be resentful of having someone tell them what to do or may regard rules, regulations, limits and procedures as silly or unnecessary.
- b. **Impulsivity** (do something quickly!) is the attitude of people who frequently feel the need to do something-anything-immediately. They do not stop to think about what they are about to do, they do not select the best alternative, and they do the first thing that comes to mind.
- c. **Invulnerability** (it won't happen to me). Many people feel that accidents happen to others, but never to them. They know accidents can happen, and they know that anyone can be affected. They never really feel or believe that they will be personally involved. People who think this way are more likely to take chances and increase risk.
- d. **Macho** (I can do it). People who are always trying to prove that they are better than anyone else are thinking I can do it - I'll show them. People with this type of attitude will try to prove themselves by taking risks in order to impress others. While this pattern is thought to be a male characteristic, women are equally susceptible.
- e. **Resignation** (what's the use?). People who think what's the use? Do not see themselves as being able to make a great deal of difference in what happens to them. When things go well, the person is apt to think that's good-luck. When things go badly, the diver may feel that someone is out to get me, or attribute it to bad luck. The diver will leave the action to others, for better or worse.

c. Some divers break rules simply for the immediate gratification of some emotional need. Even though they may know that this emotional need is not considered a healthy habit (e.g., smoking, speeding, overeating).

d. Existing rules would go a long way to remedy the accident rate; however, personality traits that cause irrational behavior also make divers prone to disregard the rules that would assure safe diving.

HAZARDOUS ATTITUDE	ANTIDOTE
Antiauthority: Don't tell me	Follow the rules. They are usually right
Impulsivity: Do something quickly	Not So Fast. Think First
Invulnerability: It won't happen to me	It could happen to me
Macho: I can do it.	Taking chances is foolish
Resignation: What's the use	I'm not helpless. I can make a difference

e. When a diver exhibits one or more of the five hazardous attitudes or irrational behavior, that diver may also be exposing any emotional weaknesses in his/her personality. While this should be a clear hint to the diving instructor to advise the student or even deny certification, it also constitutes an alarm bell for a diver himself.

RISK MANAGEMENT

Risk is the combination of the Probability of an event happening and the Damage that occurrence can cause. The product of this 2 factor is called the PxD evaluation of risk. Probability goes from zero to one. Zero the event cannot happen, one means it will happen for sure. The damage goes from nil to death (or maybe multiple deaths). Therefore we do not really care about the amount of damage an event that has

zero probability to happen will cause. Also we do not care about the probability of an event that does not cause any damage. In the first case it cannot happen in the second we do not care if it does. We need to work on limiting damage of events that can happen or to lower their probability. Or both. This is the essence in risk management.

Before working on mitigation measure (lowering damage) or prevention measure (lowering probability) we need to identify the risk areas. There are 4 risk elements involved in diving: The Diver, the Equipment, the Environment, the External Pressures. These can be committed to memory with the DEEP acronym:

- Diver:** consider factors like fitness to dive, training, experience, recent experience, fatigue, mental state, etc.
- Equipment:** right kind and amount, maintenance status, suitability for intended use.
- Environment:** day vs night dive, low visibility, overhead environment, depth, current, water temperature, sea state.
- external Pressures:** peer pressure, motivation to execute a dive (establishing personal depth records is never a good idea), finding ourselves in a boat with others and finding out the condition are bad and nobody wants to be the first to call off the dive, etc.

An example of an analytical methodology is represented in the following table. This method is not a substitute of good judgment but is a way to guide the attention to possible trouble areas. Also and foremost will help focus diver's attention to the combination of factors, which one at the time might not represent an issue but all together, since stress is cumulative, might represent an issue when faced with the need to cope with all at the same time.

The evaluation items and the scores are based on personal experience of the author, the table is only intended to be an example of the methodology and might be too complex for day to day diving, but spending a little time during the planning stages might provide insight on the safety level of the intended dive. It might be a good way to manage risk on live aboard, dive clubs and dive operator and provides a way to show that you applied due diligence in marshaling a dive.

CONCLUSIONS

Diving is an activity taking place in hostile environment which does not sustain human life, therefore survival is heavily dependent upon correct use of equipment (which is to be considered life support equipment) good decision making and skills.

Safety is a mind set, opting for the safer course of action rather than the preferred one, taking no shortcuts in training and maintenance, requires good mental discipline and strong will to adhere to principles.

This paper's objective was to show to the diving community some (or most) of the methods in use in aviation, which has been pioneering, within flying safety in the disciplines of accident analysis risk management and decision making.

These tools together with strong formal training and recurrent training have brought down incident rates in aviation, especially human factors related. My hope is that, one day, the same reduction of fatal incidents could be achieved in diving, maybe making life insurance for tech divers available/affordable.

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DIVING RISK MANAGEMENT MATRIX						
Risk Level	1	2	3	4	5	Rating
Diver						
1 Experience (Related to the planned dive)	Expert (more than 200)	Good Experience (more than 100)	Practitioner (more than 50)	Trained (more than 10)	Untrained	
2 Recent diving experience (90 Days)	More than 50	24 to 49	10 to 23	1 to 9	no dives	
3 Emotional Condition	Excellent	Good	Average	Poor	Unacceptable	
Equipment						
4 Air Reserves	Exceed Requirements		Meet Requirements		None	
5 Redundancy	All equipment redundant (I have a backup for everything and I know where it is and how to use it)	Only critical Equipment is redundant	I have some backups but no redundancy (i.e. octopus on single first stage)	I have all I need and no more	I am missing some bits, but I never use them anyway	
6 Maintenance status	Excellent	Good	Close to expiration	Will be expired by the time I finish diving	Something expired or beyond usage dates	
7 Experience with this equipment (CCR v/s OC or usage of a DPV ... etc)	Expert (intimately familiar with all equipment and used in multiple recent dives)	Good Experience but little recent experience/usage or recurrent training (drills)	Trained but little or remote experience and no recurrent training/drills ever performed	Only trained but no usage or drill performed after initial training	No training	
Environment						
8 Planned Depth	Well within experience and recent experience	Well within experience	Near or at certification limits	Near or at certification limit with little experience	Exceeds certification limits	
9 Water Temperature	Comfortable	Cold but I have enough protection to stay warm during entire dive (included deco)	Cold but I will be ok, maybe a bit hand and feet cold during deco	Very cold and I will need to move during deco to stay warm	Insufficient thermal protection: I doubt I can stay warm today	
10 Visibility	High I have no doubt I can see my buddy if we separate and can navigate only by visual references	Fair I have to stay close and better know how to use/have a compass	Low (less than 3m 10 ft) and familiar and equipped with/for conditions	Possible brown out/silt out and I am familiar and equipped	Possible brown out and unfamiliar untrained unequipped	
11 Overhead (only if trained)	No overhead whatsoever	Penetration of a single wide open ambient with no additional connection with others	The cavern zone	Cave/wreck	Untrained for overhead	
12 Surface support	Full, competent and equipped	Suitable for the need	Some available	None required	Required but not available	
13 Decompression	None	Some	One gas change	Long and with multiple gas changes or rebreather	Loss of any gas might result in need to abbreviate deco or insufficient bailout	
Pressures						
14 Alternate Dive available	There is plenty of dive sites to see: if the planned one is unavailable I will dive another			This is my last chance to dive this site	I have to dive here today	
15 Peer pressure	None	Well planned and within experience but on site conditions worst than expected		I am uneasy with this site/conditions, but everybody wants to dive here	Come along you will be ok: we dove this site in worst conditions	
16 Expedition Pressure	We already dove all the sites of this trip and achieved all objectives	There are a few dives to complete objectives but well on schedule and confident to complete	We on a tight schedule to complete the objectives	We will not complete all the objectives of the trip	We have to make this dive otherwise we will have wasted this trip	
Additional/personal factors						
					Total Risk rating ->	
Risk is within normal parameter. Diving is inherently risky. Do not take unnecessary risk and adhere to your personal limits in order to stay within your training and experience.						16-32
Elevated Risk. Dedicate extra time to review contingency plans, available gas, surface support and site conditions. Delay or replan the dive. Be extra careful with those around you and their mental status (signs of stress, voiced concerns) and competency equipment of surface support. Be very careful not to violate any personal limit and ensure your team mates do the same.						33-55
High Risk. Any 5s should be reason to abort the dive: these are already in a "never do that area". Dedicate extra time for planning and review contingency plans, consider a team review and consult a more experienced diver if available (maybe discuss your plans with your instructor). Examine methods to reduce the risk to the extent possible. Consider making training dives before executing this plan. Split dive objectives in multiple dives.						56 and above. Any 5.



“A dive is an exercise in task management...nearly all of them appear to be simple, but even the simplest tasks...can have catastrophic consequences”

- Phillip Finch, *Diving Into Darkness*

It is in technical diving (extended range, decompression, deep wreck diving) as it is in mountain climbing or any other type of extreme sport - if you do it enough and you do it long enough, it becomes a matter of *when*, not *if*, something happens. Your experience, training, and ability to stay calm are the only things that will keep you alive. I would argue from personal experience that your ability to control your emotions and not panic is what will keep you alive longer. It is only when you can control your psyche that you can rely on your training and experience. Without your wits, you will most certainly die a horrific death underwater.

In 2002 and 2003, I was involved in two underwater emergencies - one in which I rescued a panic stricken diver who ran out of air at 110 ffw, and another in which I ran out of air and had to buddy breathe with a fellow diver to the surface while completing our decompression. Neither completely prepared me for the dive I took a year later, on April 24, 2004, to the sunken steamer John J. Boland, Jr., which foundered in 1932 in a violent, sudden storm in the Eastern Basin of Lake Erie. However, those experiences helped me come away from the dive with my life...barely.

Renowned deep explorer, author, famed wreck diver, and underwater photographer, Gary Gentile, sent me an email which contained the line - “Welcome back to the land of the living” - after returning home from the hospital following a speedy boat ride to shore, a life-flight helicopter trip, and a race against the clock to get me to a recompression chamber before I was permanently paralyzed or dead.

This is my story. It is raw. It is extremely personal. This is unabridged and unabashed. Much of it has never been told to anyone before. My dear friend, legendary diver and admiralty attorney Peter Hess (God rest his soul), urged me to tell this story. He was one of the very few who knew everything that happened to me. He said it would be best to share this with as many divers as possible because it may just save someone's life. Plus, he always said it is just a great survival story. Well, Peter, here it is.....

Rescue #1: 2002 - Eastern Basin Lake Erie - wreck of the John J. Boland, Jr - Depth 140 ffw

There's no way I'm seeing this. My eyes must be deceiving me. There's absolutely no way this guy is doing this, I thought as I suited up in my gear on board a dive boat in Eastern Lake Erie. I actually made a joke to one of my buddies on board - "this fucking guy is going to kill himself". I heard he was a novice. In fact, this was his first dive after completing his open water course - *basic* open water, not *advanced* open water. He wanted to dive with the big boys. He failed to realize we had been honing our underwater skills for years. As you will read below, people like this are just as likely to kill someone else underwater as they are themselves.

We were getting ready to dive on the John J. Boland, Jr. - a 253 foot (77 meter) long steel steamer which sank in a storm in 1932, with four hands in less than five minutes. It is a beautiful wreck. It is almost completely upside down, but the port side is still above the bottom of the lake to allow divers access to the cabin and pilot house, as well as the cargo holds. The two highlights for me are entering the pilot house and the intact giant rudder and propeller.

I was diving my regular rig - dry suit, double steel 95s filled with air,

40cf deco bottle with 50% O2, multiple reels, lift bags, redundant bottom timers, etc. While the rest of us onboard were putting on our typical 150-pound deep wreck diving gear, this guy who I will name "Jack", was doing something completely different. I watched in utter amazement as Jack pulled his gear out of his bag. Everyone on board was diving dry as the water was still in the upper 30s at depth. Jack did not have a dry suit, but he did have quite an interesting one.

He first put on a one-piece 3-mil wetsuit. He then pulled out a navy blue sweatshirt with matching sweatpants and put that on over his wetsuit! I couldn't believe what I was seeing. To make it worse Jack then pulled out a two-piece 5-mil farmer-john wetsuit and put that over the sweatshirt and sweatpants! That's right, Jack was wearing a sweatshirt and sweatpants sandwiched between a 3-mil wetsuit and a two-piece 5-mil wetsuit! Not only did he look completely ridiculous, he could barely move, looking more like the Stay-Puft Marshmallow Man than a deep diver. His BCD barely fit and had to be adjusted. He put on all of the weight he brought.

After he finished suiting up he fell (notice I did not say jumped) over the side and made a huge splash. I was already in the water watching this circus from the surface. As you may be thinking, *how could Jack with all of that for a suit ever sink?* Exactly. He was so buoyant he could not slip below the surface. He had to climb back on board the dive boat and get more weight. It was Summer. Even though it was slightly above freezing at the bottom, it was hot on the surface. You can see where this is headed. Wearing that suit with all that gear and climbing back on board Jack was probably dehydrated. He was definitely overworked.

The crew on board helped him add more weight to his weight belt. I'm not sure how much weight he had, but I saw plenty of 8 pounders

on his weight belt and the bucket of extra weight on board was exhausted. Jack was weighted down heavily.

As Jack again fell overboard into the water, I was on the down line heading towards the wreck as I wanted to stay as far away from him as possible.

I spent most of the dive in the stern section checking out the gunwales and exploring the huge port side propeller. The rudder and rudder post are still attached and are quite impressive in their own right. As I hovered near the propeller I saw Jack kicking as hard as he could, swimming aft along the port side gunwale. Jack looked stressed as he was swimming with his arms and legs in a crazed motion - a very erratic doggie-paddle. Something was wrong.

I was thirty feet away and could see his eyes. They were extremely dilated. He was starting to panic. Just as I started swimming towards him to help, Jack swam to another diver and grabbed her regulator out of her mouth. He was in full panic at a 110 feet (33 meters) below the surface. Jack was so heavily weighted he dragged her towards the bottom as he tried in vain to grab anything he could on her BCD to keep her close to him. He looked like a panicked swimmer on the surface pushing the rescuer's head below the water in order to keep himself above water. This could end terribly at any moment. I thought Jack was going to kill her.

I swam quickly over to her and grabbed the regulator out of his mouth that he took and gave it back to her. I grabbed Jack's jacket style BCD on the left shoulder and pulled him over her head and away from her. Jack was grabbing at all my gear. He was pulling at my dry suit inflation hose, all my straps, and grabbing my gauge console. I was swatting away his hands so he wouldn't pull out my dry suit inflation

hose or wouldn't break any of my second stages. I kicked him away once so he wouldn't drag me down. As I did, he grabbed and broke my right fin strap. I swam down towards him and pulled out my regulator, which was attached to a six foot hose, and put it into his mouth and purged it. My second regulator sits just beneath my chin on surgical tubing around my neck. All I did was tilt my head down and my second regulator was right there. I had practiced switching regulators underwater so often that I didn't even have to think about it.

Because Jack was so heavily weighted, I swam as hard as I could away from the bottom and towards the anchor line, mindful of our depth, so we didn't crash into the bottom at 137 feet (42 meters) I grabbed the anchor line at an approximate depth of 100 feet (30 meters). I was facing Jack. My right hand was tight around his left shoulder strap. Jack's right hand was on the anchor line. As I stared into Jack's eyes I could tell he was frightened. I was hoping I could calm him down sufficiently so he wouldn't suck down the rest of my air. He was in the panic cycle. Once the cycle starts it is difficult to stop. At this point I was more worried about running out of air or not completing my decompression obligation because of him.

I signaled to Jack that I was going to control the deco stops. He nodded his head. I doubted he understood the signaling, but at least he was communicating with me on some level, even if it was a minimal head nod.

I stared into his eyes and signaled for him to watch me breathe. I inhaled a large, deep breath while motioning with my hand to breathe in and breathe out. I did this multiple times. It didn't work. He was sucking down air.

I wrote on my underwater wrist slate "CALM DOWN" in big block

letters. I knew telling a panic stricken person to “calm down” never works, but it was worth a try. It didn’t work. His eyes were large and he was breathing hard. I thought he was going to blackout.

I needed to get him to relax his breathing enough so we could surface and so there wouldn’t be two casualties. I didn’t know what to do so I unclipped my pressure gauge and handed it to him, while pointing to the gauge. The needle didn’t lie. We had air in my tanks. Suddenly, his breathing settled and his eyes relaxed. He was holding that gauge tight, like he was clinging to life, which I guess he was.

I again signaled that I would control deco. He nodded his head. Finally, it looked as if he was somewhat clear headed. His breathing had calmed enough so I could be a little more comfortable that we wouldn’t run out of air prior to finishing our decompression. We started up the line.

I did a couple of deep stops - 90 feet, 80 feet, 75 feet (27 meters, 24 meters, 23 meters) - just to be sure he was still with me. Jack was breathing nicely and was still clutching my pressure gauge with a steel grip. We ascended more.

We were making slow, steady progress up the line pausing often so I can monitor the pressure gauge with my own eyes. We continued.

We were going to start bumping into some divers on the anchor line around 45 feet (14 meters) Since I had Jack with me and he couldn’t control his buoyancy without clinging to the anchor line, I signaled to Jack that I was going to swim up the line and he would follow me from below. This is basic, two regulator, emergency breathing. I’ve practiced it, like we all should, dozens of times. Effectively the lead diver swims towards the exit (in this case towards the surface, up

the anchor line) while the trailing diver breathes off the lead diver’s regulator which is on a six foot hose and is streamlined between the lead diver’s legs. This is how two divers buddy breathe while escaping from inside a wreck, cave, or overhead environment.

After I signaled to Jack, I let go of his BCD and slowly swam above him. He was still clinging to the anchor line. I paused momentarily to make sure he was ok. I took my pressure gauge. He was breathing fine and nodded in agreement. We continued to ascend the anchor line, this time in a single file line with me above and Jack directly below my fins.

Once we, or I should say, I, arrived at 40 feet (12 meters) to warn the divers above us that we were emergency ascending, I looked down and saw my regulator wrapped around the anchor line and Jack descending towards the bottom of Lake Erie with his arms in the air. In all honesty I was more upset that my Poseidon Jetstream MK3 regulator was twisted around the anchor line than I was at having to help Jack again. He had no business being in the water. At that point I stopped caring whether he lived or died. I didn’t want him to hurt anyone else. I was more concerned with making sure I had a long enough surface interval before I attempted to recover his body.

As I saw him descending I couldn’t help myself. I untangled my regulator and swam for him. Instinctual I guess. Drowning is no way to go.

I swam hard and caught up with him. Once I reached him, Jack put his regulator in his mouth. He took one breath and nothing. He started giving me the international signal for “out of air” by violently moving his hand across his throat. His eyes were bulging out of his head. I have never seen somebody so scared. I shoved my regulator back in

his mouth and purged it again.

I shook my head in disapproval and grabbed him by his left shoulder strap again. This time I didn't let go. We ascended up the line side by side. We finished our decompression obligation without any further issues.

I thought the drama would have ended after the dive was over. I was wrong. Once we surfaced Jack started yelling and screaming - at me! He stated there were no issues at depth and he didn't do anything wrong and he had everything under control! I couldn't believe what I was hearing! I just saved his life (twice) and he was blaming me for everything.

Jack was obviously embarrassed. Instead of taking responsibility for diving well beyond his capability and without the appropriate equipment or proper training, he lashed out at me. He must have believed it was easier to shift the focus to someone else other than evaluate himself.

As politely as I could, I told Jack he wasn't cut out for diving. I told him he was a liability to those around him in the water and that instead of trying to fit in with those of us who had advanced training and an abundance of deep diving experience, he should have taken his time to gather the appropriate level of expertise to attempt the dive he made. I told him he was lucky he was alive. I told him he almost killed my friend underwater and that if there was a next time, I would let him go and not risk my own life to save his. With that said, Jack sat down and didn't say another word.

This is very similar to those mountaineering tourists who pay tens of thousands of dollars and buy all the newest equipment to "climb"

Everest. They are literally taken by the hand and guided through the entire climb. Yet, they lack any self rescue skills. Without somebody with the experience to help them through a stressful situation, they would surely die, and do. Money can buy you all the best gear, but it cannot buy you experience. Jack is a prime example of why I usually dive solo.

Rescue #2: 2003 - Morehead City, North Carolina - wreck of the *Caribsea* - Depth 90 fsw

Just a few days before I had awoken from the anesthesia with neck pain. I just had a lymphectomy. My medical team recommended the removal of a few lymph nodes from the right side of my neck in order to conduct a biopsy for cancer. The following week I was planning on diving the *U-352*, *Papoose*, *Caribsea*, *Proteus*, etc. Hell, I was even going to dive with the "Father of East Coast Wreck Diving" Michael DeCamp. We had been planning these dives for months and didn't want to miss them, so I begged the surgeon to squeeze me in before the trip.

On the dive boat, I was trimming my stitches with a dive knife - they were sticking out of my neck and were itching. Couldn't take it anymore. So in between the wave action I was cutting as much as I could. Between the shears and the knife I was able to get the stitches a little closer to the skin. I decided to put some duct tape on the scar so I wouldn't itch it any longer. Time to go diving.

We were anchored into the *Caribsea* - a freighter torpedoed by the *U-158* in World War II. More than a dozen sand tiger sharks were swimming over the wreck. Visibility was phenomenal - nearly 100 feet. I was heading for the forecastle in the bow. The ship impacted and was buried in the sand. The bow is remarkable - highlighted by

the anchor chains and windlass, but has since collapsed. The engine and boilers are very prominent and are definitely worth seeing as well.

After I was done exploring the wreck, I began my ascent. Another diver on the boat dropped their camera while they were on the anchor line. Since I just started my ascent, I swam back down, grabbed the camera, clipped it my harness, and headed back up the anchor line.

I worked my way up the anchor line admiring the view from above the wreck. Definitely not what I was used to in the Great Lakes. I was accustomed to viz significantly less. I soaked up the moment. At about 25 feet I took a breath and nothing. I was out of air. *Damn, I stayed too long*, I thought.

If you've never experienced that before, it is quite possibly one of the worst feelings known to mankind. My good friend, Mike Greuter, and I were no further than 20 feet apart. I signaled "out of air" and started swimming towards Mike. Whoever was next to Mike on the anchor line just stared at me and didn't move. (The diver later told Mike he thought I was joking. Mike told him "we never joke about that".) Mike was Johnny-on-the-spot and arrived with his primary regulator in his outstretched hand for me.

We both finished our deco and ascended to the surface together without any issues. Back on the boat I told Mike, "Thanks, brother. Glad you were there." We swapped out tanks and were ready for our next dive.

This story isn't that remarkable. Divers the world over have had an experience like this. I only mention this to contrast the difference a competent dive partner can make in an emergency. Sometimes the ability to control your mind and emotions is the only thing separating

the survivor from those who perish. Mike immediately recognized I was in trouble and needed help. He didn't think twice and calmly, but swiftly, swam over to me and gave me his regulator. Most importantly, I didn't start mauling Mike for his regulator like Jack did in the previous story. Neither of us panicked. Neither of us lost control of our minds. Neither of us did anything other than react the appropriate way, in a timely manner, and in a way we had trained for a situation just like this. Easy day.

Rescue #3: 2004 - Eastern Basin Lake Erie - wreck of the John J. Boland Jr - Depth 140 ffw

I broke the surface and was on my back. Those on board who were watching my bubbles from the depths below saw my face - it was blue. I had been submerged in 34 degree water (1.11 degrees Celsius) for almost an hour. My body turned over and my face was once again in the water. They didn't know whether I was dead or alive. I was later told they were worried my regulator would fall out of my mouth when I turned over face first in the water. I was bloated and blue. They all thought I was dead. A couple of divers jumped overboard and hauled my lifeless body onto the boat.

Needless to say, I don't remember anything that happened once I broke the surface. The only thing I vividly recall, as if it happened a moment ago, was after I broke the surface I remember seeing a white light. The light was bright and warm. I remember everything fading to black with the exception of this bright white light in a tunnel. At the end of the tunnel there was a blurry figure. I remember the figure getting closer, but I couldn't make out who it was.

I'm not sure how long I was in this tunnel but the next thing I remember I woke up with blood on my face. I could barely see because the blood

that splattered all over my mask had dried in my eyes. I couldn't hear very well either. My eardrums had exploded, but we're oozing puss and blood. I knew people were talking because I could see their lips moving but I had no idea what anyone was saying.



I tried moving but it proved too difficult. I couldn't move my legs. In fact, I couldn't move anything below my waist. Just because I couldn't move didn't mean I couldn't feel. The pain was intense. The dreaded "bends" had just taken over my body. I was laying on the boat waiting to die, again.

Someone had put an oxygen mask on my face when I was unconscious. I tried removing the mask for whatever reason but couldn't grip anything. My hands and fingers became too painful to move. I had an

extreme case of muscle tetany (involuntary contraction of muscles). My fingers and hands became torqued. The pain was excruciating. My elbows were on fire and felt like they were going to burst.

Decompression sickness (DCS) is one component of Decompression Illness (DCI), the other being Arterial Gas Embolism (AGE). Unfortunately, I had both. There is a reason why people often refer to DCS as the "bends". As I described what happened to me above, one who suffers a DCS "hit" will usually get pain and discomfort in joints. The "bends" is the result of a bunch of nitrogen built up in one's tissues that comes out of solution during a rapid decompression and results in bubbles. These nitrogen bubbles form in the bloodstream and form around joints. What happens to your bloodstream as a result of the "bends" is the equivalent of shaking a bottle of Coke and opening the top. The violent reaction of bubbles forming is what happens to a diver's bloodstream with nitrogen bubbles. It is extremely painful.

At this point I asked the captain for a gun so he could shoot me. Not because I wanted to die and not because I was giving up. It was quite the contrary. I just needed a relief from the pain so I could think clearly. I obviously couldn't concentrate with everything happening to me: extremely hypothermic, blood everywhere, perforated eardrums, and a DCS hit.

I was in and out of consciousness. I remember being very cold and then suddenly warm. I could barely move my hands. I could hardly move my arms. I couldn't move my legs.

I woke up once and saw everyone staring at me. Everyone looked scared. They were saying something about whether or not they should cut my drysuit. In my head I was thinking if I ever made it to shore, or to definitive care, it was coming off anyway. I yelled "fucking cut

it” and passed out. I woke up with my drysuit filleted like a fish. (As a side note, I do appreciate them pausing to consider whether or not to cut my \$3,000 suit. They did the right thing).



I concentrated on breathing the 100% oxygen. I knew from my studies and experience the best treatment for DCS was pure oxygen. I knew the oxygen would counteract the nitrogen bubbles. I also knew that if I didn't get to a hyperbaric chamber soon, I would most likely die or, at best, remain paralyzed from the waist down. I knew as long as I was breathing any oxygen concentration higher than that of air, I had at least some chance of living.

I was told the captain was racing to shore and that an ambulance had been called. We were too far away from the closest chamber to be

transported by ambulance. I was told a helicopter was called and that I would be transported via air to the hospital. *Shit*, I thought. I knew things were bad, but it always seems to really sink in when you hear how bad things are from someone else. For whatever reason I kept thinking, *Please let it be the Coast Guard. I hope it's the Coasties. I love those guys. I always wanted to fly in a Dolphin helicopter.* Dark humor.

The next thing I remember was the boat slowing. The captain had the engine at full throttle from the wreck site all the way to shore. Everyone on board was prepping me for transfer to the awaiting ambulance. I still couldn't hear very well, but I remember lots of people making noise and talking loud. I could sense the tension in the air. I was in immense pain. All of the sudden I felt a rush of warmth through my body. I passed out again.

I awoke after I had been transferred to the ambulance. The medics were piling on blankets. My eyes hadn't been cleaned yet, but I could see the medics trying to start IVs. I was watching them repeatedly poking me trying to get a vein. The problem was that I was so hypothermic all the blood had rushed to my vital organs from my extremities to keep me alive.

The medics kept telling me the helicopter was on its way and would be here shortly. At this point I knew I was in trouble. I knew from my symptoms and from the medics talking on the radio I was in a desperate fight for my life.

In a way to try to convince myself that things were not that bad, I told the medic that my hearing was improving. He smiled. He knew I was just trying to stay head strong. He asked me how my hearing was improving especially with all the dried blood and puss in my ears. I

told him I could barely hear the helicopter coming from the distance. I told him if I could hear the helicopter that far away, I must be getting better. He laughed and told me if I could barely hear the helicopter my hearing was terrible because the helicopter had already landed right next to the ambulance! *Fuck, I'm in deep shit*, I thought. *How could I not hear a helicopter land 100 feet away?* I could feel the life drain from me.

I don't remember much, if anything, from the helicopter flight. The one thing I do recall was the flight medic telling the pilot he didn't think I would survive the flight to the hospital. I became incensed with this comment. I just waited to feel what it was like to die again.

The next thing I remember feeling was an extreme cold. We were on the pad and I was being transferred from the helicopter to the emergency department. I saw what must have been a dozen faces around my stretcher. They were running me down the hallway. I remember seeing white everywhere.

Once we stopped moving I knew we were in the trauma room. The rest of my clothes, including my drysuit insulation, were cut off (there went another \$500). I was being examined and poked and prodded everywhere. There was a lot of noise in the room. IVs were being started, warming blankets were piled on, hypothermia protocols were being initiated, oxygen therapy continued.

I was fading in and out. I could feel pain. I still couldn't move my legs. I was tired. Suddenly, I was left alone in the room. I looked to the right. The white privacy curtain was moving. I saw a distant cousin standing there who I hadn't seen in years. I looked at him in confusion and said "Am I dead?" He smiled and said I was not dead. I asked him if he was certain I was alive. With a smile he assured me

I was alive.

The doctors had been consulting with various dive medicine and hyperbaric experts in the United States and in Canada. While they were sharing information I needed to be "prepped" for the chamber. This short woman doctor with an Eastern European accent walked in the room. She was very motherly, but all business. Behind her was a burly orderly. He was big. I never knew his name, but he was a large man.

It was explained to me that in order for me to enter the dive chamber and complete the recompression therapy, I needed to have the pressure relieved from my eardrums. I told her that my eardrums had exploded on the way up to the surface and that there was no need to do anything to my ears. She pulled out a stainless steel lancet. I shook my head and told her there was no way anyone was putting that in my ear to pop my eardrums again. Just then the orderly came over and held my head down and to the left exposing my right ear. The doctor took the lancet and popped my eardrum. The blood and puss poured out and rolled into my mouth. The taste was horrendous.

That was only the first eardrum. I tried to no avail to hold the left side of my head to the pillow so they could never get the lancet in that ear. The orderly simply turned my head and pressed down so I wouldn't move. I didn't have a chance. The doctor pierced my left eardrum. The second one hurt more than the first. As kindly as possible, she said "That wasn't that bad, was it?" I yelled at her as loud as I could. I later apologized.

Once the doctors had finished consulting with the hyperbaric experts, I was given the option to either enter the chamber or not. The choice may seem like an easy one. All the textbooks and courses teach the fact

that if you have the bends, you go in the chamber, period. However, my case was complicated by the fact that I had completed six months of cancer treatment, which included both chemotherapy and radiation therapy, four months prior. The choice wasn't that easy.

The best treatment for any DCS hit is pure oxygen, or if not available, the highest concentration of oxygen available. As an example, in the absence of 100% oxygen, a Nitrox blend of 36% or 40% will work better than ambient air containing 21% oxygen. The point is to get as much oxygen as possible. However, it was explained to me that there was a significant chance of adversely affecting my lungs with prolonged oxygen therapy in high concentrations due to a combination of the chemotherapy drugs and back scatter radiation to my lungs. In this lies the quandary. So it really isn't that easy of a decision after all. In the end I had only two options:

1. Enter the hyperbaric chamber and attempt recompression therapy. I was told I had less than a 40% chance of surviving given the complications recompression therapy posed to my body because of the effects of fighting the cancer.

Pros:

- (1) There would be a recompression specialist inside the chamber with me helping me along the way and would be able to intervene should something go wrong.
- (2) Being the ever optimist, I had a 40% chance of survival.

Cons:

- (1) 60% chance of not surviving.
- (2) Should anything serious happen in which intervention was needed (CPR, AED, etc.) I may need to be removed from the chamber in order to complete the necessary life saving intervention, which may

cause more of an issue because I would have missed and or interfered with the recompression therapy.

(3) Prolonged length of time to high concentration of oxygen.

(4) My family asked me not to.

2. Refrain from entering the recompression chamber and take my chances with fate.

Pros:

(Intentionally blank)

Cons:

(1) There were no Pros.

(2) Even if I survived, no one could guarantee I would regain any mobility or function of my legs as I was still paralyzed from the waist down.

I initially decided to enter the chamber. Why? Because that's all I was ever taught - if you get bent, get to a chamber. I would have rather played the odds with the less than 40% chance of survival than wait to see if my temporary paralysis improved.

Just as the best laid military plan works until the first shot is fired and then it all changes, nothing is textbook. After much pleading from my family, I decided the best option was to not enter the chamber. Why? Because there were less cons than the other option. Period. This wasn't an easy choice, but at the end of the day it was all academic - a basic, elementary school pro-and-con chart to determine my future.

The Dive

It was a nice day on Lake Erie for April - well, at least on the surface. Below, the water was dark and cold (34 degrees F, 1.11 degrees C).

April is not typical dive season on Lake Erie. But there was a good weather day and we were heading out to set a buoy for the upcoming dive season. The task at hand was simple - locate the mooring line secured to the rudder post, attach a lift bag, and send it to the surface so the crew could attach the buoy. After that, the rest of the bottom time was ours to explore what we wanted.

In the wheelhouse of the dive boat, I could see the wreck below on the monitor. She rested about 50 feet (15 meters) off the port side of the dive boat. Time to get wet.

I splashed in the water and was immediately glad I was wearing thick insulation under my drysuit. The water was cold. After a quick gear check one last time, I descended below. The water was dark, but I was excited as this was the first dive of the season. I had an abundance of dives planned for the year - a deep week in North Carolina where all wrecks were deeper than 150 feet (46 meters), a few TBD East Coast dives with my good friend, Peter Hess, and weekends throughout the Great Lakes on some of the best wrecks in the world.

As I submerged I inflated my drysuit to control my descent. I was making good progress, gear was working well, and I was happily warm with the exception of my face. At approximately 70 feet of depth (21 meters) I began looking for the wreck. Since the wreck rises 40 feet (12 meters) off the bottom the wreck is usually spotted from an approximate depth of 50-60 feet (15-18 meters). I dropped further - 90 feet, 100 feet, 110 feet (27 meters, 30 meters, 34 meters). At this point I started swimming towards the wreck and knew that at this depth I would eventually run into the wreck.

At 110 feet (34 meters) my mask began flooding. I didn't know at the time, but there was a slight tear in my mask skirt. I tried to clear my mask, but the water just flooded back in. I hovered there at depth and

tried to signal another diver in the water, but I was unable to do so. I saw the faint glow of a dive light in the distance, and then suddenly, it was gone. I again tried to clear my mask, but to no avail, the water kept pouring in.

I immediately started going through my checklist of emergency procedures. My respirations became quick and shallow. I tried one last time to clear my mask, but the pressure at depth was too great to overcome and the water entered just as quickly as I purged it. My mask was broken.

As all deep wreck divers do, I carried an abundance of everything - three lights, extra reels, backup dive computers, extra bottom timer, multiple lift bags, etc. (As a side note, I was wearing double steel 95 tanks banded together with isolation manifold, but opted not to carry my 40cf deco bottle with 50% oxygen. *Remember this for later.*) I also had a spare mask in one of my drysuit pockets for situations just like this. I never had to use it, but I was glad I carried it on this dive.

I let the mask flood. There was no use wasting more energy trying to clear the mask any longer. I thought the best thing for me to do was to orient myself since the water was so dark before I attempted a mask exchange at depth. However, before I oriented myself I needed to get my breathing rate lower as I was starting to breathe heavy. As I hovered at 110 feet (34 meters) below the surface, I closed my eyes and imagined my heart slowing and my lungs slowly filling and deflating. My pulse dropped and my respirations slowed.

Once my pulse and breathing rate returned to normal, I decided I was going to blow a lift bag. I inflated my wings slightly in order to ascend to 100 feet (30 meters). Once I reached the target depth I was going to inflate my bag. At a depth of 99 feet (30 meters), while I was reaching

for one of my lift bags which was butt-mounted to my backplate, I suddenly flipped over and started plummeting towards the bottom of Lake Erie. Before I could attempt to invert myself, I plunged into the bottom of the lake. The good news was that I found the wreck. The bad news was that I was stuck upside down with fins pointing towards the surface, wedged between the wreck and the bottom.

I had some serious issues that needed immediate attention. Not only was my mask flooded, but now it was covered with mud, my manifold and tops of the tanks were buried in the muck, I was upside down, and I was stuck. My canister light (made for cave diving) flew out of my hands when I crashed into the bottom. Luckily the light head was still attached to the canister. I could see a faint glow a couple feet away. To make things worse I was breathing heavy. Too heavy. So heavy that I started to worry about not only running out of air, but also worried about deep water blackout.

For those unfamiliar with deep water black out, it is a condition that develops from short, quick breaths at depth - hyperventilating. If a diver continues to hyperventilate at depth, the diver will eventually "black out" from the lack of oxygen. This is why it is essential to optimize gas exchange at depth. It is rather simple: if you black out, you drown.

I immediately checked my pressure gauge. *Fuck! I can't see the needle!* The gauge was covered in mud. I wiped off the glass - nothing. Still couldn't see with all the silt and thick, heavy particulate matter everywhere. I put the gauge up to my mask and still couldn't read the needle. This was the first time I thought I was going to die.

I screamed again into my second stage. *Fuck!* I started to breathe heavy again. With water in my mask, mud on my mask, no light,

the inability to see my pressure gauge, particulate matter floating everywhere in zero visibility, and an overwhelming amount of thoughts and information in my head, I started to get vertigo. My head was spinning.

At this point I started to get very light headed. Narcosis? On the verge of black out? Probably a little of both. Deadly combination. I was in a daze. But I was immune to everything going on for a few minutes. I don't remember being worried about being stuck, or the low viz, or not having my light, or my broken mask. I don't remember having that overwhelming feeling anymore of not being able to extricate myself. At this point I accepted the fact that I was going to die.

I'm not sure how much time passed, but I started thinking about my family, all that I wanted to accomplish in life, the fact that I just beat cancer. I was suddenly overwhelmed with an adrenaline rush and told myself that I was going to do anything I could to get out of here - dead or alive - as long as I didn't die stuck on the bottom.

I immediately worked on my breathing. I closed my eyes and tried to calm myself down. I knew I couldn't read my air gauge and I was thankful for that. There is no way I could bear watching the needle drop to empty. That is pure mental torture.

There is probably some technical term for what I am going to describe, but I always called it 7-13-20 breathing. I had practiced it for years. If I was ever going to do it for real, it needed to be now. The premise is simple - inhale for 7 seconds, exhale for 13 seconds. This drops your respirations to 1 breath every 20 seconds, or 3 breaths per minute. Each time I inhaled I counted to 7 in my head: 1, 2, 3, 4...7. And every time I exhaled I counted to 13 in my head: 1, 2, 3, 4...13. Even though I couldn't see anything, I did this with my eyes closed. It also helped

that there was no noise at 127 feet (39 meters) below the surface. Complete isolation. I was able to concentrate.

My pulse dropped significantly. My respiration rate decreased dramatically. I needed optimal gas exchange to think clearly and to conserve the one thing that was most precious to me at that time - air.

Every breath I took was one step closer to death. I had little time to extricate myself. I tried inflating my wings. No luck. Didn't budge. I tried inflating my drysuit. Nothing. I tried inflating both my drysuit and my buoyancy device at the same time and still didn't move.

I was still upside down with my manifold buried in the mud. I tried digging behind my head and digging around my tanks. The viz, which was near zero, somehow got worse as all the particulate matter billowed up from my digging. I couldn't get out.

I unbuckled my weight belt while simultaneously inflating my drysuit. Amazingly I still did not move. That's when I knew I was really stuck and in trouble. If fully inflating my drysuit AND fully inflating my wings AND dropping my weight belt AND digging in the mud to extricate my tanks and manifold didn't work, then there was only one other thing I could think of that might work.

This was by far extremely risky, but I knew I was in trouble. What's that old saying about wdesperate times and desperate measures? If there ever was a time for me, this was definitely it. I decided I was going to remove my tanks.

I quickly but thoroughly rehearsed how I was going to do this at depth. It's one thing to remove your tanks underwater during training in a pool. It's one thing to remove your tanks and push them through

a small opening in a wreck and then put them back on once through the restriction. I've done that before. But it's quite another to remove your tanks while upside down with nowhere to go but up if you let go.

I loosened the waist strap of my harness. I thought maybe before I tried to pull my tanks off I might loosen the waist strap in order for one of my lift bags to swing free. I thought maybe I could shoot a bag to the surface. I couldn't reach them due to the way I was stuck.

Since my waist strap was already off, I decided my Alamo would be to remove my tanks, try to invert myself while holding on for dear life (literally), and attempt to put the tanks back on. Again, I've done it before, in an overhead environment, but never in a situation like this. I started taking off the shoulder straps. I was really nervous and concerned about being buoyant without the tanks and weight belt. The last thing I wanted to happen would be for me to get out of the harness only to be positively buoyant and any air that I had in my suit would go to my legs (since I was upside down). I would be like a flag on a flagpole holding on to my tanks while any positive buoyancy would want to take me straight to the surface. I decided this was a bad idea.

I put the tanks back on. I took a few breathes and then started digging around my tanks again. Silt was billowing everywhere. The viz was zero. I was running low on air. I really concentrated on breathing deep and slow...7...13...20.

I felt something against my tanks. Not quite sure what it was. I heard a metal on metal sound. Must have been my tanks against the wreck. I broke free. Before I knew what was happening I could feel the buoyancy I had in my suit and wings lift me up. But there was a serious problem - I was heading towards the surface, fast.

I was rocketing towards the surface like an ICBM shot from a nuclear submarine. I was in grave danger. Instinctively, I grabbed my primary regulator and held it in my mouth while holding my secondary regulator in case the primary free flowed.

I knew I was going to get bent bad, if I even made it to the surface alive. I took a deep breath and kept talking to myself, *Don't hold your breath, don't hold your breath*. I was going faster and faster. I was waiting to feel what it was like for my lungs to explode. *Exhale!*

Before I could grab my knife to slice my drysuit to allow the water inside with the hope of slowing my rapid ascent, I was almost at the surface. *Exhale!*

Fuck! While waiting to feel what it was like to embolism, my mask turned red. Blood splattered on the inside lenses.

I couldn't hear anything anymore - no rushing water, no expanding air trapped in my suit, not even the overpressure relief valve on my wings (which was working overtime). Both my eardrums just exploded.

I could see streaks of light through the blood in my mask. I knew I was getting close to the surface. I was still gaining momentum. *Don't hold your breath! Don't hold your breath!*

And suddenly....I broke the surface and was on my back.

Earlier I mentioned that I did not bring my 40cf tank with 50% oxygen. This point is key. There was a moment I wished I had that with me. One inhalation of 50% oxygen at that depth and it would have been over for me, or at least that's what I was hoping. That's right, I was going to purposefully give myself an oxygen toxicity hit in order to

avoid me drowning and watching my needle settle on empty.

The maximum operating depth (MOD) for 50% oxygen at 1.6 PO₂ is 70 feet. Anything deeper and that mixture would be toxic to me, at least in theory. I was hoping that one hit off that tank at almost twice that depth and it would have been immediate convulsions. Lights out. But, I didn't bring my tank. I didn't need it - somewhat shallow dive with double 95s. I wasn't planning on a decompression dive. My dive plan was such that I had more than enough air to accomplish my dive with double 95s.

Why would I purposefully kill myself by inducing an oxygen toxicity hit? I vividly remember thinking one thought on the bottom: people say "he died doing what he loved". I've heard it for years about divers specifically, we all have. "*Well, at least he went out doing what he loved*". That's all bullshit. From someone who has been there (on the brink of death underwater) and having survived that nightmare. That's no way to go.

So again, why would I purposefully induce an ox-tox hit? Well, at that time, it would have been easier to induce an ox-tox hit than to suffer the mental terror of watching my needle drop to zero and then drowning while I had my mental capacity. Can you imagine what it's like to drown? Unfortunately, I can. It's not fun. It's horrific. So, at that time, the choice for me was easy. This was all predicated on the fact that I could not free myself. Fortunately, I didn't have to make that choice (although I knew what I was going to do) because I did not have the tank with me.

Epilogue

My decision to not enter the hyperbaric chamber paid off. I was lucky. The tetany in my hands and arms, the pain in my joints, and

the paralysis I had from the waist down dissipated over the course of a few days. After being at depth for 51 mins, I had a decompression obligation of 80 mins. I did nothing. Time and oxygen were my treatment. I was on supplemental oxygen for a couple days and then resumed breathing ambient air.

I walked out of the hospital (slowly) a few days later with a cane - very stylish for a 24 year old. For most of the next month I had to use the cane for mobility. My strength slowly returned.

My eardrums took a long time to heal. My right ear healed well, but I had a difficult time hearing out of my left ear for the next three weeks. (Yes, I was still mad at the doctor for piercing my eardrums that second time).

Prior to my discharge a doctor told me an embolus (air bubble - remember shaken Coke can in your bloodstream?) flowed into my heart and stopped it. Lucky for me, the embolus passed. No one was sure how long I was officially dead, but this explains the tunnel and the bright white light.

I lived literally four houses from Lake Erie. The Lake was constantly calling my name. I looked at the water everyday. I heard the waves crashing each night. I didn't know if I would or could dive ever again. The consensus at the hospital was that I was extremely lucky to have survived. Actually, extremely lucky is a drastic understatement.

It took me over a year to get back in the water. Finally, after a tremendous amount of mental preparedness I was ready to make the big dive to the bottom of a pool. My dear friend, Joe Steffen, arranged a free indoor pool for me to use late at night when nobody was around.

At first the noise of the exhaust bubbles freaked me out and I surfaced immediately. The last time I heard and saw my bubbles underwater was when I was fighting for my life. The sound took me right back to the wreck. PTSD. After a talk from Joe and some mental rehearsal I was able to submerge. *Hell, I was in a pool after all - what could go wrong? I was in less than 10 feet of water*, I told myself.

I figured the best thing to do was to start with the basics - emergency drills, doffing and donning my mask underwater, switching regulators, turning air on and off underwater, hovering, buoyancy, and most importantly, just breathing. We even did emergency air ascents (even though I successfully ascended from 127 feet (39 meters) on one breath of air). Joe and I finished with complete gear swaps underwater while buddy breathing.

After a couple pool sessions I felt I needed a "check dive" at a quarry. I made my way out to Gilboa Quarry - the legendary Midwest 14-plus acre quarry. The quarry is great as it offered a tremendous amount of different sites with maximum depths over 130 feet (40 meters). I tested my buoyancy inside the sunken school bus and the Grumman Gulf Stream Twin Turbo Prop plane. I felt nervous, but it was great to be back in a wreck again.

I finally came full circle and started diving the well preserved wrecks in Lake Erie again in the summer. I started with my three favorites in Lake Erie's Central Basin - the sunken tug *Admiral*, the three-masted schooner-barge *Dundee*, and the schooner-barge *LittleWissahickon*.

Success. The horrific nightmares I had been having on a nightly basis since the accident suddenly disappeared. It was extremely difficult seeing myself drown every night. I needed to get back in the water and wreck diving was the cure. Lake Erie can be a cruel mistress but

I had to prove to myself that I could dive again.

All was well until tragedy struck once more. Joe Steffen, my dear friend and dive partner who had been so instrumental in getting me back in the water, suffered an embolism and died while on an expedition in Canada in 2007. He hadn't been as deep as I had on his fateful dive. I will never forget the phone call I received to let me know Joe was gone - I was grocery shopping with my oldest son. The phone call ended with "you're lucky you survived". Yes, I was. That is another story for another time.

Again, if you do it enough and you do it long enough, it becomes a matter of *when*, not *if*, something happens. Yes, luck may play a part in it, but it all comes down to how well you can control your emotions, your mental state, and making sure you stay calm and not enter the panic cycle. Once you get in the cycle it's difficult to get out, if not damn near impossible. At that point, evolution and ancestral instincts take over. It's imperative to break the cycle otherwise "fight or flight" can kill you underwater. Seconds count below the surface and sometimes all you need is one to make the difference between someone telling you my story, and me telling it to you.

"Don't jump in the water unless you are prepared not to come back from it"

- Tony Maffatone, died while diving the *USS San Diego*, 02 Aug 2000

Safe diving.

Erik Petkovic began his diving career in 1997 and has logged hundreds of dives along the East Coast and the Great Lakes region of the U.S. An avid shipwreck researcher, he has been published in multiple international dive magazines. He is currently authoring two forthcoming books Shipwrecks of Lake Erie and a yet to be titled photographic companion book. Erik is available for seminars and speaking engagements. He currently resides in Southern Maryland with his wife and two sons.

"*Deep Into Deco* is a stimulating read which covers almost every facet of diving from breathing to technical decompression. It is well referenced and dives into (forgive the pun) great detail concerning the past and present of diving theories. I recommend this book for all divers from novice to technical expert because Asser Salama makes even the most difficult topics seem easy and understandable. No diving collection is complete without this super overview book. I will keep mine on the coffee table as a discussion piece."

—Commander Joseph Dituri,
US Navy Saturation Diving Officer (ret) and Vice President of IANTD

"This book is long overdue. And it's worth the wait. What Asser Salama has accomplished with this book is remarkable. He has taken that early history of experimental trial and error and produced a stunning reference text that brings the science into sharp focus."

—Bret Gilliam, founder of TDI

"Asser's book is the best general overview of decompression modeling I have seen. The information it contains is relevant to divers of all levels, from the occasional sport diver who wants to know more about how their dive computer works to the technical diver planning extended decompression dives. It certainly is a welcome addition to my dive library!"

—Jeffrey Bozanic, PhD, author of *Mastering Rebreathers*



*Hyperbaric Oxygen
Therapy
By Bruce Konefe*

In the past hyperbaric chambers were primarily used for commercial divers and a few cases of Decompression Illness (DCI). Each year there are countless numbers of newly trained divers and the need for more chamber facilities and staff. The technology that divers and doctors have now is much more advanced than what it was 20 years ago. Today, divers are doing much deeper, longer dives with different multiple gases with greater risks involved. The risks go beyond that of just DCI to include things like inert gas counter diffusion and high pressure nervous symptoms. Being in the water with someone experiencing some of these issues and having to miss required decompression definitely makes for a bad day.

Outside of diving, doctors have been experimenting and finding that Hyperbaric Oxygen Therapy (HBOT) has many more uses other than just for DCI. There are actually 14 U.S. *FDA Approved Indications* for HBOT. Doctors have found that HBOT can help patients that have such issues as DCI, air or gas embolus, carbon monoxide poisoning, clostridal myositis and myonecrosis (gas gangrene), crush injuries, arterial insufficiencies, compromised skin flaps or grafts, severe anemia, intracranial abscess, necrotizing fasciitis (fourniers gangrene and others), osteomyelitis (refractory), delayed radiation injury (soft tissue and bony necrosis), acute thermal burn injury and idiopathic sudden sensorineural hearing loss. Outside of the U.S. in countries such as Russia and China there are as many as 74 approved indications, with others being studied at this time.

There are basically three different types of hyperbaric chambers that are in use today.

PORTABLE CHAMBER

Portable chambers can be found in liveaboards and are used extensively by expedition planners. They are almost always mono place. Some

of these units can be unpacked and set up ready for treatment in 15 minutes.



MONO-PLACE

MULTI-PLACE

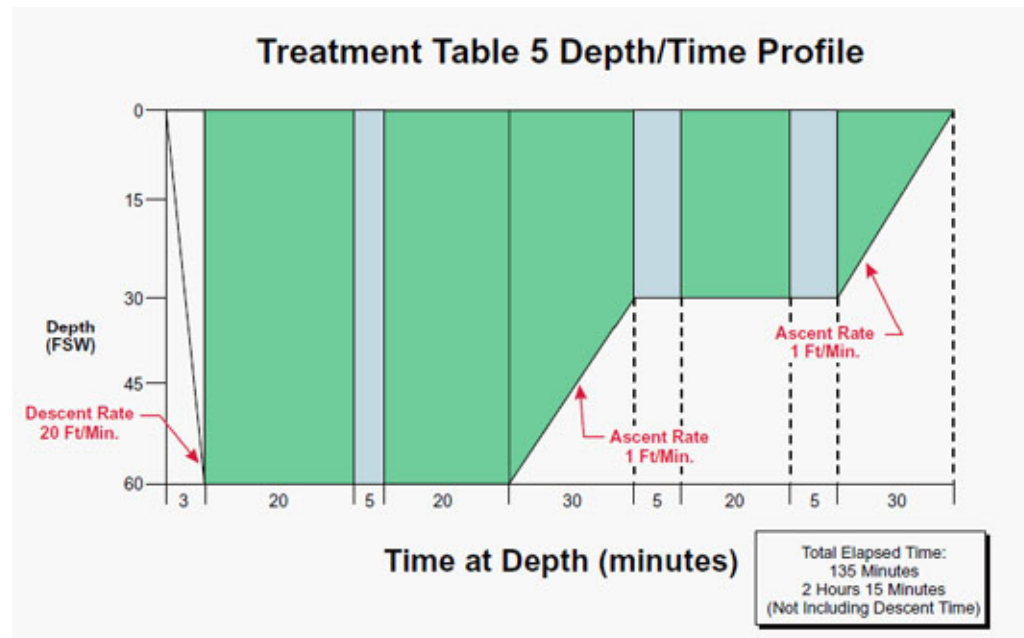
Multi-place chambers can range in sizes that can treat anywhere from 4 to 14 patients and even more. These chambers allow multiple patients and also have a chamber tender inside to take care of the patients. These chambers have improved drastically. Now you can literally walk into the chambers, have temperature controlled and even TV. One of the bigger safety factors of these large double lock chambers is that they have a second lock that allows a doctor to enter in the middle of a treatment in case of any emergencies or just to bring in any medical supplies.



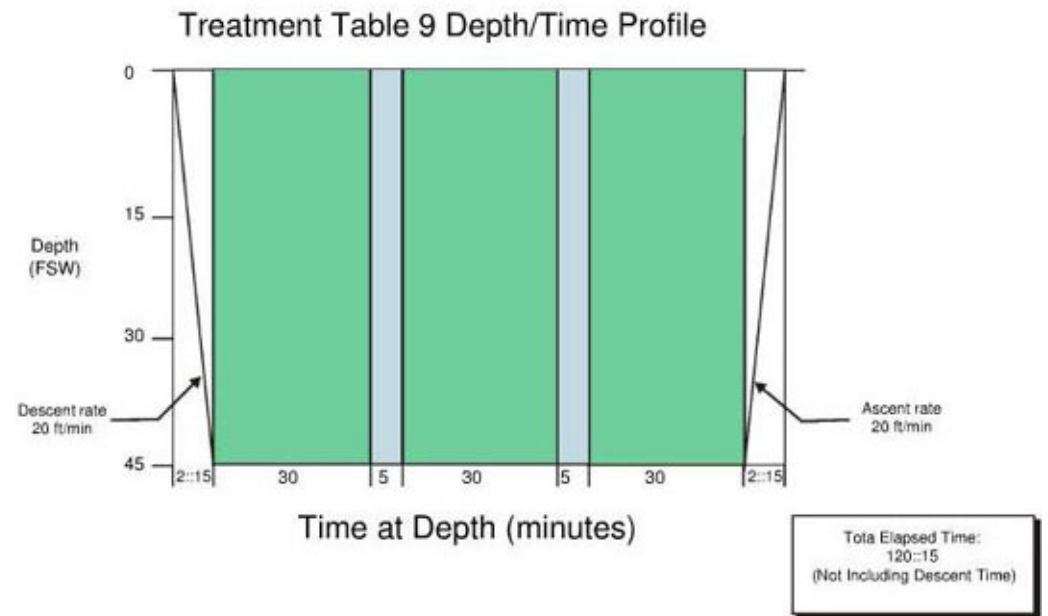
Advanced Hyperbaric Life Support
(Quezon City, Philippines)

Diving Medical Officer (DMO)

The role of a DMO is to perform a medical checkup on the patients. The DMO is the one who will prescribe the actual treatment to the patient. There are 3 basic chamber treatments that are commonly used, however these treatments can vary slightly from different countries and chamber facility. The US Navy table 5 & 6 are most commonly used for DCI treatments while the table 9 for healing wounds. Tables can be altered and lengthened if the original treatment is not sufficient.



With more use of hyperbaric chambers increases the need of chamber operators, tenders and diving medical staff.



Diver Medic Technician (DMT)

is highly trained in advanced medic first aid and paramedical techniques in an emergency situation. The DMT training is well above the basic life support learned in recreational diving. It is usually a two week (80 hour) training program covering topics in Advanced Medical Care.

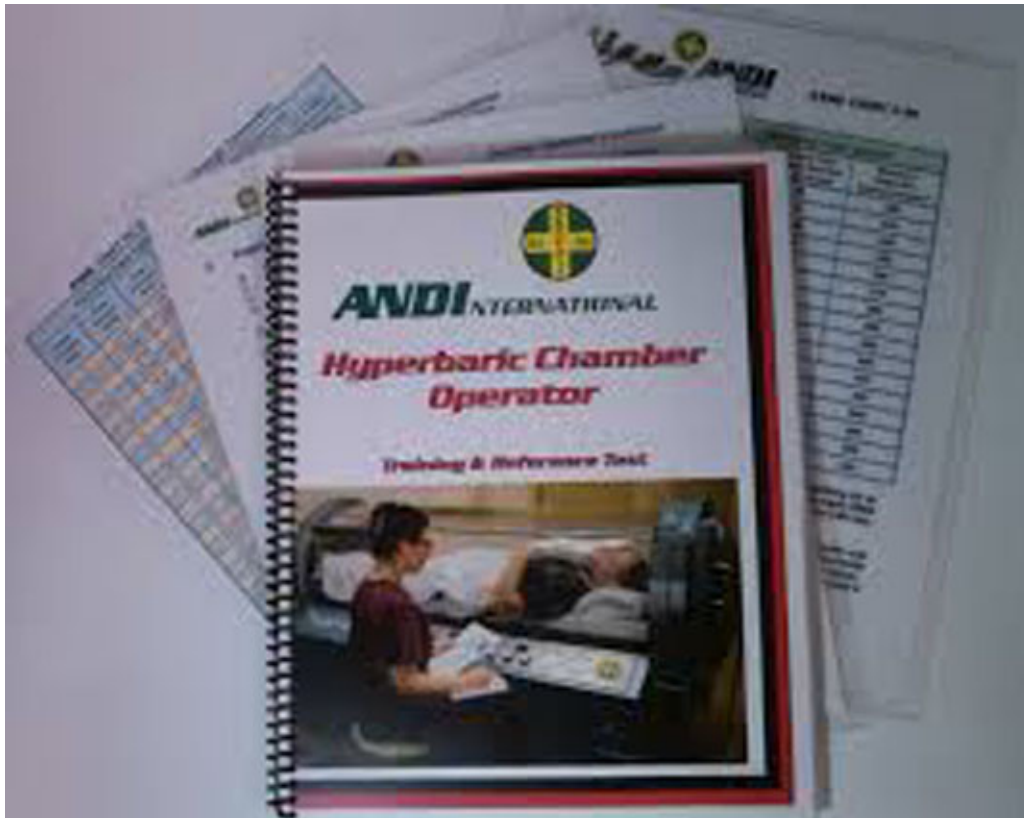
It is required that at least one non diver on a commercial diving operations be DMT certified. The goal for the future is to have every member be DMT certified. With the technology and the types of dives that technical divers are doing today it is highly recommended to have a DMT there who can help assist in the case of an emergency. It is not unusual to show up to a dive site and a team of technical divers will be doing dives in excess of 150m/500ft using Closed Circuit Rebreathers. This is a far cry of what divers were capable of doing 20 years ago. Much more medical assistance is needed on a dive like this than your basic life support. The DMT will be able to render assistance while being in contact with the local DMO.

Hyperbaric Chamber Operator

is trained in all of the theory, function and delivery of clinical treatment protocols for a specific mono-place and multi-place hyperbaric chamber in a clinical environment.

Hyperbaric Chamber Tender

is provided the background in physics, physiology and procedures of hyperbaric treatment, in general, along with patient care and counseling so as to allow the individual to assist a fully certified Hyperbaric Chamber Operator in the handling and treatment of patients in a multi- place clinical environment.



To become a certified Hyperbaric Chamber Operator and Tender you will find most courses will last 5 days.





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