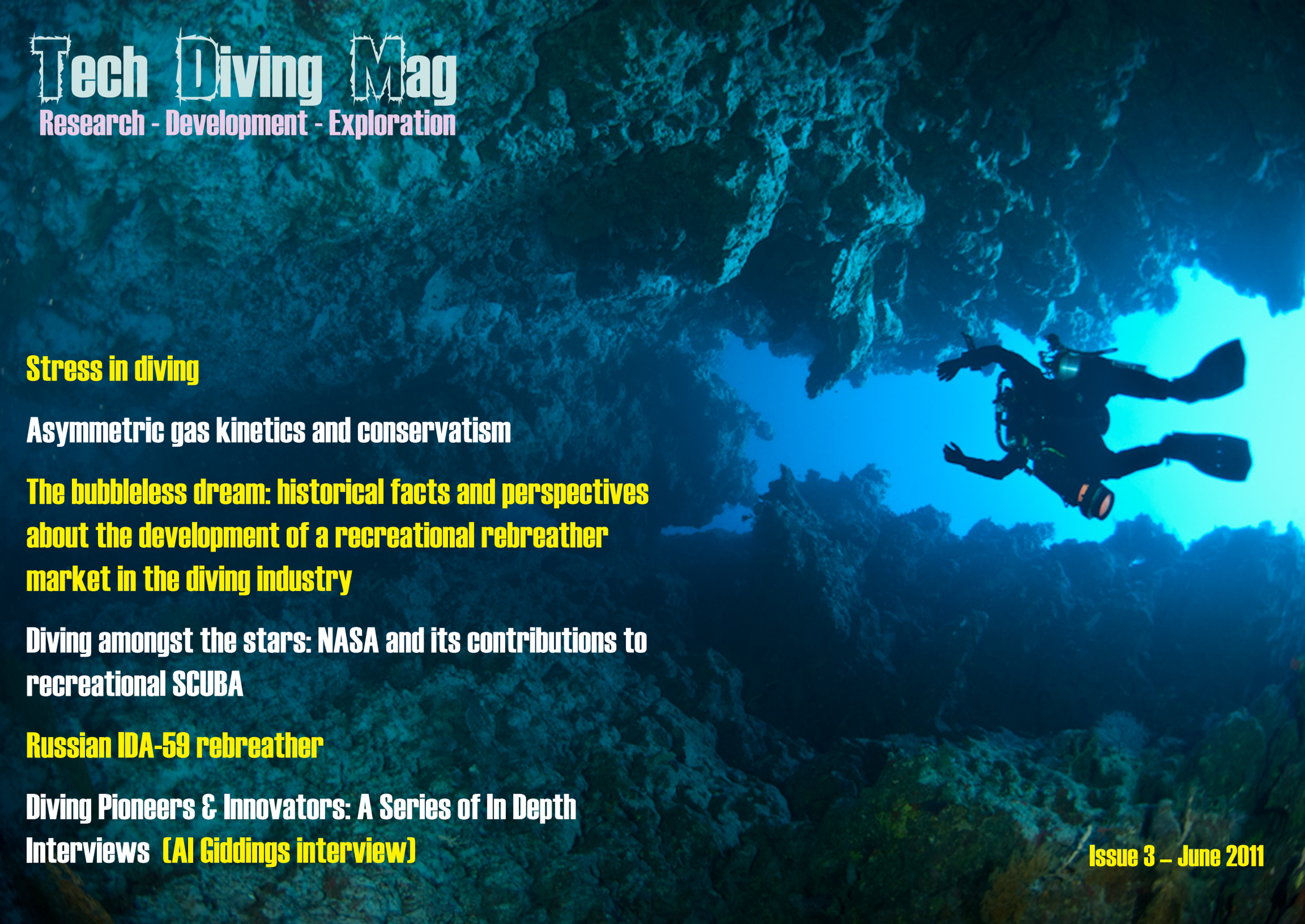
Tech Diving Mag

Research - Development - Exploration



Stress in diving

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Diving amongst the stars: NASA and its contributions to recreational SCUBA

Russian IDA-59 rebreather

Diving Pioneers & Innovators: A Series of In Depth Interviews (Al Giddings interview)

Issue 3 – June 2011

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Editorial

Welcome to the third issue of Tech Diving Mag.

The inaugural issue was a great success, and thanks to the interesting topics and quality articles the contributors presented, the success continued with the second issue. In the third issue of Tech Diving Mag, the contributors have, once more, brought together a wealth of information. The contributors for this issue are world renowned industry professional Bret Gilliam, retired NASA researcher Michael Powell (MS, PhD), technical diving instructor trainer Matti Anttila (MSc, PhD) and technical diving instructor Jorge Mahauad. Read their full bio at www.techdivingmag.com/contributors.html.

In addition to articles, Tech Diving Mag will start publishing a chapter at a time of the very interesting book "Diving Pioneers & Innovators: A Series of In Depth Interviews" by Bret Gilliam.

Tech Diving Mag is very much your magazine and I am keen to have your input. If you have any interesting articles, photos or just want to share your views, drop me a line at asser@techdivingmag.com.

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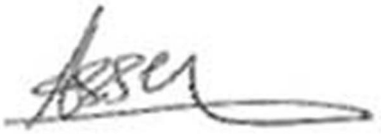

Asser Salama
Editor, Tech Diving Mag

Stress in diving

By Bret Gilliam

I don't want to participate in any sport in which my species is not at the top of the food chain.

Ken Fonte

Stress in diving is probably the central problem in the accidents and resulting injuries and fatalities that occur to divers . . .

Art Bachrach and Glen Egstrom

STRESS

Many divers do not seem to place traditional activities in the context of stress-inducing scenarios. Diving is supposed to be fun, right? The following passage is excerpted from Bachrach and Egstrom's (1987) *Stress and Performance in Diving*:

"We will cover your nose and eyes with a rubber and glass cup that will give you tunnel vision and prevent breathing through your nose. A snorkel which is partially filled with water will increase breathing resistance, especially when you work harder. A rubber suit will increase your surface area and your buoyancy while creating a restriction over each of the body's joints. (A partial adjustment will be made by fastening 15-20 pounds (6.8-9.1 kg) of lead to your waist.) Fins for your feet will make walking more difficult and require more energy when swimming. A buoyancy compensation device will provide additional drag, especially when it is inflated to increase your buoyancy. Approximately 40-50 pounds (18.2-22.7 kg) of steel or aluminum will be fixed between your shoulder blades by means of a backpack with a series of straps and buckles, which will terminate somewhere under the buoyancy compensator near the weight belt buckle. A regulator with various and sundry hoses and gauges will be attached to the tank and will cause you to breathe against an added resistance both during inhalation and exhalation. Various other items, such as knives, gauges, goody bags, cameras, spear guns, gloves, hoods and booties will be added for your comfort and convenience."

These learned authors (by this humorous accounting) have accurately placed into perspective the realities of the stressful environment that scuba divers willingly subject themselves to. By necessity our sport is "equipment intensive" and simply donning that equipment can produce levels of stress far in excess of what the average person may be comfortable with. Indeed, divers have been observed to reach heart rates approaching 200 beats per minute... nearly 3.5 times the normal rate, just gearing up!

Technical diving not only subjects the participants to added stress but the deeper environment also makes coping with such performance detriments critical. In our discussions we are most concerned with recognizing the early effects of stress and dealing with the effective management of these stimuli underwater.

Stress is variously defined: McGrath (1970) describes it as "a result of an imbalance between the demands placed upon an individual and the capacity of the individual to respond to the demands." Sells (1970) states "for a situation to be stressful the individual must perceive the consequences of his failure to be important." These two views provide perspectives from both the physical and mental effects and clearly show the potential for compound stress stimuli to be at work simultaneously in the diver. Smith (1979) provides a succinct overview, "in the context of human behavior, stress might be regarded as a force that tends to break down an individual's ability to perform. Physical stress tends to weaken or injure the diver; psychological stress leads to behavior impairment."

The role of stress in technical diving applications cannot be ignored. Typical reactions to stress include such signs as rapid breathing or hyperventilation, the consequence of which should be immediately apparent. Importantly, stress is so varied to individuals that even what may be considered a "routine" problem can be highly stressful in some divers. Bachrach and Egstrom (1987) describe stress as "basically learned" and this perception is learned through "modeling" behavior. If your mother was afraid of reptiles, this phobia may well be passed along to you subconsciously. Likewise, many of the public have an inherent dread or horror of sharks or moray eels with no actual experience to justify such fear. Experienced resort guides think nothing of hand-feeding eels or swimming with sharks but to the uninitiated the mere appearance of such a creature can rapidly induce stress reactions that can lead to near panic.

We all probably have a few skeletons rattling around in our mental closets... some that we may not have even a vague recognition of. Well-experienced divers have reported extreme anxiety in their first encounter with "silting-out" situations in caves or wrecks. Willful control of this stress anxiety through discipline and fall-back on training can prevent escalation to a threat scenario.

SOURCES OF STRESS

"**Time pressure**" is a classic method used by psychologists to alter experimental testing and induce error by test subjects. Problems that are easily accomplished become increasingly difficult and sometimes impossible if the element of time is introduced as an opponent. Diving, especially deep diving, is time dependent: we only have so much allotment due to constraints of decompression and/or gas supply.

This emphasizes the importance of dive planning so that orderly progression of the dive is maintained within the dive envelope

calculated. Deviations from the plan can cause rapid acceleration of time pressure stress inducements. This is true not only for the dive itself but for pre-dive activities such as gearing up. Do not allow yourself to be hurried into mistakes. How many times have you observed divers entering the water without a mask or without fins? Simply putting the gear on an empty cylinder without checking its pressure happens too often.

"**Task loading**" is another factor well known to produce errors in performance. Simple enough: give the diver more projects (tasks) to do than he reasonably can accomplish in the time period allotted. Or give him competitive, multiple jobs that require him to do two or more things at the same time. Divers are already burdened with monitoring gauges, keeping track of their position underwater (pure navigation and also depth trim), noting the performance of a buddy, etc. Add to this equation an underwater camera system or duties requiring written observations and we have a fairly well "task loaded" diver before any contingencies may arise. And let's remember that all this activity is being attempted in water deep enough to have effects from narcosis and gas density for breathing purposes.

Environmental considerations such as current, cold water or reduced visibility will all contribute to stress loading. Further, physical exertion to deal with such environmental detriments *and* any normal exertion on the dive will lead to compounding of stress factors.

Equipment alone can be a primary source of stress inducement simply due to its bulk, weight, drag etc. Take note of the experienced diver whose gear is streamlined and well organized. This individual will be wearing a BCD selected for its suitability for the dive situation. Tropical wall diving in warm water is far more easily accomplished with a light wet suit (2mm) or dive skin with a neoprene vest. Combining this with the newer editions of BCD's that feature less volume, form fitting styles and a full-foot power fin eliminates the needless bulk of heavier wet suits, booties etc. Gauges conveniently mounted in a single console with a dive computer provide easy viewing and no distractions of arm or wrist attached devices. Combining the "octopus" second stage into one of the inflator/second stages further streamlines the diver. A light-weight belt sized for neutral buoyancy at low tank pressures (to facilitate safety and/or deco stops) completes the package.

Obviously, this equipment package must be modified as we deal with cold water, cave or wreck situations but the emphasis on effective management of equipment should be obvious. Consider the equipment stress of the diver outfitted for deep water mixed gas wreck diving: we see him in a dry suit, dual 120 cu. ft. (17 liter @ 200 bar) cylinders, redundant regulators and gauges, redundant BCD's and inflators, heavy weight belt, lift bags, decompression reels, and, in many cases, stage bottles of NITROX and O2 clipped to his rig. This individual may well have in excess of 200 pounds (91 kg) of equipment strapped to him.

All this adds up to a diver who is heavily predisposed to performance-limiting detriments before he ever leaves the surface. Indeed, this individual may already have exceeded his physical limits to safely conduct a dive simply due to the equipment load he has strapped on. Is this a comfortable, relaxed diver? Maybe... but add a rough sea and a pitching boat with a violently surging swim platform or ladder, and unless this diver is a superior physical specimen, it will be a major stress loading activity to deal with the equipment and get into the water safely.

This leads into the current debate about what equipment is necessary for deep diving. Many experts *do* have some concerns about trends that exhibit a fascination for equipment-intensive outfitting far in excess of the practical requirements of the dive. At some plateau, the point of diminishing returns is reached: is carrying 300 cu. ft. (42.5 liter @ 200 bar) of gas effective if the performance detriment by the sheer weight/size/drag of such gear requires the additional gas supply? Gilliam (1990) deliberately chose a single cylinder (115 cu. ft. – 16 liter @ 200 bar) and regulator package to lesson his equipment load on his record 452 fsw (137 msw) compressed air dive. With proper breathing techniques etc. he was able to comfortably complete the dive on this reduced rig. He relates, "some would argue that redundancy is a requirement at such extreme depths but with DIN fittings I was not concerned with a regulator failure at the valve. Therefore, the physical stress and distraction of extra equipment to me was not justified. I wanted to carry enough gas with me to do the dive, obviously, but the single cylinder provided that for me and I was far more comfortable in the water." This was over 21 years ago and today an abundance of alternative gear options exist.

Logically, deep divers must carry the gas volumes necessary to do the dive plan with an adequate safety margin. Extended decompression in colder water will dictate larger gas storage carried by the diver but we caution our readers to carefully weigh the equipment stress load with operational requirements of the dive site. There will always be debate on what equipment *is* necessary but a perspective on what is realistically matched to the dive plan must be encouraged.

An experienced diver dresses for the occasion as it were. A tuxedo is not required for a backyard barbecue. Veteran divers who have access to the most advanced gear will not hesitate to simplify a gear set when conditions allow. Gilliam's record dive to 452 feet (137 meters)

was focused on a specific goal and was of limited duration. In such extreme depths on air, he balanced his gas volume needs based upon vast experience against his performance ideals dictated by a stripped-down and low-drag configuration gear set. In contrast, Sheck Exley's record mixed gas dive to 881 feet (268 meters) had totally different requirements due to cold water, multiple gas switches, extreme depth and drastically extended decompression time. Both dives were extremely hazardous and conducted solo, but both were successful, in part, by balancing equipment packages to the precise operational need.

Divers should be aware in intimate detail of their personal gas consumption rates at a range of depths and dive situations. Likewise, a consideration of their thermal comfort and suit needs must be plugged into the equipment equation. For Caribbean divers conducting multi-level drop-off wall excursions to depths up to 200 fsw (60 msw), a single BCD is probably adequate with an oversized single cylinder and a regulator with DIN fittings. Some would like the redundancy of a Y-valve for regulator back-up. Fine...we are still dealing with a manageable gear package. The same dive conducted on northeast wreck will obviously call for an expanded gear set including doubles, dry suits etc. But let's always keep in mind the common sense rule of equipment stress: Match your gear set to your operation.

Ego threat stress is significant as well in our dive planning. Smith (1979) notes, "An individual can be effectively destroyed by tearing down self-esteem, pride or ego. . ." The overextension of capabilities by personal challenge or peer group pressure is a leading contributory factor to deep diving accidents. Individuals must seek at all times to do dives within their own limitations. Gentile (1988) relates the case of an experienced northeast coast wreck diver who elected to sit out the last dive of the day as conditions worsened. Unconcerned by any supposed negative peer reactions, Gentile praises this individual for his good judgment in knowing when to quit.

We must not let perceived ego threats intrude on our good judgment. Divers should not encourage others to participate in deep diving activities with which they are uncomfortable. The emotionally mature diver can abstain from diving in any situation with no attendant ego damage. Smith (1979) puts it best: "The truly mature person can do this even when others may extend themselves further into the situation because of either their superior ability or their own foolishness. The threat to one's ego when one must back away from a challenge can be quite stressful, and tolerance to this stress is important in diving. . . A diver who is incompetent and knows it may be stressful. An incompetent diver may also be stressful to other divers who know about the incompetency. A diver may even stress companions into death by threatening their ego through constantly challenging them to test their limits to save their pride."

EFFECTS OF STRESS

Even a passing review of the material will demonstrate that sources of stress are varied and quite probably unlimited. Now we shall briefly look at the behavioral mechanics of stress and the resulting mental narrowing. As we heap stress loads on our diver he becomes less sensitive to his environment and less able to intelligently focus on problems. These interferences with mental thought processes manifest in several classic ways:

"**Perceptual narrowing**" whereby the diver is unable to notice or deal with subtle developing aspects of a situation and perceives only the grossest or more obvious elements of a problem. At depth, the effects of such narrowing are more serious. A diver who finds himself unable to maintain neutral buoyancy and continues to fixate

on depressing the inflate button of his BCD to no avail has lost the intellectual ability to perceive another solution to his problem.

"**Cognitive or analytical narrowing**" whereby the diver is hampered in his ability to analyze a problem. Example: a diver barely reaches his decompression stage bottle because he was low on air. As he begins his 20 foot (6 meter) stop, he has trouble breathing but the indicated pressure is 2500 psi (170 bar). Under sufficient stress he may not realize that the valve is not open all the way or that switching to the "octopus" would solve the problem.

"**Response narrowing**" occurs when the diver is unable to focus skills and knowledge upon problems. This typically manifests with loss of poorly learned skills or behavior. Over learned, reflex action type skills are retained longest. The obvious importance of drills and skill repetition until reactions to certain situations are second nature cannot be overemphasized.

"**Panic**" is usually described as unreasoning fear, the ultimate plateau of mental narrowing. Smith (1979), "As stress increases, the diver's ability to diagnose and respond to them properly may diminish accordingly. In any stressful situation, it is critical for the individual to break out of this escalating cycle as quickly as possible. . . . early detection is important. Thus, it is desirable to recognize the early symptoms of stress in your own behavior and in the behavior of others before these symptoms reach panic proportions. Panic is the end of the line. It is usually terminal and contagious."

SIGNS OF STRESS

Rapid breathing, hyperventilation
"Wild-eyed" look
White-knuckle gripping; muscle tension
Rapid, jerky, disjointed movements
Irritability, unreasonableness
Fixation, repetitive behavior
High treading, attempts to leave the water
"Escape to the surface" behavior
Stalling
Imaginary gear problems or ear problems
Contact maintenance (e.g. clutching swim ladder, anchor line, etc.)

SUMMARY

The anticipation of problem situations in a dive and the ability to adopt contingency plans calmly and rationally are vital in technical diving. Experience plays a great role in the individual's ability to deal with stress and to formulate alternative reactions to threat scenarios presented. Over learning of all relevant skills and complete familiarization with equipment is necessary. If over learning can be taken to its highest level, then much of the reactive behavior in an emergency will be reflexive and not require conscious thought processes. Smith (1979) notes, "Over learning takes all doubt out of human performance under stress as far as that particular skill is concerned. This not only greatly reduces the probability of human error on certain tasks but also frees the diver's mind to deal confidently with more complex aspects of the problem."

Stress accompanies us everywhere and is magnified in deep diving activities. Know yourself, know your buddy and/or your diving team. Dive within your limits.

NOTE

Excerpted from "Deep Diving: An Advanced Guide to Physiology, Procedures & Systems" by Bret Gilliam (with Robert Van Maier and John Crea), 2nd Edition 1995.

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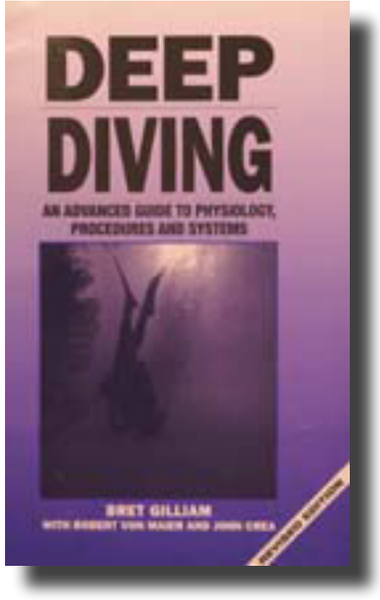


ASYMMETRICAL GAS KINETICS AND CONSERVATISM

By Asser Salama

© Haitham Aziz.

In my "Golden compartments" article featured in the second issue of Tech Diving Mag, I mentioned that I frequently use zero level conservatism when planning decompression schedules. I added that "when I feel like adding more conservatism, I just adopt the very same zero conservatism profile and add more minutes (usually 3 to 5) to the last stop (usually at 6 meters – 20 feet using either 80 or 100 percent oxygen)." I use a tailor made VPM-B decompression planning tool I developed.

Handling conservatism is VPM

Now let's take a closer look at what VPM does for different degrees of conservatism. What both VPM-0 (the original VPM release) and VPM-B (the newer VPM version with Boyle's law compensation) algorithms do is assume initial critical radii, one for nitrogen and one for helium. Only bubbles with bigger radii than the critical radii are allowed to grow. Smaller bubbles will collapse. The current default initial critical radii values that we feed the VPM-B algorithm with are 0.55 and 0.45 micron for nitrogen and helium respectively. The older VPM-0 used a default value between 1 and 1.2 microns for nitrogen, and a default value of 0.8 micron for helium. VPM-B needed to reduce the initial critical radii values because it lets the nuclei (the bubble seeds) grow at each stop according to Boyle's law as the pressure is reduced at each ascent stop.

What VPM-B based programs do for handling conservatism is assume bigger initial critical radii values. For instance, 20% conservatism is 0.55 x 1.2 = 0.66 micron for nitrogen and 0.45 x 1.2 = 0.54 micron for helium.

Now use your favorite VPM-B planning tool to schedule some "normal" dives. Let's say for instance, 75m (246ft) – 20 minute TBT, 90m (295ft) – 15 minute TBT and 100m (328ft) – 10 minute TBT. Try different conservatism levels and you'll find that a 3 to 5 minute increase in run time offers a sensible margin. By experience, it seems that adding these extra minutes to the last stop on the richer mix rather than spreading them on various stop depths doesn't make any significant difference.

Conservatism for deeper and longer dives

Divers frequently double-check their plans and compare the generated schedules using different software planning tools with different algorithms. They often compare the VPM-B generated schedules with those of Buhlmann and gradient factors. This usually works fine for the "normal" type of dives like the ones mentioned in the previous section.

But what about deeper and longer dives with bigger decompression time penalties? Try for instance 165m (540ft) – 25 minute TBT, just to discover that the VPM-B generated schedule is not as close to that of Buhlmann. The profile comparison you used to carry becomes invalid. At this point, some divers believe it is mandatory to add more conservatism to the VPM-B generated schedule. Combining VPM-B and neo-Haldanian model plans does this. Now let's try a different way!

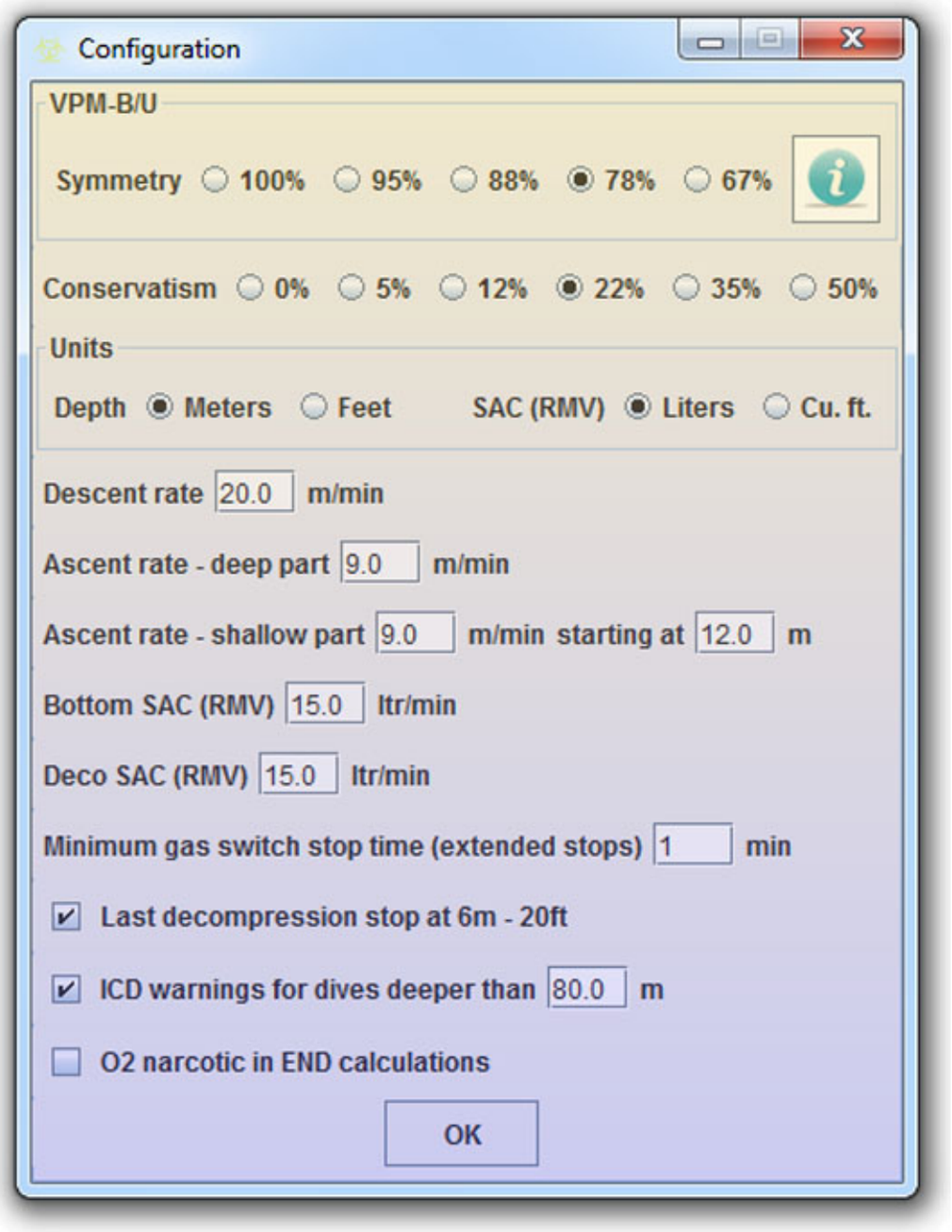
Asymmetric Gas Kinetics

In 1960, H.V. Hempleman presented evidence from animal studies that the uptake and elimination of inert gases are not symmetrical [1]. Body tissues absorb inert gas quicker than they eliminate it. In 1969, to fix the rate of elimination, he suggested a default value of 0.67 multiplied by the rate of absorption [2]. Based on observations from physiological experiments, T. Berghage, C. Dyson and T. McCracken concluded in 1978 that the rate of uptake and elimination of inert gas is not the same [3]. This concept has been confirmed by the experiments of R.E. Rogers and M.R. Powell in 1988 [4].

Several decompression models evolved around this principle and were implemented in dive computers. This was done in one of three ways. The first was to assume higher half times for the elimination process (on-gassing halftimes are lower that off-gassing halftimes). The second was to implement an exponential-linear model rather than the Haldanian exponential-exponential model (one of Haldane's basic assumptions is that both the uptake and the elimination of inert gas by tissue compartments take the exponential form). The third was simply having a symmetry variable multiplied by the rate of absorption.

Asymmetry and VPM

Jurij Zelic, the developer of VPM Open, an open source VPM-B based decompression-planning tool says, "the VPM is using a symmetrical on-gassing/off-gassing algorithm. Asymmetrical algorithm has been



proposed for simulation of cold water diving, but has, at least to my knowledge, not been studied deeper."

I've implemented the asymmetry concept in my tailor made decompression-planning tool. I call this new variation VPM-B/U (U for Ultimate). I use the third method, which is to have a symmetry variable multiplied by the rate of absorption. Setting this variable to 100% takes you back to original VPM-B results. The different degrees of asymmetry are 100% (symmetrical), 95%, 88%, 78% and 67% (the value Hempleman suggested back in 1969).

Results

Now let's try the 165m (540ft) – 25 minute TBT dive. Descent rate is 20m/min (66ft/min), ascent rate is 9m/min (30ft/min), travel gas Tx16/61 to 60m (200ft) in 3 minutes, bottom mix Tx8/71, decompression on travel gas starting at 90m (300 ft), Tx40/31 at 30m (100 ft) and Nx80 at 9m (30ft). Last deco stop is assumed at 6m (20 ft).

Using Deco Planner 3.1.4, the total dive time using:

- VPM-B with lowest level of conservatism (level 0): 423 minutes.
- VPM-B with highest level of conservatism (level 4): 516 minutes.
- Buhlmann with 30/85 gradient factors: 647 minutes.

Using my tailor made tool (Ultimate Planner 1.0, alpha version), the total time using:

- VPM-B with lowest level of conservatism (0%): 417 minutes.
- VPM-B with highest level of conservatism (50%): 532 minutes.
- VPM-B/U with moderate level of conservatism (22%) and high level of asymmetry (78%): 640 minutes.
- VPM-B/U with lowest level of conservatism (0%) and highest level of asymmetry (67%): 674 minutes.

Conclusion

Implementing the asymmetric gas kinetics concept in VPM allows using two dimensions of conservatism with multiple levels each. It seems to offer an additional margin of safety to the generated schedule.

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The bubbleless dream:

historical facts and perspectives about the development of a recreational rebreather market in the diving industry

By Jorge A. Mahauad

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Innovation plays a vital role in any industry. The development of new business concepts; the evaluation and improvement of core processes and the "invention" of new products is very closely related to the capacity of an industry to innovate. As a result of innovation, growth is driven and opportunity is developed. And it is this recognition of opportunity by entrepreneurs who are brave enough to challenge the established cannons what breathes life into a mature industry or what creates new ones. But innovation is not necessarily a process requiring geniality, inspiration or passion; it is more of a structured discipline that brings creativity, knowledge and common sense into a known situation and then redefines perspective. Given that the rewards are attractive enough; the right people, sufficient resources and simple change in approach could result in substantial innovation and therefore in a whole new world.

What if we could reach about 90% of the consumers in the market with a product that appears new and high tech; that provides interesting features that could be explained and escalated as the customer grows; that provides considerable physiological advantage; that will boost enjoyment and make the user look and feel "cool"? What if this industry already had the basic technology and know-how to promote, manufacture and distribute such a high profitability innovation? What if we knew and had the technology to solve almost every barrier we have identified as a limiting factor? I think any business minded industry professional would like to take a close look at a hypothetical situation like this.

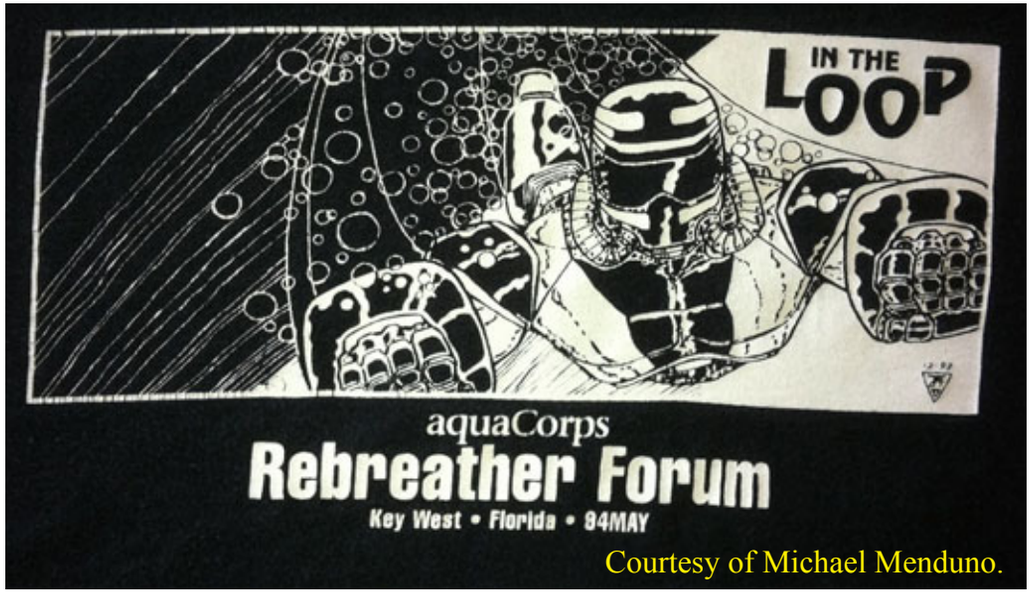
Now, what if in that analysis, we business minded industry professionals look back and find out that others have already failed in trying to achieve such innovation? What if after considering the risks we conclude that the quest for achieving such product is not only a source of competitive advantage and return of investment but also, a bet that could literally kill the customer; what if all the attractive product attributes we communicated bring considerable liability and potential bad press to everyone who is involved? I think this is what recreational rebreathers are about and my objectives in this article are to summarize and bring the facts forward with some analysis involved.

© Natasha Maksymenco, ANDI Underwater Photography Instructor.

Although a rebreather is often regarded as "new" or "innovative" in press less than rebreather or technical diving specialized, this simple concept has been around since at least 1650. The first certainly known working rebreather is credited to Henry Fleuss in 1878 and diving rebreathers are in use since about 1900. Several improvements and enhanced applications were introduced in their military use and important contracts with private companies supplying the military drove their development and fine tuning. On the other hand, restricted access to information and classified secrecy from manufacturers held back the rebreathers and their technological advances from sport divers.

Rebreathers were carried to the sport diving arena by the highly trained and experienced military divers who decided to make sport diving a hobby. With divers exploring deeper and longer into caves or wrecks and with pioneers pushing the envelope of mixed gas and decompression theory the advantages of diving semi closed and closed circuit mix gas rebreathers became essential. At this stage rebreathers started to become a mission oriented tool for particular jobs that usually required expensive gases and long periods of time underwater. As a result, so called "boutique" manufacturers started developing rebreathers but did not provide mass market support, proper liability insurance or third party testing. Most of the existing manufacturers in the early years of sport rebreather diving were home builders designing, developing, testing and diving their units according to their own philosophies and standards.

Since this article is about recreational rebreathers and not rebreather history great detail in the early development of these devices has been omitted. Probably the first recorded and formal mention to the business potential of recreational rebreathers would be in 1994, during the Rebreather Forum hosted by Michael Menduno's magazine *aquaCORPS*. This event gathered over 90 industry participants representing rebreather manufacturers, training and government agencies, commercial diving companies and private federations, military and many guru's in different aspects of rebreather diving. The main objective was to clear up the many myths associated with rebreather technology and discuss where to go from there.



Courtesy of Michael Menduno.

"Rebreathers seem to come back every thirty years and now it looks like they will remain with us for some time. With a virtually unlimited gas supply, optimal decompression, low bulk and bubble free silence, closed circuit technology is an idea whose time has surely come" observed Alan Krasberg, one of the godfather's of closed circuit systems during the forum. The event addressed many subjects including military operations, unit reviews, hazards and potential liability, ample discussion about training and a marketing and financial forecasts presentation. As the forum advanced the consensus seemed to be that semi-closed rebreathers would likely represent the first wave of product if a consumer rebreather market was to develop. SCR units

were ideal for this due to their relative simplicity and relatively low cost. Moreover, semi-closed circuit equipment needed to supply only one breathing gas; that gas was usually the oxygen enriched air or nitrox.

Rebreather Forum came in a tense time within the diving community. The "hard" distinction between technical and recreational diving in the industry was starting to shape. Menduno had just christened the activity "technical diving" in 1991 and the technological advances that came from it were slowly filtering into the mainstream recreational diving aficionados. At the same time, many of the training agencies were rejecting several of these advances because they considered that changing practices would be harmful for the business, dangerous for the customer and therefore for the industry. All the differences converged into one point: the use of nitrox.

By trying to get this on perspective and in search of a trend, a comparison between recreational rebreathers and the development of oxygen enriched air as a recreational diving gas could be regarded. As we know, using a closed or semi closed circuit rebreather optimizes the fundamental nitrox benefit: less inert gas loading. In addition, the use of a rebreathing device increases the potential hazards and general cost of diving, just like nitrox was perceived to do back then. But similarities could end here. In the early ages of recreational nitrox the gas mix was being rejected by the recreational diving industry while nitrox illustrated technical divers were pushing its use as a safer choice for a diving gas given that proper training was provided. Today, rebreathers have been regarded as the next wave of innovation and the recreational diving industry has been calling for suitable and reasonably safe devices in the last few years while many technical divers resist the access to rebreathers by divers less qualified than them.

Rebreather Forum Crew

Back to the nitrox episode, the end result was simple. In the face of undeniable physiology and more illustrate divers, 1995 saw PADI announce they were going to offer full educational support for oxygen enriched air and in 1996 their programs were officially launched. PADI's endorsement put nitrox as an optional gas for the standard recreational diver and gave diving stores an economic reason to offer nitrox: The entry level nitrox user would require an entire course and certification to use this diving gas and a premium amount had to be charged for gas blending; in addition, new and specialized diving equipment and accessories were needed and this generated revenue for the store. This is probably the reason why PADI's representative Karl Shreeves stated, 'When rebreather technology is ready for the mainstream, PADI will be there to offer training' during the Rebreather Forum and the reason why the recreational rebreather market is something so attractive and expected today.

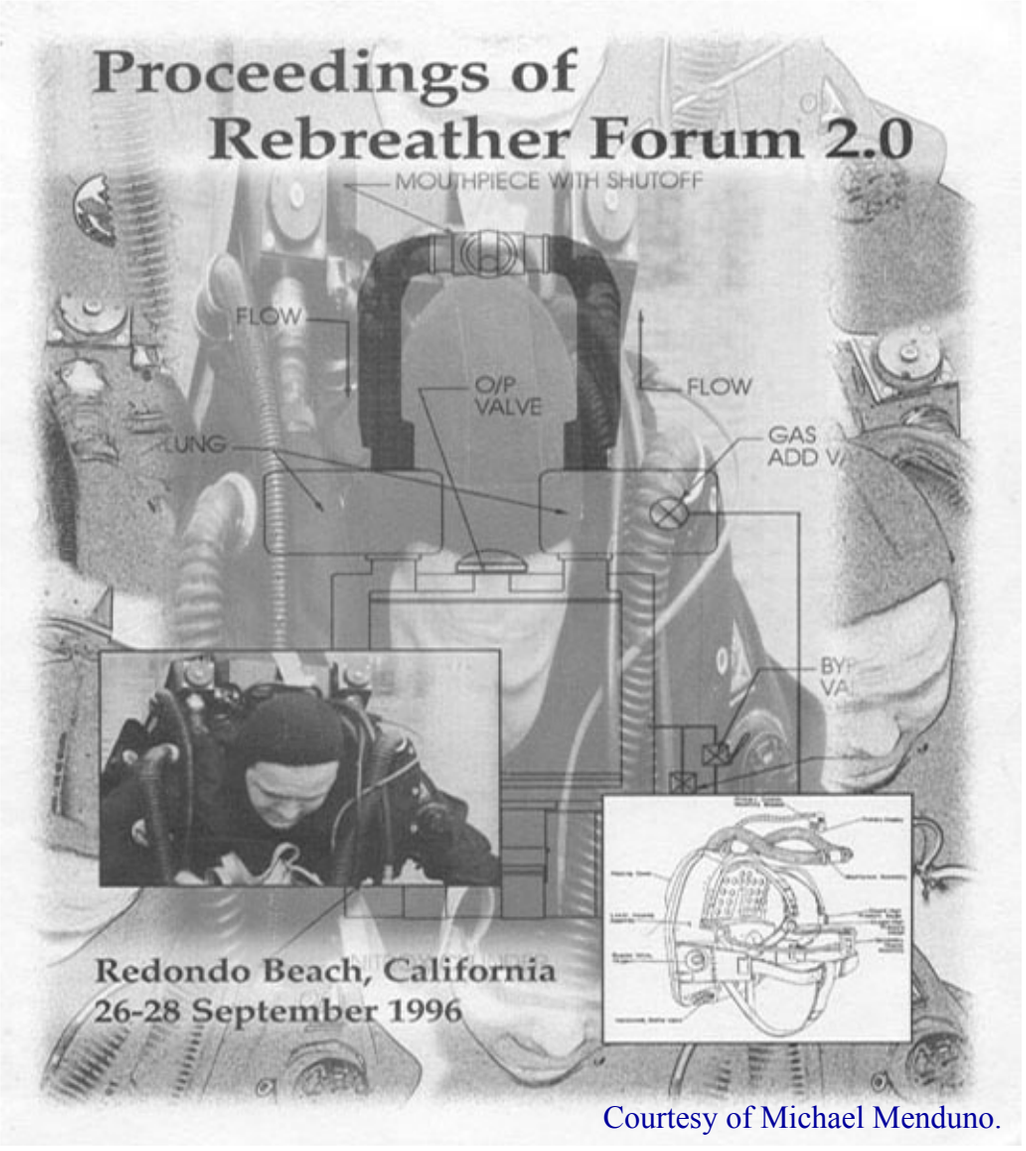
A few years passed and September 1996 brought Rebreather Forum 2.0. Christian Schult from Dräger assisted the forum and made a very interesting statement: "back in 1994, the company attended the first rebreather forum. We came back very confused. Where is the market

for recreational rebreathers?" – he said. Like a few other companies, Dräger had been in the rebreather business since the beginning of the century with their main business in military and commercial diving. A firm like Dräger was called to be the lead player in the sport diving rebreather: they had the technology and financial resources to develop such apparatus. But even in 1996, everyone seemed to know that the recreational rebreather market was not there yet.

In the same forum, Menduno stressed that the rebreather community needed to "work together to grow a rebreather pie". His reasoning was that there was no consumer market for rebreathers at that time. In any case, Dräger had embraced the position of an industry leader and placed the first real bid for the recreational rebreather market. They seemed optimistic, "now we have been on the market for about ten months and are more than happy about the results" Dräger's spokesman stated while referring to the Atlantis, a SCR unit launched in 1995 and distributed by UWATEC. "It is too early to say we went the right way. I would like to get more input coming out of this workshop, go back out on the market again, and come together for Rebreather Forum 3.0 and say: <<What happened>>?", he added.

Rebreather 3.0 has not arrived yet but the question was answered long ago: Nothing. The Dräger SCR's are no longer sold and the firm has no available rebreathers aimed to the sport diving market today. The Dräger experience, along with others like the O.M.G Azimuth and Grand Fleu's Fieno can help draw some conclusions about the market in that particular time: High cost, extensive training requirements, limited depth capabilities and the need for custom gasses limited the spread of SCR's aimed for the recreational market.

Despite the commercial considerations on the SCR's back then, Rebreather Forum 2.0 brought a great amount of information and thinking. Great advancements on independent testing; procedures and configuration; training and legal considerations and the main direction a consumer oriented rebreather should follow were sketched at the conference. The subsequent Conference Proceedings were published and this document is still considered an exceptionally useful reference paper to this day.



Courtesy of Michael Menduno.

In 1997 Ambient Pressure Diving launched their CCR to the market and it achieved several major milestones. The Inspiration was the first closed circuit rebreather to achieve mass production, worldwide distributorship and unit-specific training courses by major training agencies. Another marketing achievement was the perception of it as affordable and safe due to its CE rating. The Inspiration CCR became an award-winning and best-selling unit available for advanced sport divers quickly. But things would not be so easy for APD either.

With the increasing popularity of closed circuit rebreathers and more divers getting closer to the high end of the sport accidents started to happen. With a few high profile deaths as good fuel rebreather fatalities became a very attractive story. Diving a rebreather was considered exotic and the wide scope of possible deadly problems gave great room for appealing stories in local newspapers and among rebreather illiterate divers. Many lawsuits against established manufacturers were filed. The considerable variations between models and specific training required gave lawyers ample room for work. Deaths and lawsuits were followed by the media and the dark side of rebreather diving quickly spread in the rebreather illiterate diving community and in the public opinion. In the end, most of the accidents ended being regarded as "the user making fundamental mistakes with regard to basic equipment assembly, setup, or monitoring" but the public image of rebreather diving was already affected permanently.

As a result of the "rash of deaths" at least one training organization announced prohibition to its members from using rebreathers. On the other hand, the advent of mixed gas diving and deep helium based mixes rebreathers took off and rebreathers became a very valuable, sometimes essential tool. Technical divers and underwater explorers embraced the closed circuit systems because of their gas efficiency, fixed PO2 and the ability to manage the loop in several modes. The specialized use of these mechanisms and the high level of training and competence that users showed allowed ample room for modification and innovation in the technical diving subculture; a place where death is a price that many people accept as potential outcome and where pushing the limits is part of the very core. Technology has been a big challenge indeed and thanks to such passionate individuals, most of what we need to create a recreational rebreather is in place today.

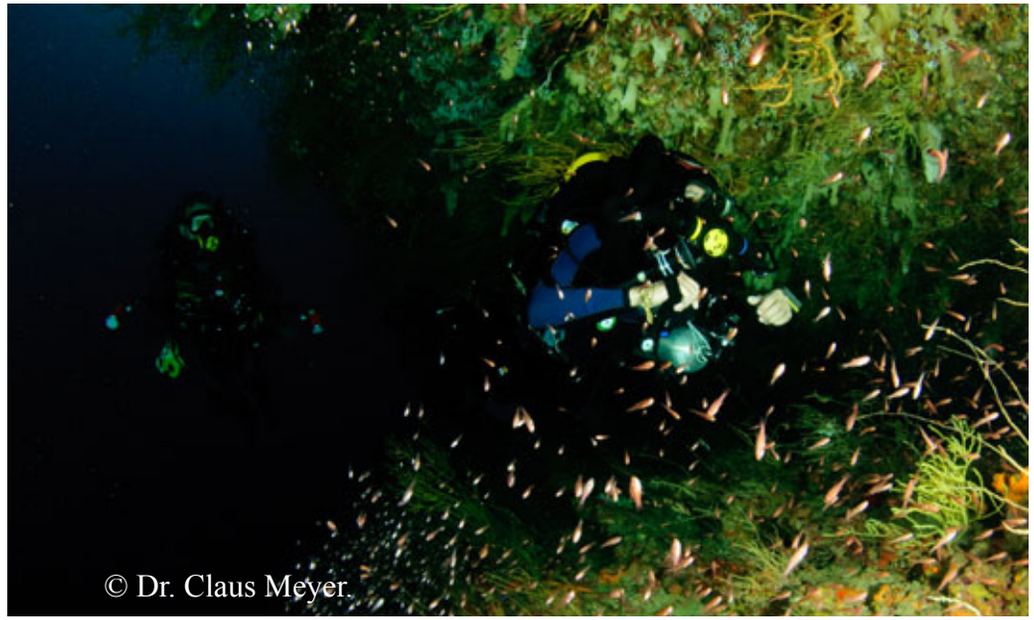
Rebreather Forum 2.0 Stand

But this technology did not come cheap. One major fact that kept the hands of many sport divers away from using a rebreather was cost. Even today, a closed circuit rebreather can be priced as high as a small car; to that argument, many deep helium mix divers justify the gas efficiency as a real cost offset. But, is this a convincingly strong enough argument to sport users in the recreational envelope? Clearly not; on the other hand, other people has approached cost issues from the enjoyment perspective. Diving is a hobby and so doesn't always have to be justified on cost offsetting analysis. One thing is for sure,

cost is an important component of what marketers call "product mix" and a 5 to 10 thousand monetary unit attribute has demonstrated to be a less than attractive component so far. But the fascination rebreathers excerpt on people continued to show up in the media and between 2000 and 2010 more than 15 articles on rebreathers were published by *Undercurrent*, one of the leading magazines read by "thinking" divers.

The only topic in which everyone seems to agree is that proper training is a keystone in diver safety and that this is paramount in rebreather diving. Since the 1990's several major training agencies in the technical or advanced diving had developed courses on rebreathers and course scopes changed widely. Almost every training organization had an entry level (air diluent, no ceiling) course but this level was often regarded as a stepping stone to more advanced forms of diving involving decompression, helium and overhead environments. If a recreational market was to be developed different strategies and marketing approaches were needed.

In the last few years, different strategies came to play. ANDI for example, partnered and provided a training facility dedicated to a specific rebreather, the Nautilus. Another example is the Rebreather Association of International Divers (RAID), who started marketing training on rebreathers for purely recreational diving purposes. This was an association created with the recreational model and developed training for divers using rebreathers from entry level; in addition, their courses were equivalent to the core levels sanctioned by the WRSTC. About the time RAID was created, many training organizations were presenting and developing e-learning programs that would complement their courses. RAID benchmarked this approach and implemented on line learning as the primary knowledge development mechanism. RAID's flagship unit was the Discovery MK6 and a partnership with Poseidon Diving Systems was evident; training in other rebreathers as distinctive specialties was available as well.



The similarity with the nitrox episode comes to mind again. A new association is created to offer training, companies with a more innovative approach jump into the market and start offering training. But when talking about recreational diving the undeniable master is PADI and when they started talking about rebreathers many eyes opened. According to PADI, an continuing that encourages continuing education, Enriched air is the most popular specialty in the world. This contrasts with the fact that currently there are no "coned" options for a number of potential nitrox certified divers who already meet the foreseeable requisites for a recreational rebreather course and that might be interested in maximizing the EANx benefit without talking about decompression and with the brand they have been told to be loyal to. PADI apparently saw this and in March 2009 that PADI's DSAT Technical Diving Division hosted a conference in New Jersey.

According to PADI's Director for Rebreather Technologies, Mark Carney in order for a new technology to be successful in the diving industry three things must be in place: Technology, training and travel. The conference addressed the subject on recreational rebreathers, among many others, and a list of desirable features was presented.

According to PADI an "R" type rebreather should be a robust unit, that can't be put together wrong way, which will not operate without scrubber, or that warns diver if scrubber is absent. The preferred carbon dioxide scrubber would be a standard pre packed cartridge. Other ideal characteristics would be wet activation, a simple emergency

status indicator and an automatic bailout switch that could be activated without removing the mouthpiece from the mouth. According to Carney, warnings should include empty or closed supply cylinders or low gas supplies, flooding, CO2 breakthrough, electronics failure, PO2 and PCO2 alarms. In conclusion, the recreational rebreather should be reasonably able to maintain life or, not permit diving if proper function is not 100% tested. All of the above made affordable by mass production of course.

Courtesy of PADI.

During DSAT Technical Diving Division Conference, Kurt Sjöblom from Poseidon Diving Systems presented the Poseidon MK6 Discovery, a rebreather intended for recreational divers. According to Sjöblom, the Discovery reasonably met all the items on the "wish list" except CO2 monitoring. At that time, a CO2 sensor useable in CCR was yet to be invented. A few months later (May 2009) a working CO2 detector was in final testing during Inner Space. Although a 100% accurate technology to properly measure CO2 is not available yet, at least two major rebreather manufacturers have CO2 sensors commercially available with their units, either as an upgrade or as a standard feature and advances are happening quickly on this regard.

2009 also saw PADI allow the use of rebreathers by supervisory staff in certain situations, the new guidelines for members were presented in DEMA. Months passed and PADI staff did a lot of "tire kicking" on new and existing models, dove several rebreathers and gathered with many industry professionals including manufacturers and rebreather courses were finally confirmed in August 2010 with the subsequent presentation of the advancements in Las Vegas during DEMA Show. February 2011 saw the testing of the PADI's rebreather courses and the courses will be launched later this year. Several advances have been made in the technology and training fields. To follow PADI's schema for success in the recreational diving market we should look a bit at the travel component. Actually, travel and support for rebreather divers seems to be the less developed component of all three.

Until now, most rebreather friendly facilities have been supporting technical diving; this is often the reason why they became rebreather friendly in the first place. Much of the existing infrastructure in stores offering technical diving can be adapted to the traveling recreational rebreather diver very easily. On the other hand, as the new breed of rebreather divers multiplies many stores will need to invest some revenue in order to keep up. Some issues are still to come and will become problematic as the market grows. At this time, there is no standardization in the basic items required to support a rebreather diver. Things such as in line of k valves; cylinder size, buoyancy, capacity; type of absorbent; type of oxygen sensors; tools, o rings,

mushroom valves, batteries and virtually every component varies from one unit to the other. This lack of standardization makes it is very complicated for travel destinations to have decent stock rental equipment and consumables for sale. In addition, some consumables such as oxygen sensors, CO2 absorbent and even breathing grade oxygen have expiry dates that require constant stock rotation and controlled storage conditions.

As security and luggage regulations coming from airlines and governments make it harder to travel with a very sensitive and broadly misunderstood piece of life support equipment, an opportunity for the local provider would appear. On the other hand, the amount of money needed to have a choice of units that are specific to a particular training will be very high and the only way to offset that investment would be a considerable volume of divers flowing into the rebreather friendly businesses or a generic component of training that could provide all the knowledge framework of rebreather diving and short "user manual" type of unit specific courses. At least in the beginning, a professional rebreather friendly facility, that could team match and support divers appropriately, would have a competitive advantage for both open and closed circuit diving.

2010 also saw development. EN14143, the European standard covering rebreathers was reviewed by representatives from recreational and technical training agencies, manufacturers of rebreathers, open circuit and commercial diving equipment and a number of subject experts in other fields evaluated rebreather safety in areas covering third party testing, work of breathing, absorbent duration with different gas densities, electronic security and PO2 / CO2 tracking and a broad number of other mechanics regarding direct sunlight / temperature, sound / vibration, failure mode analysis or "black box" recording, etc. In the meantime, during DEMA 2010 many manufacturers displayed new rebreathers, such as the "hybrid X" from VR technologies, or the KISS GEM, something they don't call a rebreather but that can be considered a PSCR. Other manufacturers like Aqualung, that had no business in sport rebreathers before also displayed their military or commercial units. Dräger was there as well, displaying what they have in production now and the long discontinued SCR's they developed for the sport diving market back in the 1990's. During DEMA, the Rebreather Education and Safety Association (RESA) was announced. According to the founders, "the objective of this association is to set a higher degree of cooperation amongst CCR manufacturers. It is intended that this group will also address manufacturing standards and some of the issues that will make their products more appealing to a greater audience."

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Rebreather Forum 3.0 will be held in May 2012 in Orlando. It's going to be the biggest rebreather conference to date and a significant event in rebreather thinking. There is no doubt that conference will bring an impressive amount of shared knowledge and fresh perspective to the debate. In the meantime, technology has definitely advanced regarding closed circuit rebreathers and the industry is aiming for these devices to become the next wave of product. Most of the engineering problems have been solved, many others are being addressed and new hybrid technologies are redefining the SCR – CCR differences. Training programs for the recreational market have been developed and the major player in the diving industry, who is said to provide training and branding to more than 60% of the divers worldwide, will release its recreational rebreather training courses this year. Even though the travel component of the industry is not able to support a great number of recreational rebreather divers yet, it is foreseeable that given the proper incentives it will quickly develop. Social media and personal channels will play a big role in the popularization and "cool" factor. Internet will allow great marketing opportunities, a capacity not available back in 1995.

On the other hand, the challenges that the first wave of SCR's had to face remain quite similar. In comparison, startup costs for recreational CCR's are as high as with the first recreational SCR's. Training requirements continue to be fundamental and the time needed to be comfortable underwater with a rebreather cannot be supplied by any e-learning program. In addition, the need for custom gasses remains similar since pure oxygen and EANx mixes above 36% are rarely provided by recreational dive operators. If people start dying on rebreathers, complaining about their function or commenting on the ugly truths of rebreather diving things can go wrong very quickly. From social media and Internet reputation to civil protection and manufacturer liability; a number of latent stakeholders awaits for an industry investing a considerable amount of money in a bubbleless dream that could pop off very easily.

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Diving amongst the stars:
NASA and its contributions to recreational SCUBA

By Michael R. Powell, MS, PhD

A DIVER BENEATH THE OCEAN and an astronaut performing a spacewalk might look as though they have little in common, but the truth is quite different. While performing extra-vehicular activity, or EVA in NASAese, an astronaut is actually at risk for decompression sickness (DCS). "Why might this be?" you will posit. The answer lies in the reduced pressure of the space suit (4.3 psi – 0.3 bar) and the difference between this and the spacecraft pressure. The cabin pressure of the International Space Station (ISS) is one atmosphere (1 ATM or 14.7 psi). This pressure was selected such that any changes found to the physiology of the astronauts could be compared to Earth-normal values, also 1 ATM. In terms of reducing the risk of DCS, a lower pressure ISS would be better, but would not allow the easily obtainable Earth-normal values.

The work in this paper describes research work of interest to recreational SCUBA divers and, it was performed under my directional during the years I was at the Johnson Space Center near Houston, Texas (1989 to 2005) and head of the Environmental Physiology and Biophysics group.

The Prebreathe for the Space Suit

Some background is in order prior to the story. The NASA space suit is referred to as the *Extravehicular Mobility Unit* or EMU [figure 1]. It is, in reality, much more than a suit. It is a small space ship having a life support system that can add oxygen and remove carbon dioxide, mobility components, shielding against micrometeors, and a communications system. [It is quite expensive, but it does come with two pair of pants. Not really!] The low pressure of the EMU is required to allow easy flexing of the limbs, especially the wrist and fingers. Even with the reduced pressure, fatigue of the hands is a major concern. This lower pressure of the EMU is equivalent to the pressure at the top of Mount Everest and the breathing gas is entirely oxygen. A direct, rapid ascent from the sea level to that summit would definitely result in a case of DCS. In this paper, I will tell of the research to provide a countermeasure (another NASA word) against DCS and relate the manner in which this information relates to safety of recreational SCUBA divers.

Fig. 1

The procedure by which DCS can be eliminated in an astronaut is to prebreathe oxygen prior to egress from the ISS. As one can imagine, if oxygen is breathed long enough, you can eliminate all nitrogen from the body. Clearly, while very effective, considerable time and precious (high pressure) oxygen would be consumed. So, the question becomes just how much is enough? To determine the requisite prebreathe duration, experiments were conducted at the Johnson Space Center near Houston, Texas. The object of the work was to determine the minimum time required. Time is money, right? Even to NASA.

Test subjects, both men and women, were selected to correspond to the age and weight range of current astronauts. These then performed an oxygen prebreathe of one hour to several hours. They then were depressurized in an altitude (hypobaric) chamber, two at a time, for several hours while performing a set of exercises. These consisted of a torque station (pulling and pushing wrenches), and cranking a hand ergometer [figure 2], all while the subjects stood and walked from station to station. At fifteen minute intervals, a technician would monitor them for gas bubbles with a Doppler ultrasound bubble detector. The probe was placed over the heart (precordial position) and the subjects then moved each arm and leg in a cyclical fashion. This maneuver would free bubbles in the vessels of that particular limb. All bubble signals were graded by the Spencer system and recorded for study later.

From the DCS and Doppler data collected over a period of several years, it was possible to derive a statistical estimate of the risk of DCS for the length of prebreathe selected for eventual on-orbit use. The actual estimate gave about twenty two percent risk of mild joint pain to be expected during EVA and an approximate five percent risk of DCS that would be considered incapacitating. In the latter category would be either neurological DCS or intense joint pain that prevented movement. In actual practice, no problems were reported by the astronauts – or likewise by Russian Cosmonauts. Speculation ran from the belief that pain was being missed because of the discomfort of the suit, specifically that it would mask DCS pain, all the way to under reporting by the astronauts for fear of being removed from EVA duty. This latter was strongly denied by NASA that grounding would result and, equally staunchly denied by astronauts that there was a reticence. The astronauts claimed that "disinclination to report" would be unreasonable to their colleges since that would be tantamount covering up a known danger.

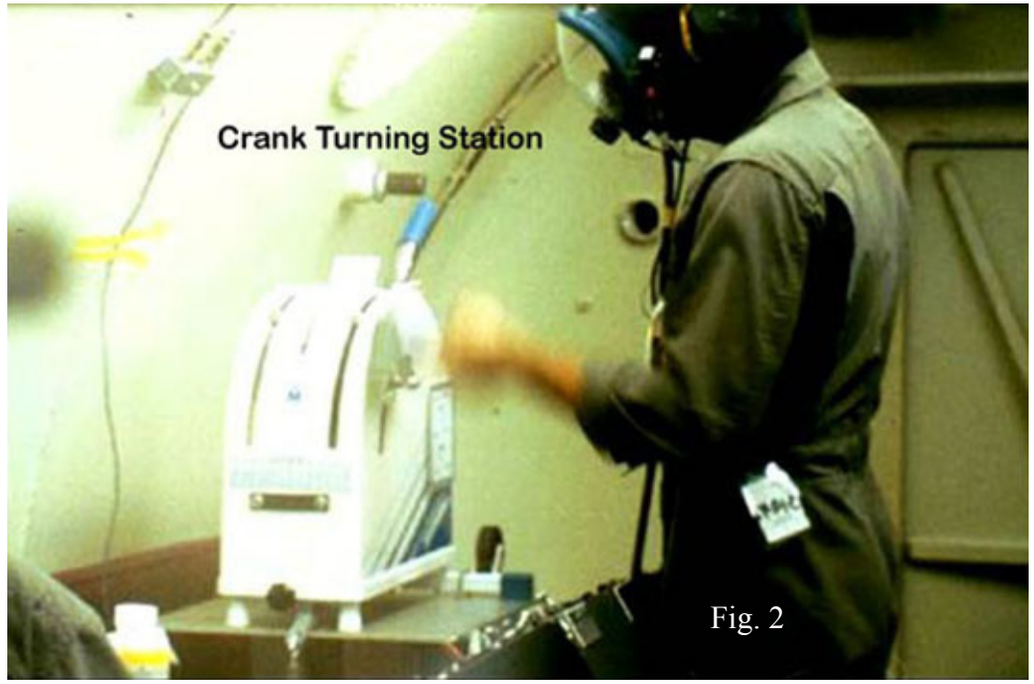


Fig. 2

At a meeting called in the fall of 1989 to discuss the lengthening of the prebreathe, I heard proposed an addition of about thirty minutes and a rebuttal of that proposal by astronauts who claimed it unwarranted. I thought to myself that, if the astronauts *inwardly* desired greater protection, they would need only to say something to the effect that, "Well, not necessary, but OK if you want it." (This

is akin to the President allowing a bill from congress to go into law without his tacit approval by simply not signing it. The bill is not given his stamp of approval, but it likewise is not vetoed.) Actually, they vigorously protested the addition of time. On the way back to our offices, I remarked to my colleague Jim Waligora that, if DCS was really lower in space something good is happening, and we should know about it. There is value there!

I knew from my barophysiology research a couple of decades earlier that gas bubbles formed primarily in tissues that moved. (We shall see why shortly.) Since astronauts on orbit in zero gravity (0-g) do not actually walk, there is little musculoskeletal stress. I reviewed the ground-based test data and found that indeed, the greatest percentage of DCS and Doppler-detectable bubbles came from the legs [figure 3]. This was even when the ground-based exercise was in the arms and wrists. Studies showed that 83% of DCS occurred in the ankles, knees, or hips. Reports of others likewise indicate a similar distribution. I thought that if there was a predilection for DCS in the lower extremities, null gravity and a reduction in dynamic stress could mitigate this.

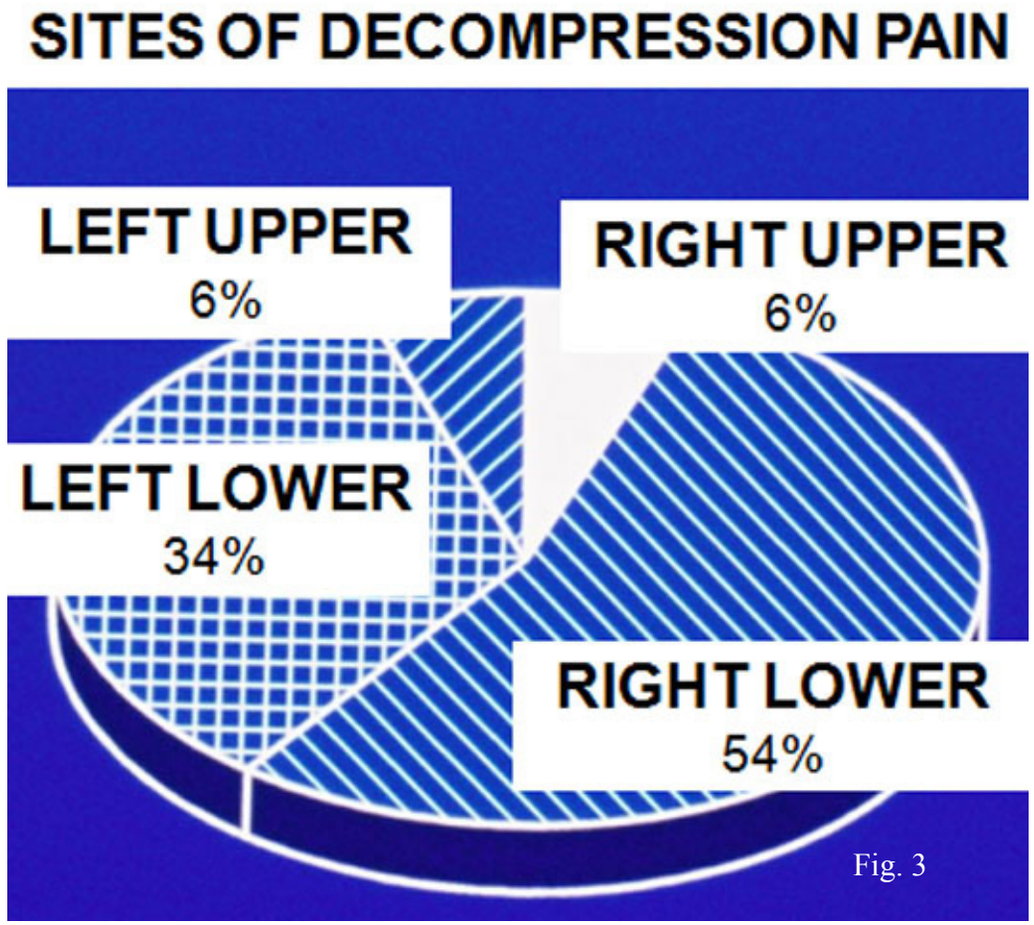


Fig. 3

Stress-assisted Nucleation in 0–g and the Abaropheric Hypothesis

Scientists have known for about two hundred years that simple supersaturation will not produce gas bubbles. This whole process is referred to as a *phase change* and covers both bubble formation and crystal growth, both from supersaturated conditions. The supersaturation limits for the production of a decompression gas phase *in vitro* in quiescent water is about 2,000 psi (about 130 ATM). This exceeds by two orders of magnitude that supersaturation for in vivo systems. Traditionally, a change of 1 ATA (33 fsw – 10 msw to the surface) is thought to be the decompression limit (for very long dives, anyway).

All bubbles have a constricting force known as *surface tension* [figure 4]. This is produced by the unbalanced forces on water molecules when they are not completely surrounded. If one side is against a gas (as with a bubble), the intermolecular forces are unbalanced. The water molecules tend to pull together, and the bubble is constricted. This inward pressure from surface tension is referred to as the *Laplace pressure* (named after the French physicist Pierre-Simon, marquis de Laplace who first described it in the early 1800s). As bubbles become smaller, the Laplace pressure becomes hundreds of atmospheres and bubble growth is impossible.

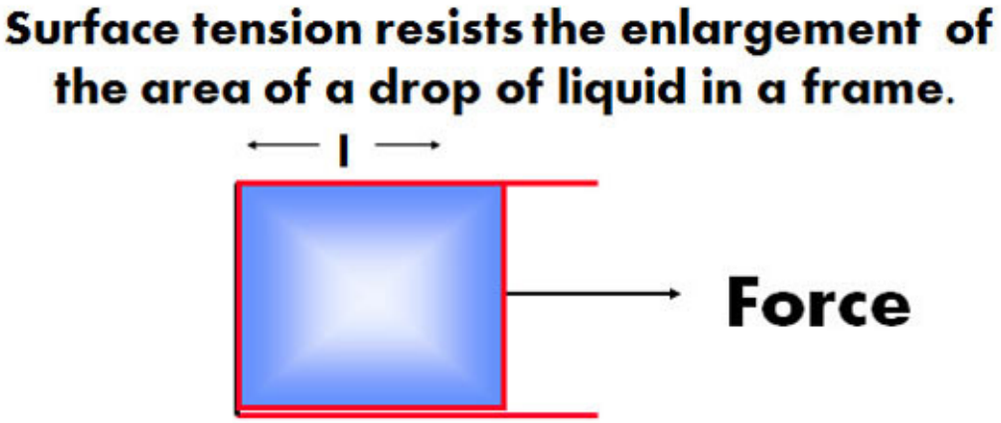


Fig. 4

Within the last twenty years, the easy formation of decompression gas bubbles has been attributed to the presence of preformed *tissue microbubbles* capable of serving as *"seeds"* upon which the decompression gas phase will grow during ascent. The postulation of the existence of these quasi-stable, preformed microbubbles in living tissue forms the basis for the decompression systems known as "two phase," an example of which is the *Reduced Gradient Bubble Model* (RGBM) of Bruce Weinke, PhD. One origin of the microbubbles in physical models is *physical stress*, as when surfaces with water in between are separated (processes called by names such as *tribonucleation, viscous adhesion*, or *tacky adhesion*). In living tissue, movement of muscles affords opportunities for surfaces to separate. This is especially true with the walls of capillaries [figure 5]. The physicist Edmond Newton Harvey proposed in the early 1940s that these microbubbles cold reside between the walls of capillary cells; these were sometimes called "Harvey pores" [figure 6]. This whole process is referred to as *"stress-assisted nucleation."* These processes allow bubble formation to arise since work is added to the system and bubbles are not formed solely by gas supersaturation.

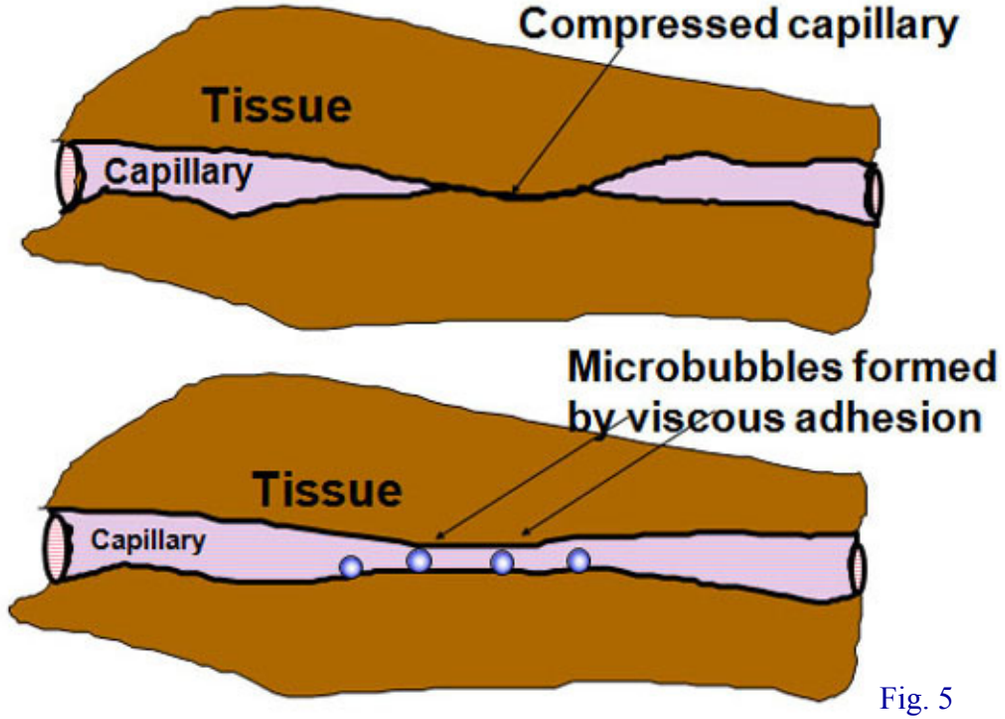


Fig. 5

Because astronauts use the lower extremities but little on orbit (*hypokinesia*), the reduction in the effects of stress-assisted nucleation and thus the number of microbubbles in tissues would be a strong possibility. This reduction in activity (*hypokinesia*) in space of the lower limbs and the lack of weight-bearing loads (*adynamia*) on the legs, I called the *"abaropheric hypothesis."* I coined the term from the Greek words "a" (the negative), baros (weight, pressure), pherien (to carry, bear).

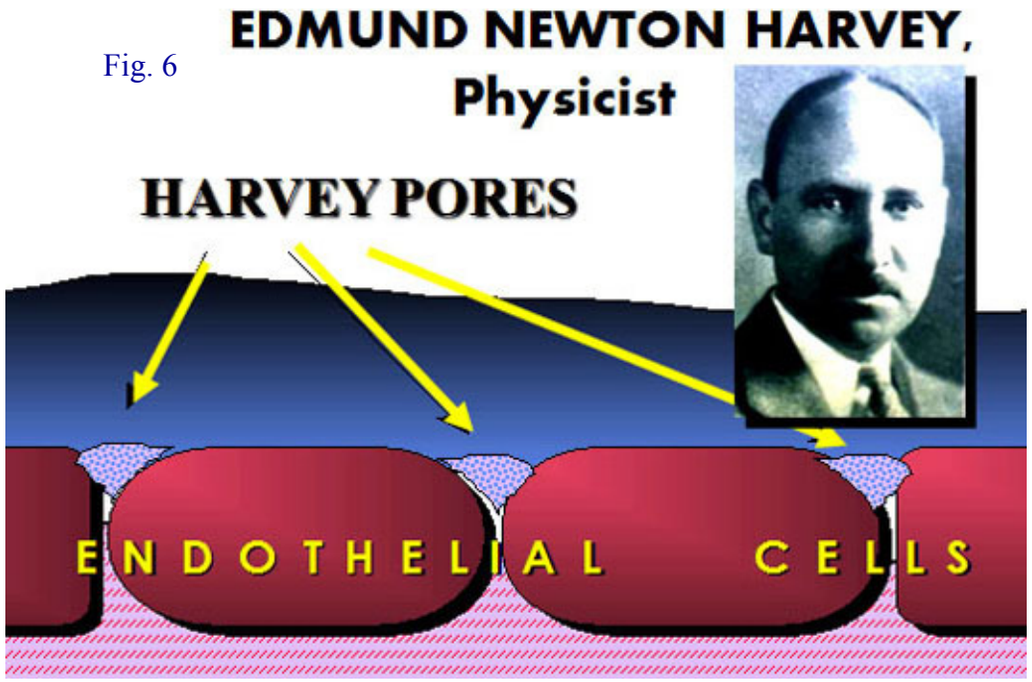


Fig. 6

The *ARGO* Studies

With this abaropheric hypothesis as the possible reason for the zero incidence of DCS on orbit, I wrote a proposal for the NASA Human Subjects Research Committee and submitted it in the fall of 1989. It was christened Project *ARGO*, and, contrary to the usual NASA way, does not actually represent an acronym. It was named after the ship of Jason and the Argonauts! After considerable preparations, the first depressurization commenced in July of 1991. The idea is that tissue micronuclei have a limited lifetime, and they are continuously regenerated. If you do not walk, the bubbles will not be formed [figure 7]. As hours pass, the nuclei will shrink [figure 8]. The actually bed rested for three days prior to depress). The project plan consisted of twenty subjects in a cross-over design. The subjects were [condition A] either to walk from exercise station to station, or [condition B] be lying in a bed with the exercise stands nearby [figure 9]. Some subjects were adynamic in the first series and then later were switched into the ambulatory group. The other half were ambulatory then adynamic.

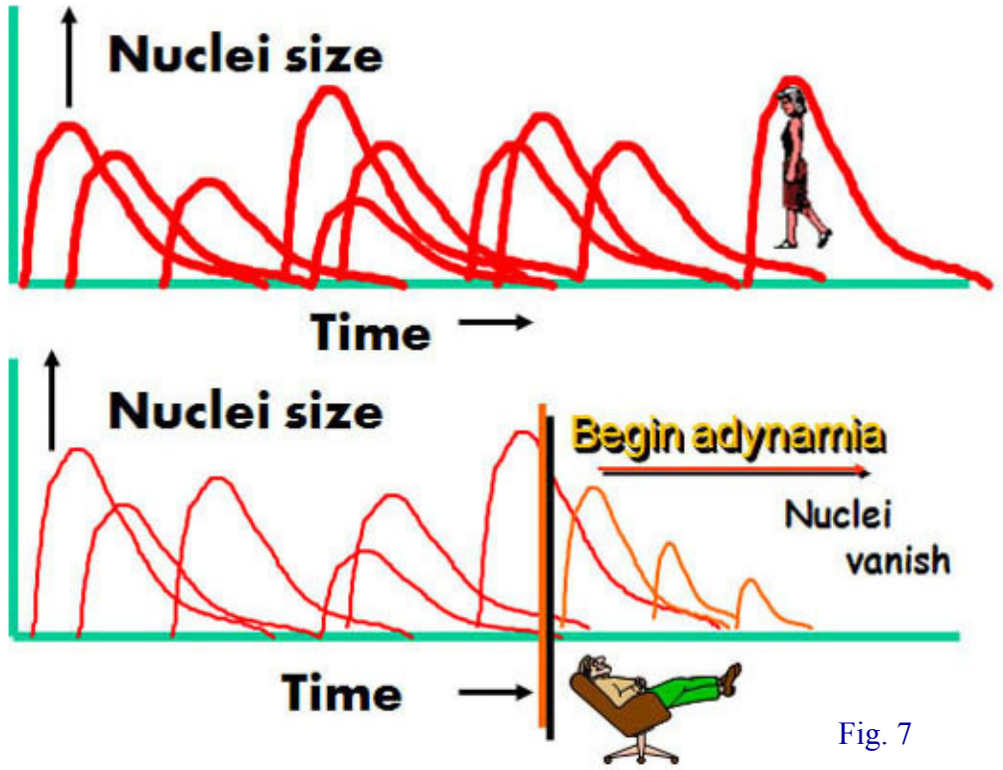


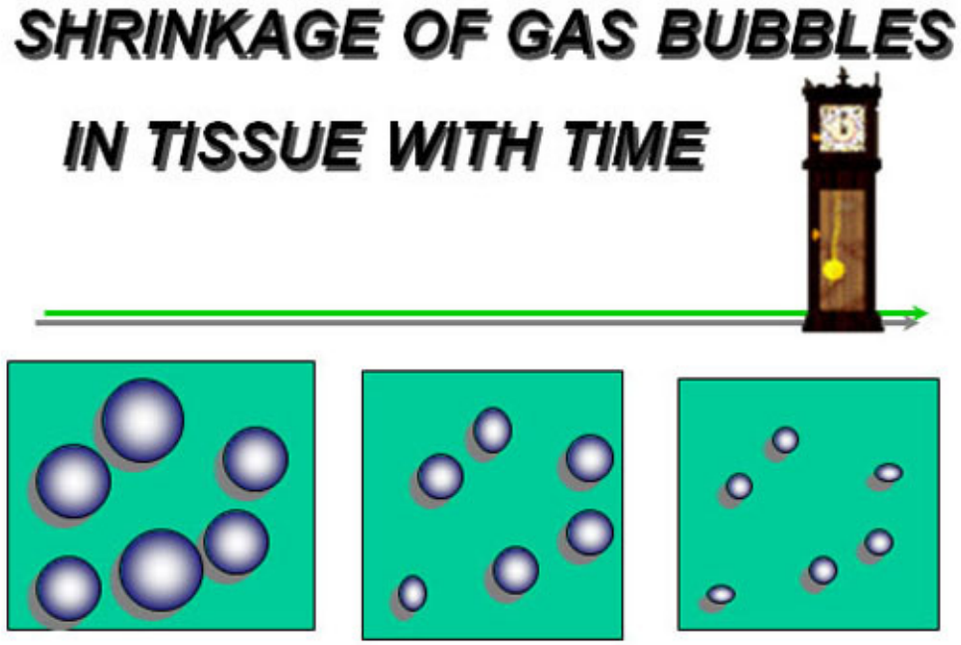
Fig. 7

The Doppler bubble results were definitive. In both groups, bubbles from the arms were about equal; however, leg bubbles in the adynamic group were considerably reduced [figure 10]. His indicated that something to do with adynamia played an important role. There was no way to tell that the effect was actually caused by a reduction in nuclei since there is not easy way to determine this. There could have been some biochemical factor, although I do not know what this might be. In any case, *exercise was demonstrated to be a large factor in DCS bubble formation.* It indicated that the lack of DCS in null

gravity conditions could be attributed to a reduction in weight bearing on the lower extremities. Another two more series were performed, *ARGO* II and III, with variations primarily directed towards the length of time in adynamia.

What we determined can be applied to recreational divers, namely, that ***physical activity (musculoskeletal stress) was a large factor in influencing the risk of decompression sickness.*** We shall return to this later.

Fig. 8



The Advantages of Altitude Depressurization in Research

Altitude depressurization is a convenient way to study decompression sickness in humans for several reasons. Allow me to enumerate some of these advantages.

First, reaching sea level is effectively a pressure treatment. Any subject with joint pain is repressed. This likewise serves as a *"test of pressure"* allowing a confirmation to be made between DCS and simple joint fatigue. Everyone leaves the laboratory with a return to "initial pressure." While cases of DCS in aviators have been known to require hyperbaric therapy, this is a very rare occurrence. Test subjects are given a phone number to call at the first sign of a problem, but I do not recall such a return was ever required.

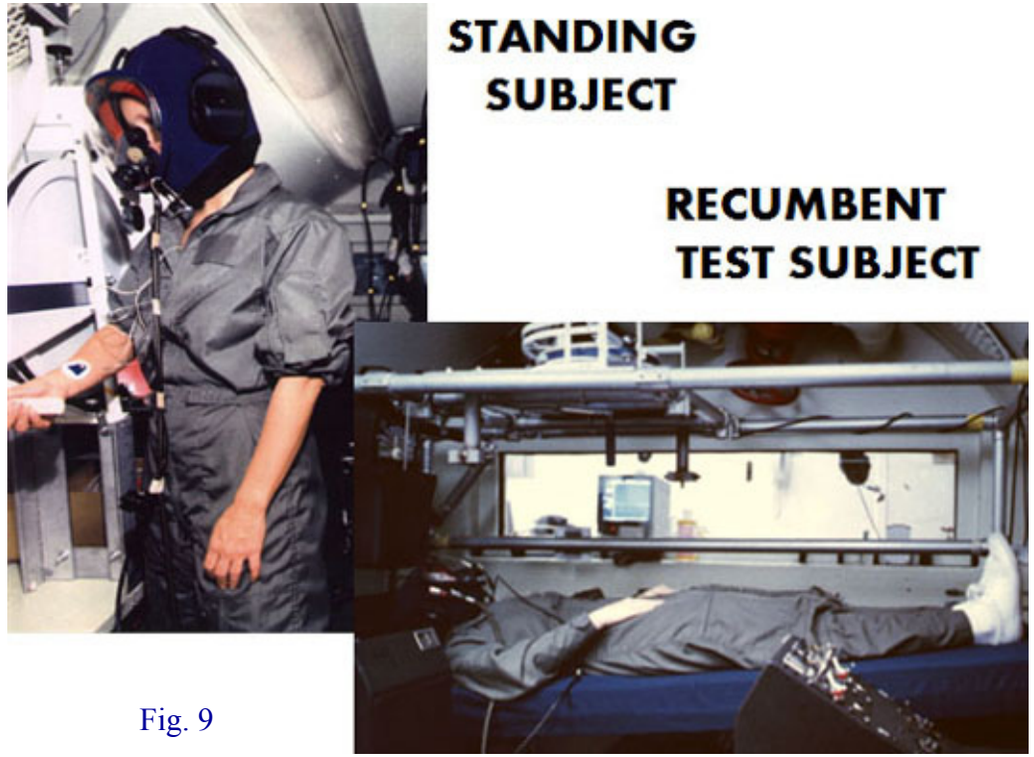


Fig. 9

Second, we have the added benefit that gas loads are *always equal* in the test subjects. Everyone has 1 ATM of air (nitrogen and oxygen) in the tissues and there are not any variances in gas uptake that we encounter with subjects going to depth. It is a level playing field.

Third, because the pressure differences are not great (this is

limited by the minimum oxygen pressure for breathing) problems of *spinal DCS are not encountered*. Human subject committees appreciate this aspect very much.

DCS is a multifactorial event, with pressure and bottom time being the primary factors. Exercise is a big one also and aspects of this have been known since studies of "flyers bends" during World War II. Yet we still hear of "hydration" as a factor. Not really. Certainly it plays some role, but in most divers this has not been shown to be a "big player."

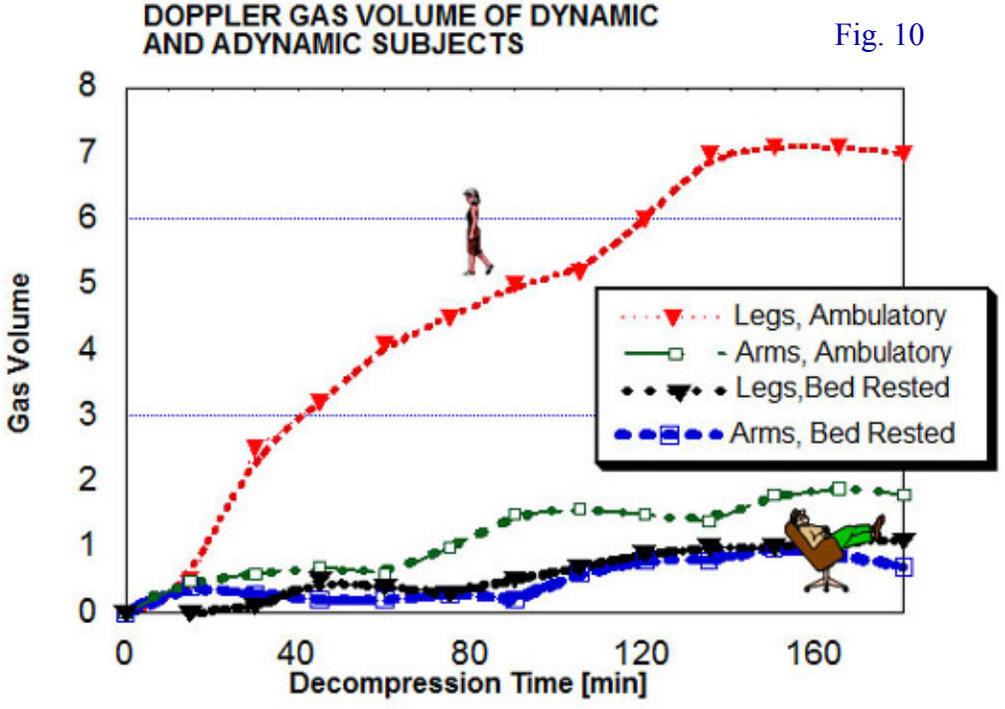


Fig. 10

Bubble Nuclei and Nuclei Lifetimes

As we read earlier, the pressure changes needed to produce gas bubbles during decompression are several orders of magnitude less than those required for gas phase formation *in vitro* in quiescent liquids. Preformed micro bubbles acting as "seed" nuclei have long been proposed, dating back to Harvey and others in the early 1940s. The origin of these tissue gas microbubbles have been attributed to a gas phase in either hydrophobic (water resisting) cavities, or surfactant-stabilized microbubbles, or, as discussed here, arising from musculoskeletal activity. Experiments with rats [figure 11], frogs [figure 12], and crabs [figure 13] showed that physical activity increased decompression bubble formation. These studies were also performed with men as test subjects [figure 14]. It is this last category that I discussed under stress-assisted nucleation. The lifetimes of these micronuclei have been variously estimated from as short as a few days to several weeks. Under the hypothesis of the *ARGO* experiments, however, it was my idea that bubbles of a radius that could play a role in DCS lived but a few hours.

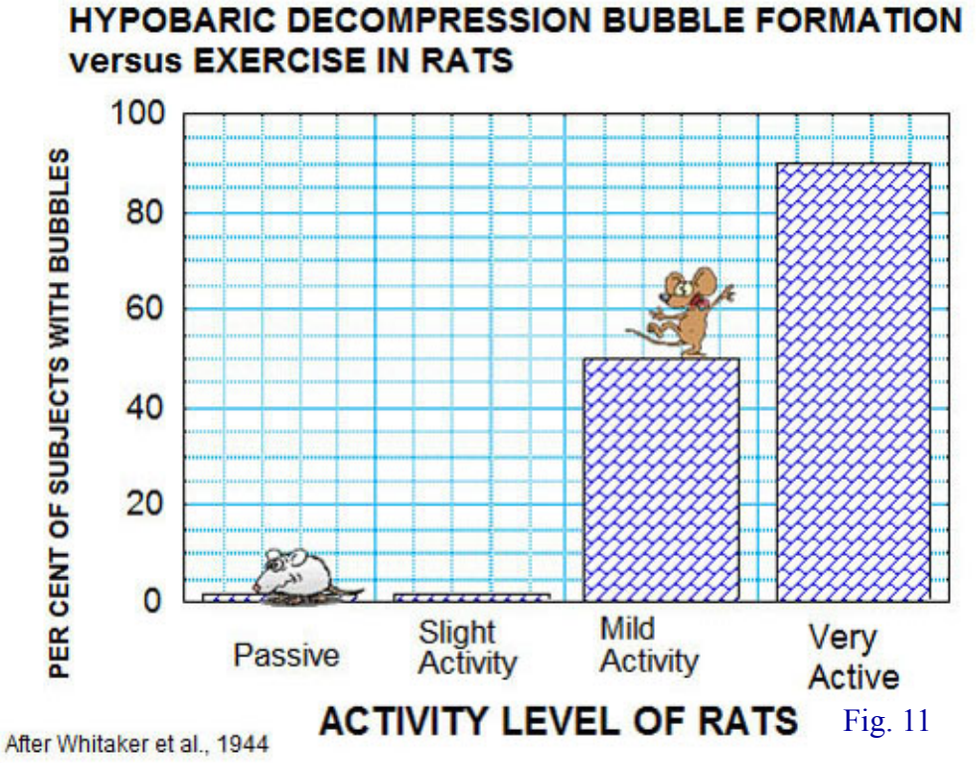


Fig. 11

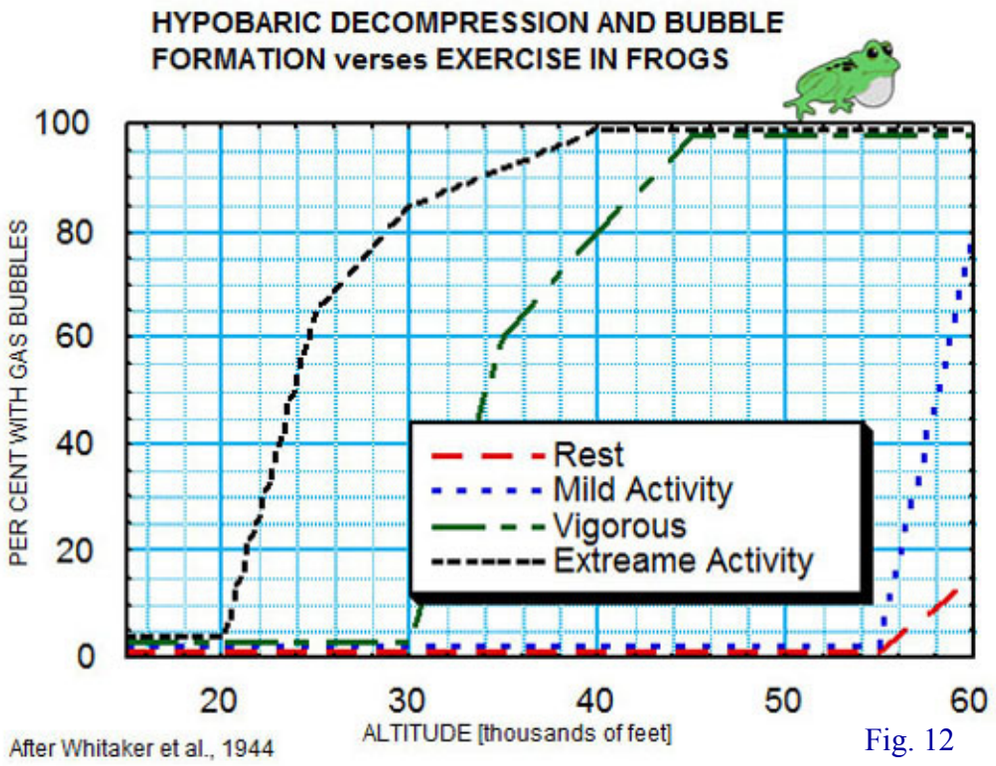


Fig. 12

A test was made at NASA to estimate this lifetime. After a prescribed regimen of exercise and rest, a depressurization was made and gas bubbles were detected by precordial Doppler monitoring. In a cross-over design, twenty individuals (15 men, 5 women) at sea level exercised by performing squats (150 knee flexes over ten minutes) either at [a] the beginning, [b] middle, or [c] the end of a two hour chair rest period. There was no oxygen prebreathe. Seated subjects were then depressurized to 6.2 psia (22,000 ft – 6,700 m) for 120 minutes with no exercise performed at altitude. Ten of twenty subjects with Doppler-detectable bubbles in the pulmonary artery demonstrated greater bubble incidence with exercise performed just prior to depressurization, with decreasing Spencer Bubble Grades and incidence as the duration of rest increased prior to depressurization [figure 15]. The other ten subjects never produced any detectable bubbles. They were resistant even with exercise [figure 16]. An analysis of the Doppler bubbles by a summation technique (Doppler Gas Volume) yielded the average for the subjects and definitely showed more bubbles with a short resting duration [figure 17].

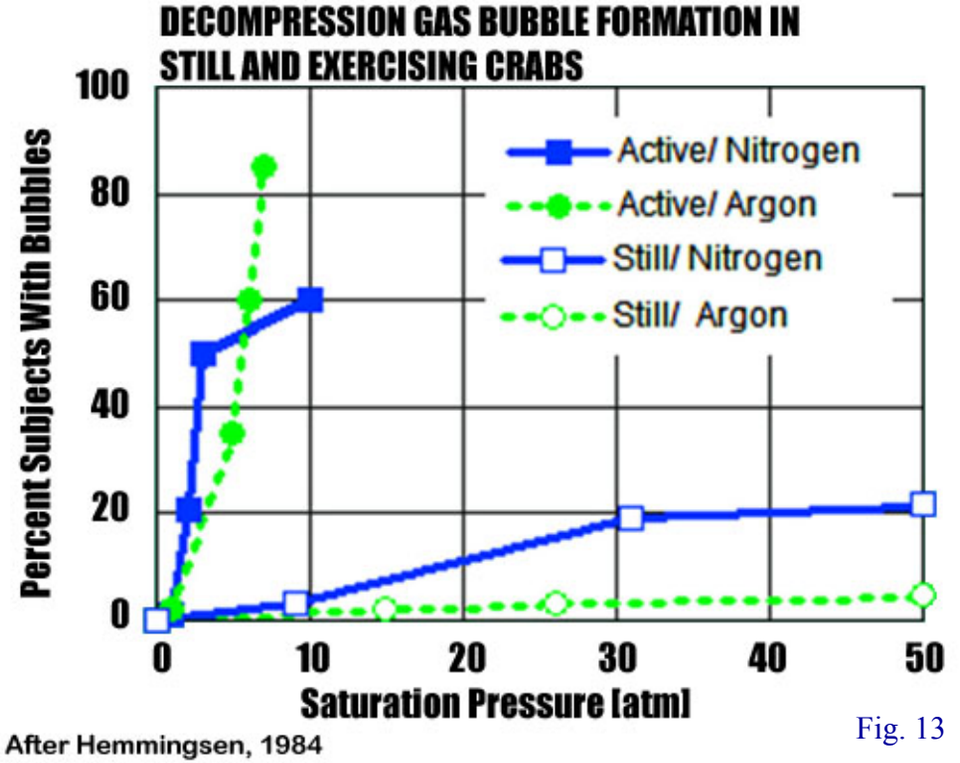
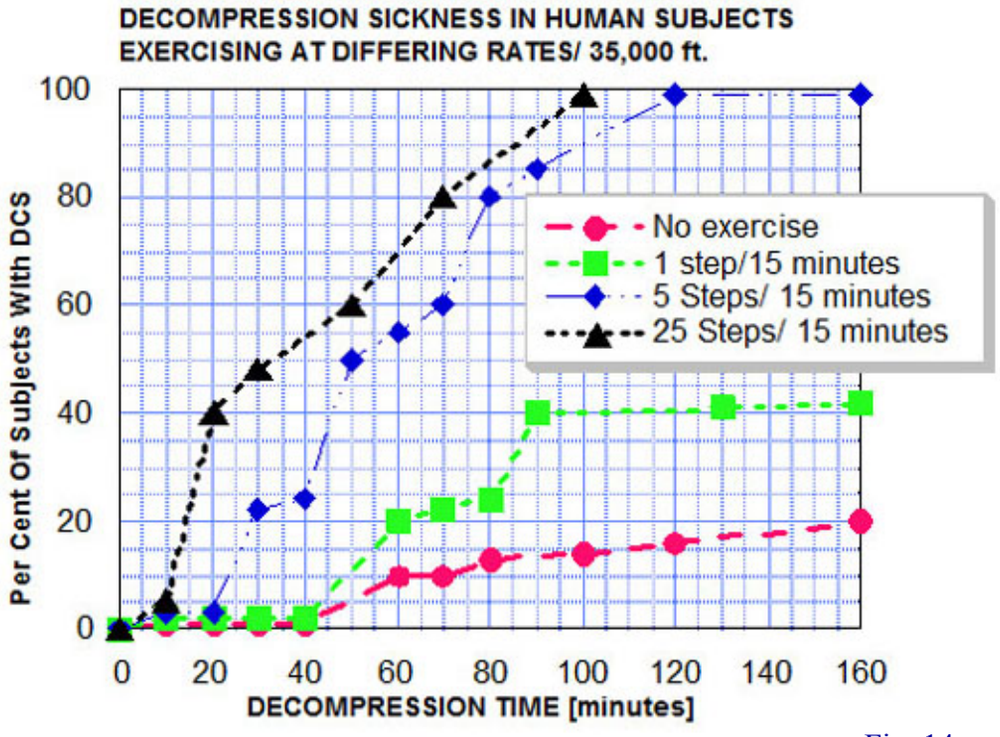


Fig. 13

Analysis indicated that the micronuclei producing the Doppler bubbles had an average half-life of approximately sixty minutes under these conditions. Some subjects had longer halftimes and some shorter. For recreational divers, this would indicate that nuclei do not persist for long times, but it must be remembered that *activities such as walking constantly produces new ones. The worst offenders would be, e.g., heavy lifting, climbing ladders, and surface swims.*



After Ferris et al., Committee on Aviation Medicine, Report 363, 1943

Fig. 14

Tissue Microbubble Sizing

An interesting small study was begun while I was at NASA, and I understand that interest remains even years after I have left. This is the question of sizing the tissue micronuclei. The basic device was developed for NASA by Creare Inc. when I was the contract monitor. They developed a bubble detection and sizing instrument using a dual-frequency ultrasound device that emitted "pump" and "detection" ultrasound signals at two frequencies. The low-frequency pump signal caused a bubble of a certain radius to resonate. When the first frequency hit a resonating bubble, mixing signals are returned at the detector as the sum and difference of the two frequencies. Another transducer detected these. A graduate student used this as a part of his thesis research and was able to show, to a limited extent, that bubbles in gelatin and small animals could be sized and these corresponded to visual images in a microscope. Further funding limited these studies. This work could have contributed to our understanding of tissue nuclei, but, alas, money is often an issue.

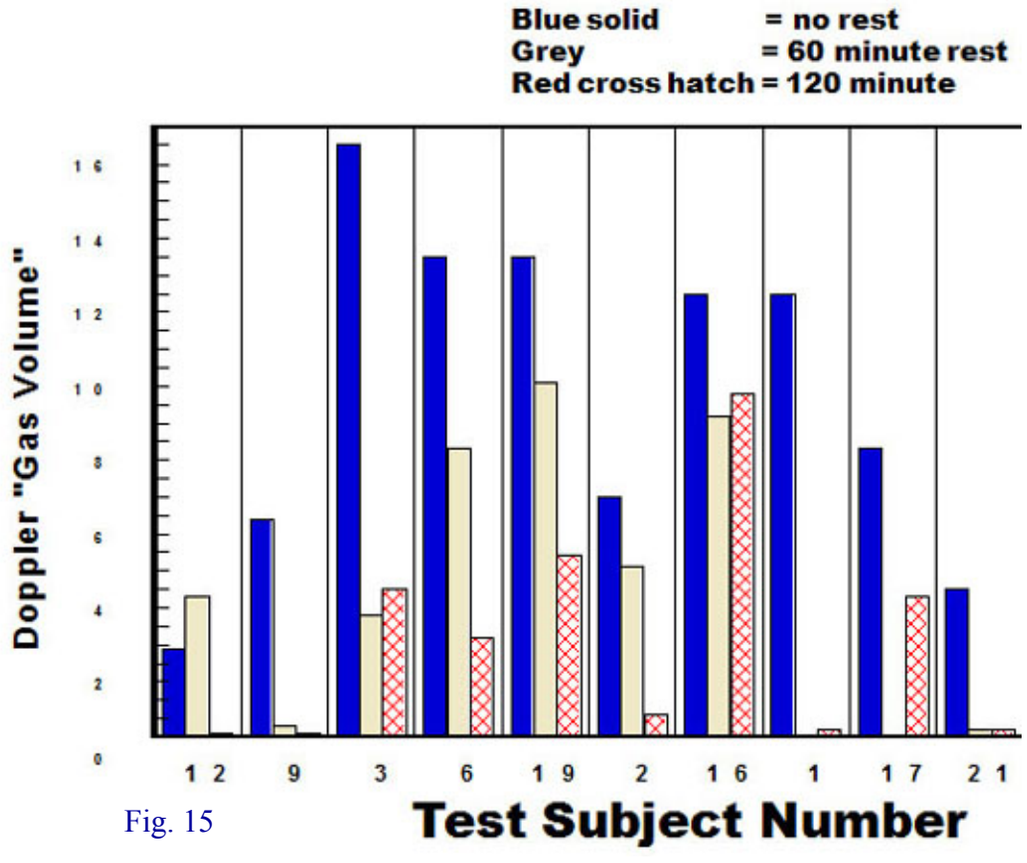


Fig. 15

Pulmonary Dead Space

Many believe that numerous gas bubbles in the pulmonary blood vessels can modify gas exchange, limiting it, in fact. We looked

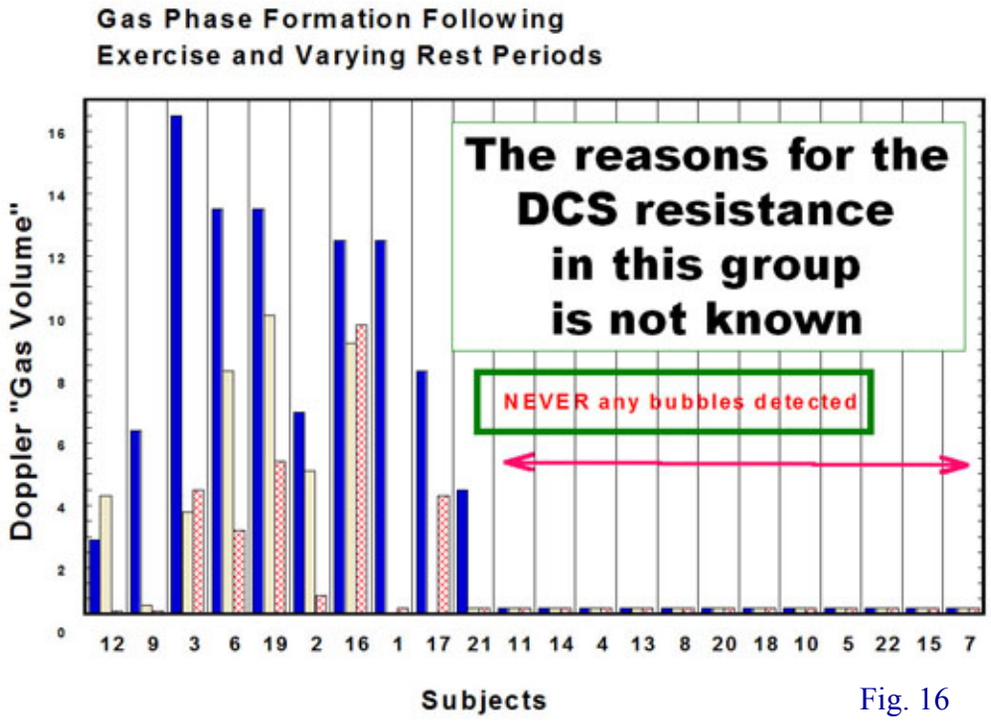


Fig. 16

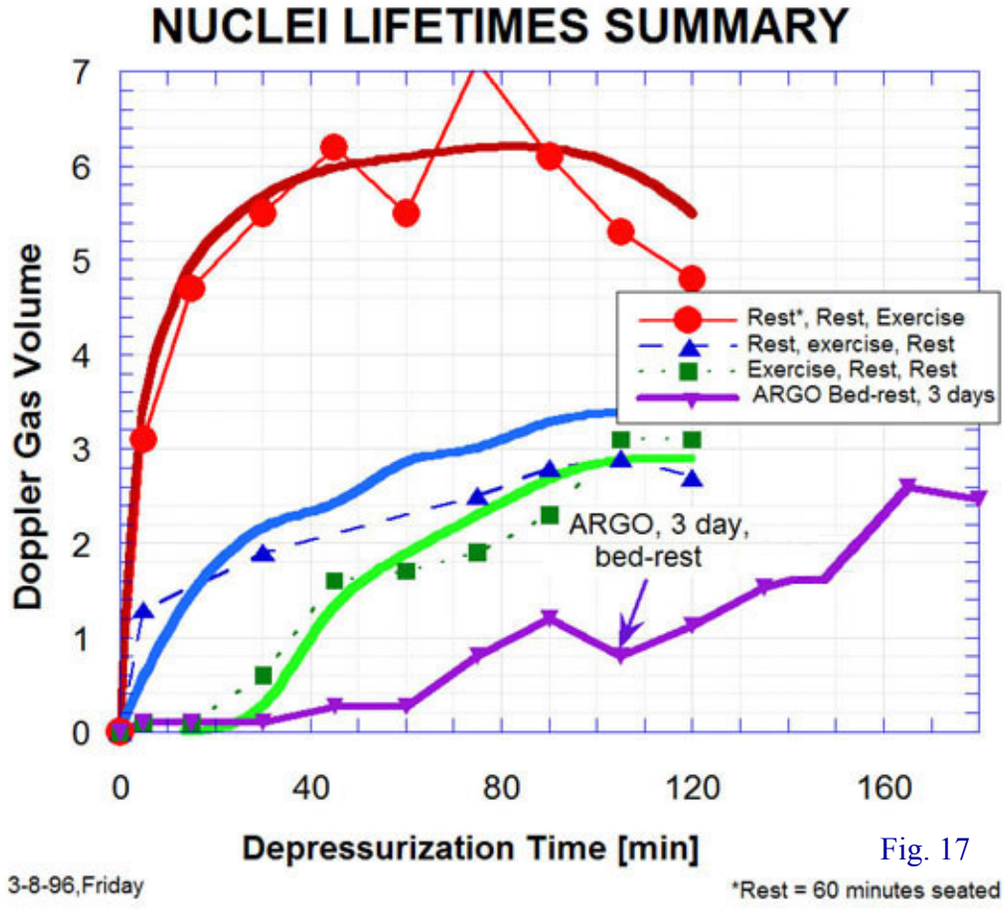


Fig. 17

into this and took advantage of the fact that altitude depress often produces copious numbers of bubbles in a high percent of the test subjects. Techniques are available that allow for the measurement of what is termed "pulmonary dead space." This is what occurs in the lungs when air can enter and exit the alveoli (little air sacks) but blood does not flow to them because the capillaries are blocked. In our case, the blockade would be caused by gas bubbles.

The test is simple and noninvasive and requires the ability to measure carbon dioxide in the arterial blood and the exhaled breath. To our mild surprise, no evidence of impairment of gas exchange was found. This means that *bubbles do not modify nitrogen elimination even when a great many gas bubbles are present in the lungs*. Individual exposed to our high altitudes produced more bubbles then you would ever expect in a recreational diver

Passage of Gas Bubbles through a Patent Foramen Ovale

In decades past, bubbles were thought to move from the venous to the arterial side primarily through the blood vessels of the lungs ("arterialization"). I believe (from my early studies in the 1970s) the majority of gas bubbles in the venous return have their genesis in muscle and adipose capillaries and then are released, especially during muscle contraction, into the central venous return. Studies by other researchers showed that vasodilators (blood vessel expanders) would allow bubble "spillover at the lungs in anesthetized dogs.

Other researchers had measured mean right side and left side atrial pressures (in the heart) in anesthetized pigs. Pressure measurements did not give an indication that right (venous side) was increased over left (arterial side) when arterialization occurred with the relatively large gas loads employed. However, at *some point in the cardiac cycle*, the *gradient did reverse* if only *momentarily* with these large gas loads. Unfortunately, these reversals can be caused by the Valsalva maneuvers or something similar. We did not get the chance to study this in the detail while I was at NASA, but I did study the medical literature and noted reports of *"Valsalva-like maneuvers" following activities such as straining, coughing, sneezing, pulling, tugging*, and the like. This is very important for SCUBA divers since a *slight breath hold while climbing a boat ladder is a Valsalva maneuver* in everything but name. Yes, a rose by any other name is still a rose, as Shakespeare once said.

As a part of our *ARGO* decompression studies at NASA, transcranial Doppler (TCD) ultrasonography of the cerebral arteries was performed in the hypobaric chamber. TCD is noninvasive, and gives unequivocal evidence of the presence of gas bubbles in the arterial system of the brain.

Monitoring was performed with TCD on individuals with microbubbles on precordial Doppler at the conclusion of a 3-hour exposure to altitude during the ARGO series. We chose the *end* of the altitude run to eliminate the need to repressurize the subject when brain bubbles occurred (they were repressurized anyway). We wished to know if DCS occurred with brain bubbles present it would have appeared and repress was just moments away at the end of the experiment. (This satisfied the ever-vigilant Human Subjects Committee.) Comparisons made between: (i) ground level saline-contrast echocardiography for patent foramen ovale, (ii) precordial Doppler severity (Spencer grades), and (iii) cerebral artery Doppler signals during hypobaric exposure.

Of the individuals who generated decompression gas bubbles (18 in our studies), two had a resting PFO and only one gave evidence of arterialization at the end of the three-hour hypobaric exposure. These two individuals displayed "resting arterialization," that is, a Valsalva augmentation was *not* needed to demonstrate the patency in the ground-level test. One, surprisingly, did not evince arterialization in the hypobaric chamber even with Spencer Grade IV bubbles (the highest grade). From this limited data base, a patency without provocation and a high Spencer Grade appears to be a necessary *but not sufficient condition* for arterialization. We were not able to secure funding for further studies, but divers should be aware that a PFO is not "the kiss of death." Many divers want to get a PFO test not realizing that a PFO appears to be of little concern for DCS, and the test is expensive and not entirely without risk. In addition, bubbles can arterialize not only through a PFO, but also through the pulmonary capillaries [figure 18].

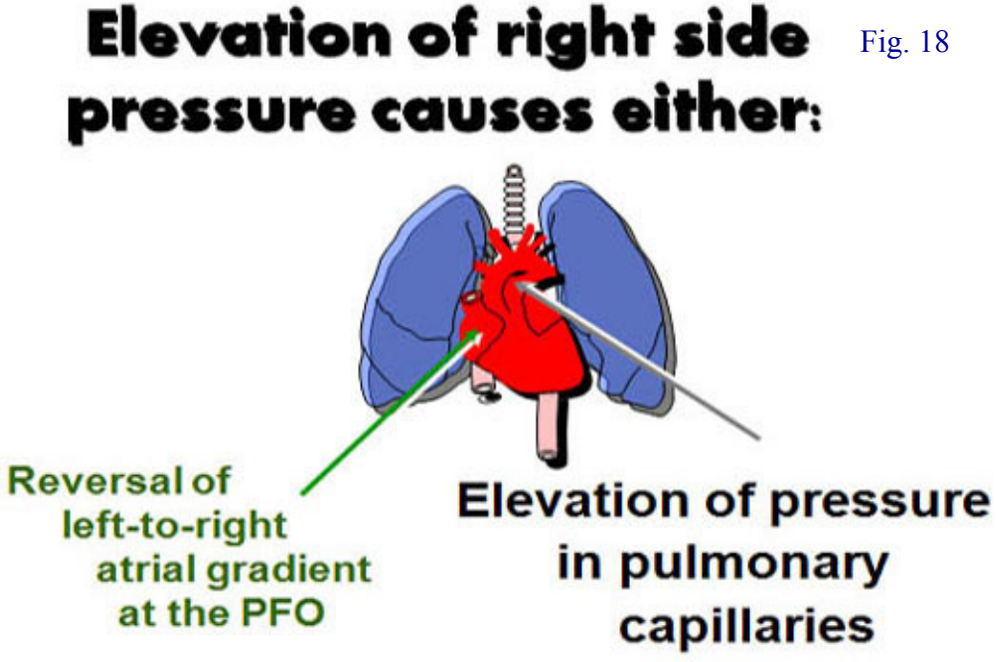


Fig. 18

Oxygen Prebreathe and DCS Reduction

In studies with rats, we noted that oxygen breathing prior to hyperbaric exposure reduced the formation of DCS bubbles. The original study was directed at what I termed hyperbaric exposure prior to an altitude exposure. This was to reduce micronuclei, I postulated. What was actually found was that the *oxygen (often several hours prior to depress) protected against bubble formation.* Certainly some *biochemical aspect* was at work here. Time and funding did not remain to study this effect further.

Individuals are Different in Response to the Nitrogen Dose.

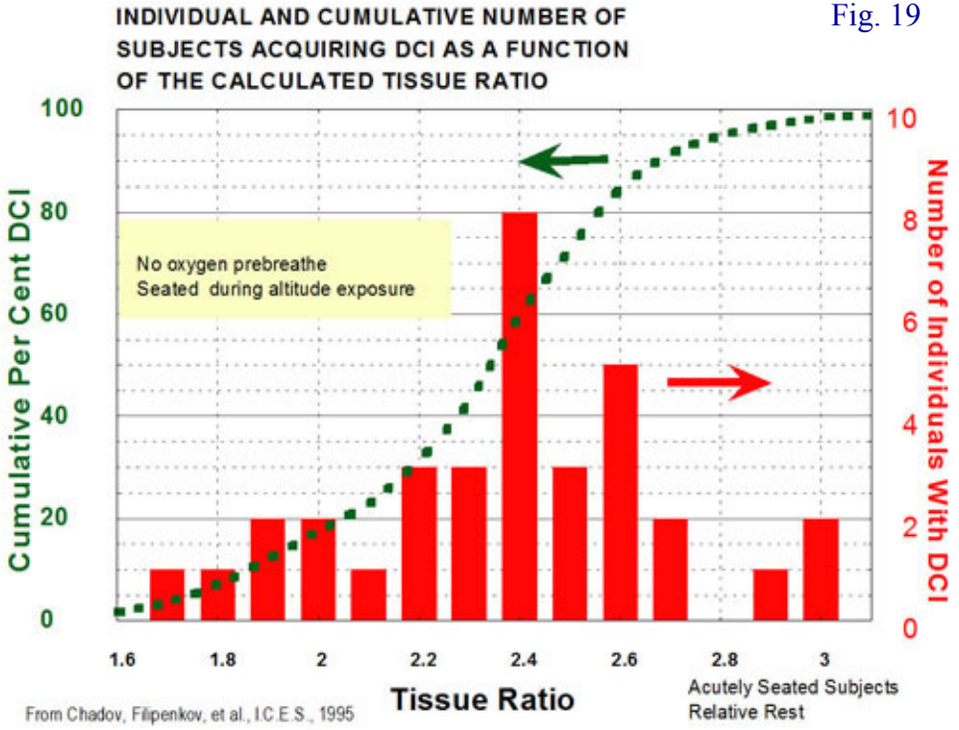
It is of interest to report here a Russian study partly inspired by the ARGO tests. A group of thirty four individuals were depressurized in a chamber to high altitudes (not all at the same time) until some got joint-pain decompression sickness. These were removed and a few days later, the group was depressed to a higher altitude. As subjects got DCS, they were removed from the group until all had finally succumbed to joint pain. The distribution of subjects formed a normal S-shaped curve [figure 19]. The difference between the "sensitives" and "resistants" was quite large in terms of susceptible pressure.

This illustrates what has been strongly suspected for decades. While the work was not performed as described by the Russian scientists, it was similar to the "selection tests" done by the US Army Air Force during World War II.

Exercise and the Work of Packing Gear.

When looking at the observable effects of strenuous activity, it is clear that recreational divers should avoid heavy physical activity both in the interdive period and at the end of the dive day. I have heard of a diver who thought that he got DCS from climbing a hill that was 450 feet (137 meters) in height. He though it was an effect of altitude. No, it was from the *work of the climb* itself. Divers should avoid climbing onto a boat with all of their gear [figure 20]. This is strenuous, produces bubbles, and can lead to Valsalva-like maneuvers. We have seen test subjects develop bubbles with a maneuver (pulling themselves with their arms) that immediately cause the evolution of bubbles from that arm [figure 21].

Fig. 19



Coda

This article also affords me the opportunity to mention two other items that arose while I was at NASA. These were not connected directly with NASA, however. The first is a Question and Answer

Fig. 20

forum that would be of interest to readers and is *"Ask Dr Deco."* This is located in *SCUBABOARD.com* or can be found by a quick search. This began in the fall of 2000 and has been going strong ever since answering questions concerning decompression physiology. My colleagues at NASA are also considering a similar form for aviators called *"Ask Dr Aero."*

The second is a class in decompression physiology offered at the Catalina Hyperbaric Laboratory of the University of Southern California. It can be found by looking at USC Catalina Hyperbaric Chamber Educational Programs. All of the monies from this program (except travel funds) go to the programs of Karl Huggins, the program director.

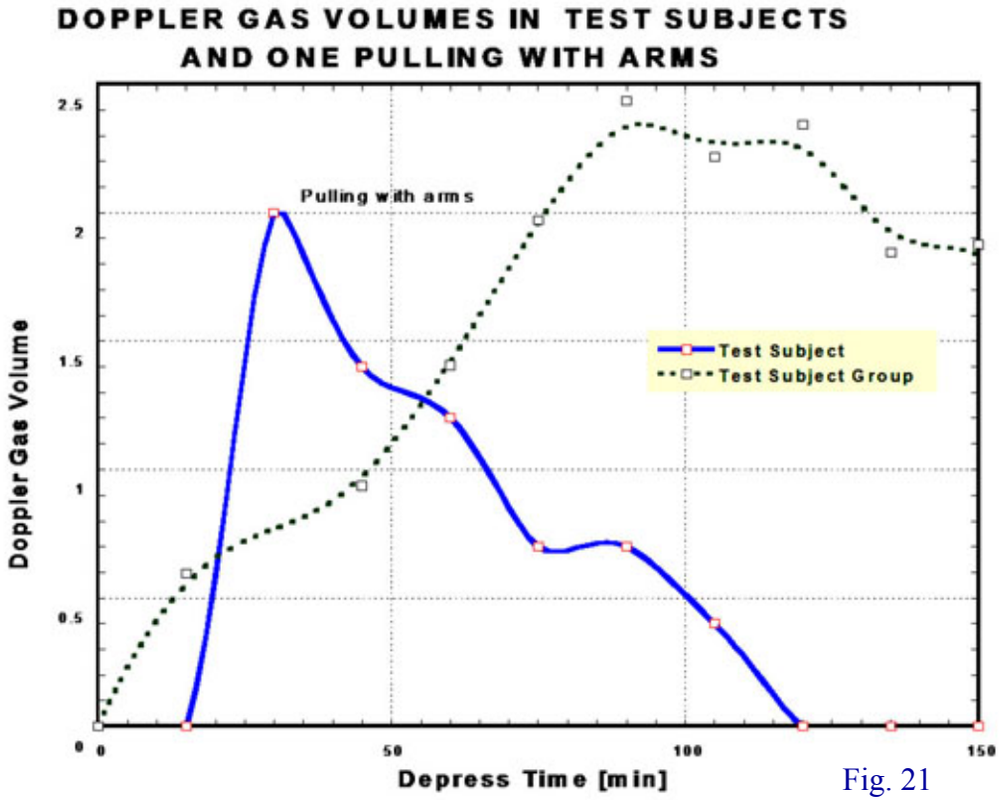


Fig. 21

I hope that this short article illustrates a few don'ts in diving. It also illustrates that there are many spinoffs of NASA research. People gripe about "money spent in space." Actually, no carries a penny up there; it is all spent on the ground. Some of the studies described here were terminated for lack of funding. NASA does not receive 10% of the US Government budget. It is actually about 0.7%. Perhaps in a different lifetime, I will know the answers to some of these many questions!

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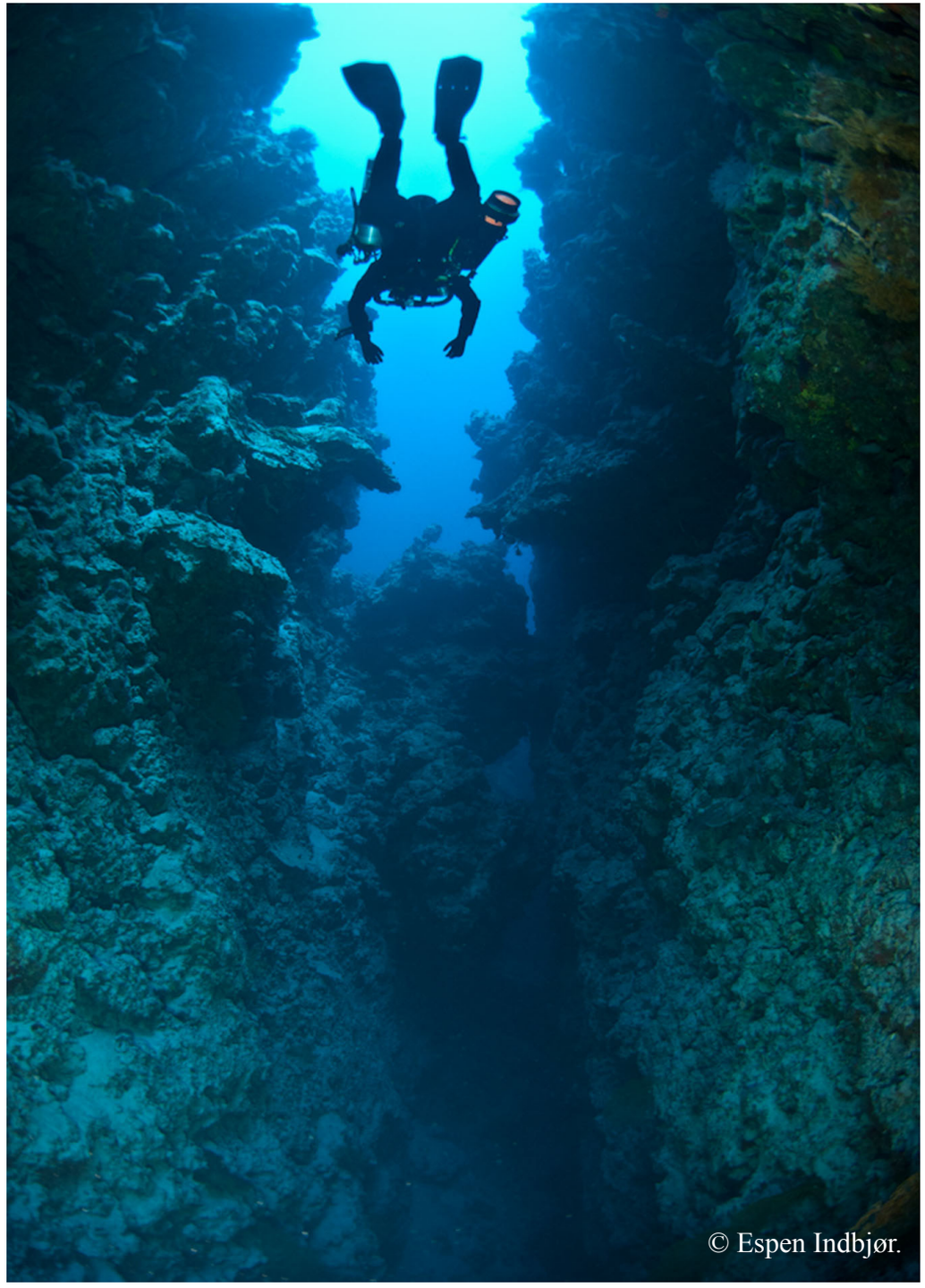

Russian IDA-59 rebreather

By Matti Anttila

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As world is full of varying rebreather models, Russia makes no difference. They truly have a wide variety of SCUBA units. Some of them are considered highly experimental, while others as least interesting. A dominating feature of most of them is the usage for military purposes.

Russia has a long history of submarines. One aspect in submarine warfare is the design for bailout units for the navy soldiers. In case the vessel is stranded to the bottom of the sea, there must, or should, be some way to escape the ship. One method is realized by using air lock and SCUBA units. The men enter the air-lock, fill it with water to the ambient pressure, and open the hatch to the surrounding sea. This means extremely rapid increase in pressure, and ear drums will most probably tear during this process. That process is followed by a quick ascent to the surface using the escape apparatus. Some submarines are equipped with an escape capsule, but for sure it can't fit all the crew. The Russians have designed several types of submarine escape SCUBA units, and IDA-59 is one of them. In fact, IDA-59 is capable in operational diving also, not only to the escape phase. As the model name says, the model has been released in 1959.

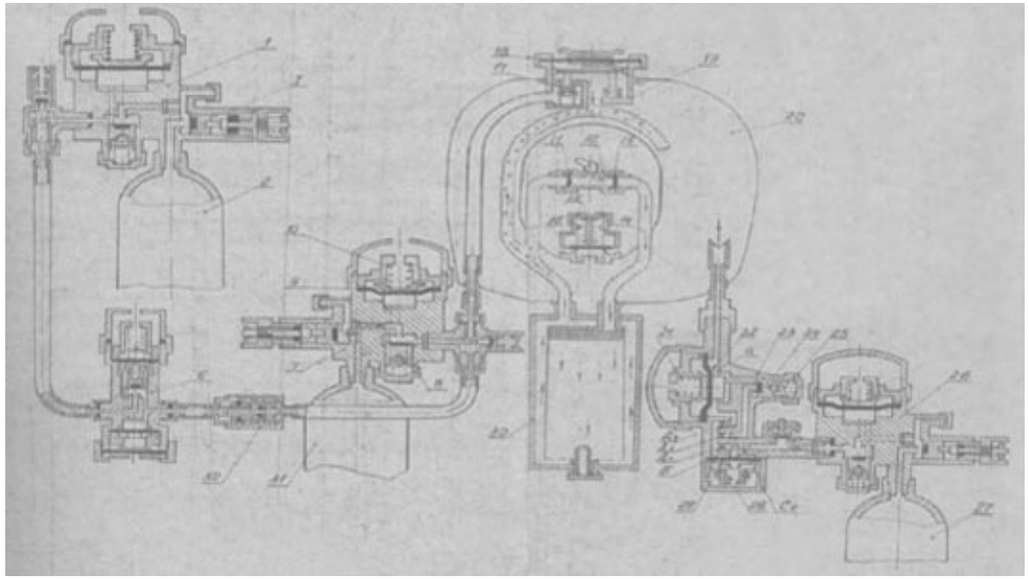
The rebreather

IDA-59 is a fully closed circuit trimix rebreather. Maximum operation depth is 300 meters (1,000 feet) according to the original manual. This requires an additional diluent cylinder, which is connected to the off-board diluent connector. Without this extra diluent cylinder, the maximum operation depth is limited to about 90 meters (300 feet).

IDA is an acronym, which stands for Russian words (in non-Cyrillic letters) *"individual'nyy dykhatel'nyy apparat"* (meaning "individual breathing apparatus" in English). There are numerous IDA diving models for different purposes. The number after the acronym means the design year.

Is it truly a CCR device? Or just SCR?

This is a common misconception, since both SCR and CCR variations exist, made by keen amateurs like myself. IDA-59 is a CCR when it is properly configured. If the oxygen mass flow controller is configured to too high, IDA-59 acts more like a constant ratio/quasi-constant PO2 semi-closed rebreather. What is more important than the gas consumption is that the FO2 will increase in the loop if the oxygen flow is too high. To be properly configured and act as a CCR, the scrubber should be filled with O2-producing material (Russian "O3" superoxide), and the mass flow properly tuned to low enough. This way the loop's FO2/PO2 stays low enough, but not too low (because of the O2 incoming from three sources: trimix diluent, scrubber material and oxygen cylinder). If the oxygen flow from the CMF valve is too low and the diver uses, for instance, regular soda lime, hypoxia will occur, resulting in a rather disappointing conclusion.



The operational diagram of the IDA-59 from the unit's manual

In fact, IDA-59 belongs to a category called CCCR, which stands for Chemical CCR. The term "chemical" refers to the O3 absorbent, mentioned above, which replenishes the oxygen in the breathing loop.

IDA-59 and O3 scrubber material

Originally, the scrubber canister should be filled with potassium superoxide (the so called "O3" chemical), which gives off oxygen as it absorbs carbon dioxide:

$$4KO_2 + 2CO_2 = 2K_2CO_3 + 3O_2$$

This explains why IDA-59's O2 flow is set - in some diving situations - even less than one liter per minute flow, which itself would be inadequate to sustain the O2 level in the loop. This O3 chemical makes it possible to dive for longer periods, but it is also dangerous because of the explosively hot reaction that happens if water gets on the potassium superoxide.

I have been filling the IDA-59's scrubber with Sofnolime, and compensated the lack of "O3" by tuning the O2 flow accordingly.

O3 potassium superoxide material inside the scrubber. Don't use this.

First glimpse of the unit

I bought my IDA-59 from EBay in October 2006. The unit came from Latvia. After I received the IDA-59 and took it out from its bag, I made quite a thorough examination to it. It appeared to be in very good condition. All external rubber parts were well covered with talc powder and the harness, counter-lung etc. showed no signs of aging. Similarly, all visible metal components were free of corrosion and stains, as seen in the photographs in this article. As mentioned, the model name refers to the design year, not necessarily the year of the unit you have in your hands. In fact, I have no clue when my unit was build.

The machining of the metal parts is well-made and robust. The mouth piece one-way valve (mushroom diaphragm) is practically eternal; it is made of stainless steel and glass. Normally the surfaces, in modern day units, are rubber and plastic. In IDA-59, the diaphragm is made of very thin Mica-type glass, and the counter-part surface is extremely sharp stainless steel with similarly made spring. It will not wear out even after decades of storing.

One noticeable issue is the lack of safety features. There is no water trap in the loop, so if the mouth piece floods, sea water will enter the loop quite widely. There's also a reason why the manual won't tell you the usual procedures how to act with a flooded loop. You won't. The Russian "O3" potassium-based superoxide scrubber acts violently with water, and the result will be an explosion. Rule number one: don't flood the loop.

The scrubber canister itself is well-designed. It takes about 2 kg of Sofnolime (note the fact that I won't even try the "O3" material in there!). The structural design forms a thermal bottle with double-walls, and there are metallic internal pieces to prevent the channeling

of the carbon dioxide inside the scrubber.

The unit has an ADV, which supplies diluent gas to the loop when the ambient pressure is higher that the loop pressure. However, the diluent flush button is situated in the back of the unit, near your neck, and it is very hard to reach. No oxygen bypass valve exists, but the over-pressure valve is easy to use and adjust. Because of the lack of O2 bypass button (and due to the fact of using Sofnolime), I adjusted the O2 flow quite high. The O2 cylinder valve is very easy to reach, so it can be turned off periodically while diving.

Pre-dive testing, more testing, and even more testing before diving…

The first real test was to use the diluent side of the system. To my happy surprise, my old AGA Airi low pressure hose fit to the off-board diluent connection of IDA. I just screwed away the AGA full-face mask and then screwed the hose connection to IDA; that simple! AGA intermediate pressure is also very close to IDA's. My AGA has about 8 bars of IM pressure, while IDA diluent side has about 6 to 7 bars. No detected leaks, ADV worked well and the OPV was tested also with filled counter-lung. Great!

After testing the diluent side, it was time to test it with real stuff. I managed to get a ¼-to-DIN converter which made the fillings easier. I didn't want to fill the IDA dil cylinder yet with compressor, so I just whipped in some pure, definitely oil-free gases from helium and oxygen bank cylinders. After filling, I connected dil cylinder to IDA and once again, it worked well, so the first stage functioned correctly.

Oxygen side testing (O2 first stage and CMV)

The diluent filling went very smoothly, so I thought why not O2 also! Wrong. Here's where the problems started. The first filling from oxygen bank resulted nothing but a screaming over pressure valve in the CMV of O2 regulator. As the first phase, CMV and its second piece of first phase are all attached to the cylinder valve, they all are pressurized during cylinder filling. I tried numerous times to fill the O2 cylinder, and tried to find the leak cause, but with no good results. When I came home from our diving club's warehouse, I submerged the O2 system and tried again to fill it. The cause: CMV OPV, again, and only it. I then opened the first phase and to my (this time unhappy) surprise, all high pressure parts (seat, spring etc.) were missing!! Damn, this really was a show-stopper! I guess this is typical in military devices. When some part misses, take it out from another device. And my unit was, in this case, the other device.

OK, so the O2 first stage is unusable. Now what? I decided to try the rest of the O2 block by feeding gas to the system from an external source. I connected the filling connector to an external Apeks 1st stage and fed 10 bars to the system. Then I could test the CMV.

More nasty surprises: The CMV gave nothing out! Not even a tiny bubble. After all, it was supposed to give continuous oxygen flow. But nothing! I needed to take apart the CMV, which was not my original intention, since it is factory-calibrated and I did not have the tools at home. So I calculated and marked every screw position and tightness and tried to put it back afterwards in the same manner.

After cleaning the CMV (which was really stuck with corroded dust, salt, mud, aluminum/copper oxide and similar stuff), it finally worked. Then I managed to feed the O2 side with my external tank and Apeks 1st stage and the system worked!

Even more surprising and delighting news came later, after first test dive though. I had e-mailed the vendor about my problem, and after

two days only (!), I got a letter from Latvia containing the missing parts! I guess now there is another IDA-59 somewhere lacking some parts.

ppO2 meter/handset

IDA-59 without ppO2 meter can be a very dangerous device, when diving deeper than 6 meters (20 feet), and even shallower, if not filled with only O2. That's why I bought an OxyCheq's El Cheapo oxygen analyzer kit, and constructed a handset for that kit. The idea is to keep the handset interior in ambient pressure, so I lead the counter-lung's pressure to the handset via a normal regulator LP hose. By this design I avoid the need to construct pressure-tight box, and only need a water-tight box with some pressure capability (although the handset that I built, probably withstands pressure quite well, being a 3mm aluminum with good fittings). The power switch rubber parts are taken from a DiveRite wreck-canister. Display hole and plex are self-made, as is trimmer fitting too. The O2 cell will be placed to the inhale-side with a T-piece.

The ppO2 handset I added to the original device. Don't use the IDA-59 without this.

I finally managed to construct the T-piece, which I put in the inhale tube. The T-piece contains Teledyne R-17MED oxygen cell. The wiring goes inside a LP hose to the handset, so the handset remains in ambient pressure.

Test diving of the IDA-59

November 18, 2006. Air temp +5°C (41°F), water +4°C (39°F). Lohja, Finland:

I re-checked all the fittings and filled the scrubber with Sofnolime. It was not as easy task to fill and pack as, for example, the Inspiration scrubber, because you have to fill the IDA's scrubber through a narrow hole. Diluent cylinder was filled with heliox 50 (because it was easy to whip in from oil-free bank cylinders to another tank first, then to the IDA cylinder). Positive and negative pressure tests proved no leaks, and the system did not leak any bubbles while submerged.

I decided to keep the full-face mask on, since I wanted to get the real feeling of IDA-59! As the O2 first stage lacked HP seat (before I got it from the vendor), I fed O2 intermediate pressure to the CMV directly from an external tank. This 7 liter aluminum cylinder served also as a bail-out cylinder, as I intended not to go deeper than 6 meters (20 feet) anyway. No other modifications were made (except that scrubber material was Sofnolime instead of original "O3"). The O2 flow was adjusted to ~2 liters/minute, so it was slightly more than needed, which also resulted in a need to deflate the counter-lung from time to time to avoid excess buoyancy.

I have experience in AGA MK2, Airi and other Interspiro and Kemira FFM, so wearing a full-face mask was not a new thing. However, IDA FFM was definitely something new! It was not very comfortable. It was very tight, vision was strange (two eye holes placed in angles

with respect to each other), very narrow vision and rather large dead space. But, to consider the purpose of the system: if you're stranded in a submarine in the abyss, you don't have much to choose. Do you?

First dive was to 4 meters (13 feet), 10 minutes. It was rather a buoyancy drill, and the safety divers (thanks Thomas and Mikko!) asked me the OK sign very often. In fact, all that I saw was them signaling the OK question all the time. I tested the OPV and ADV by deflating the counter-lung by squeezing the bag. OPV was quite slow, even trimmed to its max position. ADV worked fine, and I could hear it working. Work of breathing was very nice and easy. Oxygen flow was too high, since the bag inflated too quickly. And the mask was awkward. Scrubber seemed to work well, and no leaks were detected. But I decided to change the FFM to a regular mouth piece!

Second dive: I changed the FFM away, and now had a regular Mares mouthpiece. Very comfortable! The device showed really its good sides now. Work of breathing felt very easy now and using a normal mask was really a good choice. I had larger field of vision and thus I could access the controls easier. With some buoyancy testing and playing around, I made a diluent flush (this time it was easy: just deflate the bag via nose/mask) and dived down to 7 meters (23 feet). Total dive duration was 16 minutes. This dive was fun! Support diver Thomas also tested the IDA and had some fun in 6 meters (20 feet).

Diving with the ppO2 handset
December 9, 2006. Air temp +6°C (43°F), water +4°C (39°F). Lohja, Finland:

This time a new, better T-piece and handset were used. No full-face mask, just an ordinary mouthpiece. Diluent was filled with trimix 47/22 (200 bar) and O2 cylinder was filled with O2. This time I also had the original high-pressure seat and other parts in the O2 system, so no off-board gas was used (except that I carried an EAN50 bail-out).

The dive was smooth and easy. Buoyancy control went better than last time, ppO2 reading varied between 0.35 ATA and 1.05 ATA during the dive. Maximum depth was 18 meters (60 feet) and total dive time 35 minutes (including stops at 6 meters (20 feet) for 5 minutes and 3 meters (10 feet) for 3 minutes). No leaks detected anywhere. Thanks Jusu and Mikko for supporting the dive!

Key parameters:
Diluent consumption: 100 bar (100 liters, several ADV uses on-purpose).
O2 consumption: 25 bar (25 liters). I manually controlled the O2 flow by shutting the valve from time to time.
O2 flow: 3.3 liters/minute (when cylinder was on).

And still more (ice) diving: two IDA-59 divers!
February 4, 2007. Air temp +0°C (32°F), water +1°C (34°F). Lohja, Finland:

The handset and T-piece were fine-tuned again and the airways to the O2 cell were improved. The ppO2 reading was somewhat faster now. We had now two IDA-59 divers: Klasu and I! Another new thing for my "IDA diving career" was ice. There was thick ice, so extra care was taken because direct surfacing was not an option now.

The dive was smooth again. Maximum depth was 13 meters (43 feet) and total dive time was 18 minutes. No leaks were detected whatsoever.

Key parameters:
Diluent consumption: 45 bar (several ADV uses on-purpose).
O2 consumption: 30 bar. Again I manually controlled the O2 flow by shutting the valve from time to time.
O2 flow: ~3 liters/minute (when cylinder was on).

Conclusion
Later on, I did some other shallow dives with my IDA-59 unit, and even later took it down to 30 meters (100 feet). The unit performed well, but I must emphasize the importance of the ppO2 monitor. I wouldn't dive without it.

My original goal was to have fun, plain and simple. I never intended to use the IDA unit as my primary diving gear, and didn't want to play it in caves, although I took it couple of times under ice, not far from the surface access though.

As an engineer and a diving instructor I got what I wanted: I proved to myself that I could buy and fix an old Russian submarine escape SCUBA unit. I had fun, but after having done several successful dives with my unit, I have no intention to take it further. It remains a good memory, and I'll keep the unit in working order. But for the upcoming dives, I'll do them in my modern OC or CCR gear.

Matti Anttila
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Special On-Line Version of
Diving Pioneers & Innovators: A Series of In Depth Interviews
By Bret Gilliam

In November of 2007 a unique book was released profiling 20 of diving most enduring professionals. The massive 489 page, five pound hard cover edition was critically acclaimed and moved swiftly to achieve notoriety as the definitive work chronicling a highly personal look into some of the industry's most defining characters. The book was over a decade in the making.

Author Bret Gilliam relates, "It started with a lengthy interview I did in DeepTech magazine in 1996 with Bev Morgan. He probably best personified the role of 'pioneer' and the iconic image of him seated in commercial hard hat equipment holding a Mark V helmet in one hand opened the piece. Bev was responsible not only for a lot of the earliest sport diving equipment including being one of the inventors of the wet suit and the nucleus of the Body Glove manufacturer, but he also helped design regulators and define some of the earliest standards for scuba instruction. Later he revolutionized commercial diving with his inventions of the first fiberglass lightweight diving helmets with Kirby-Morgan and later DSI. He had always shunned the limelight and avoided interviews but I persuaded him to sit for two long sessions and candidly discuss his career. It was both revealing and, at times, brilliantly funny. That led to a series that continued in DeepTech and later Fathoms magazine."

The features became so popular that Gilliam was urged to turn the magazine pieces into a book. Choosing the subjects was tough. Initially, he conceived it to only cover the "first generation" of diving professionals but was urged to expand it to include representation from the "second generation" as well. The book sold out completely in February of 2010 and has become a collector's item.

He sent a copy to Tech Diving Mag's publisher Asser Salama who then asked permission to release it a chapter at a time through his on-line magazine. The first installment this issue features legendary filmmaker Al Giddings who was the underwater director of such

Hollywood blockbusters as *The Deep*, *The Abyss*, *Never Say Never*, *True Lies*, and *Titanic*. He also added scores of television projects and documentaries as well as IMAX films in the course of his career.

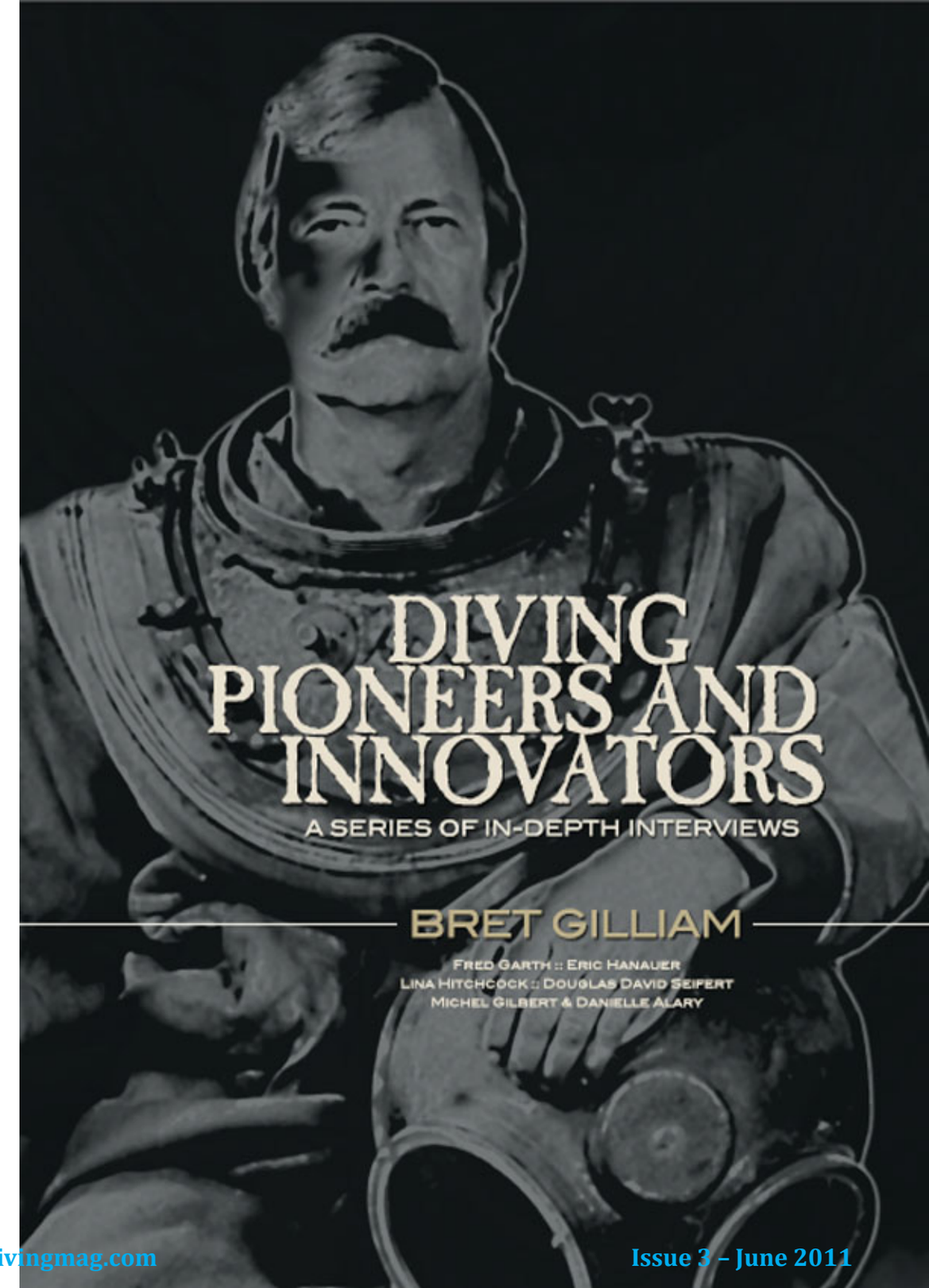
Over the course of our on-line publishing series we will also release the interviews with author Peter Benchley, explorer Bob Ballard, Scubapro founder Dick Bonin, photographer Ernie Brooks, wreck diver John Chatterton, documentary filmmakers Mike deGruy, Oceanic founder and *Andrea Doria* explorer Bob Hollis, fish and marine life ID publisher Paul Humann, IMAX guru Greg MacGillivray, filmmaker Chuck Nicklin, *Sea Hunt co*-star and "First Lady of Diving" Zale Parry, cave diver Wes Skiles, Australian shark and film experts Ron & Valerie Taylor, legendary Bev Morgan, filmmakers Howard & Michele Hall, the ageless hero Stan Waterman, and lastly Bret Gilliam himself.

Contributing authors who conducted some of the interviews include Fred Garth, Eric Hanauer, Lina Hitchcock, Douglas Seifert, Michel Gilbert and Danielle Alary.

There are also about 75 copies of the original book still in Gilliam's personal inventory. They are available as a Signed/Numbered Limited Edition personalized to each buyer by Gilliam as $200 each. He can be contacted for purchase at: bretgilliam@gmail.com.

The book is lavishly produced and illustrated throughout with photography that is dramatic and provides a unique and intimate perspective on these divers how literally shaped the industry in so many ways.

Our series starts with Al Giddings… enjoy!



Review in *Diving Adventure* magazine, second issue
By Derek Hodge

I recently had the chance to see an advance copy of a fascinating new book by Bret Gilliam that all serious divers will enjoy immensely. As many of you know, Gilliam was the founder of International Training Inc. that operates the training agencies TDI and SDI. But that was just the tip of the iceberg when it came to his investments and projects in the diving industry that spanned 35 years until his recent retirement.

Although he contributes to this magazine, he now primarily concentrates on a series of highend books through New World Publications. This is the first title in that series. And it's a fitting inaugural volume of diving's history told through interviews with 20 of its most interesting characters.

"I wanted to help preserve the oral history of diving while the people who shaped the industry were still around to tell their stories in their own words," he told me. It proved to be an exhausting task that took him a decade to complete. He started the interviews as part of *DeepTech* magazine back in 1997 and continued more when he founded *Fathoms* magazine in 2001. They proved to be one of the most popular sections of both publications and he was constantly asked by readers to expand the interviews into a book. After selling the last of his diving companies including *Fathoms* in 2005, he decided to do exactly that.

"Retiring from the day-to-day operating duties of running multiple enterprises finally gave me the time to focus on book projects and the interviews were the perfect place to start. Paul Humann and Ned Deloach at New World Publications had done an amazing job with their company starting with their award-winning fish ID books. They branched out with Stan Waterman's autobiographical book of essays called *Sea Salt* released in 2005 and it did extremely well, selling out its first press run in less than a year. So when we had a chat about a book of interviews they were interested in adding it to their library of titles. It was a perfect match for me as their reputation for quality was well known and they served both the diving market and mainstream bookstores. We quickly came to an agreement," Gilliam reflects.

Well, the book is a winner in every respect. It manages to combine humor, adventure, tragedy, triumph, heroism, and even some forays into the risqué… while chronicling the careers of 20 enduring personalities that helped make diving what it is today. Some of those interviewed are retired now, one (author Peter Benchley of *Jaws* fame) recently passed away, and many are still making history through their ongoing work. It's quite a group.

Consider that the lineup includes actress and Sea Hunt star Zale Parry who also set the depth record for women divers back in 1954. Stan Waterman provides both the book's Foreword and a revealing insider look at his seven decades in diving. Living legend Bev Morgan pioneered the first dive training programs along with revolutionizing commercial diving equipment. His image in full hardhat dress also graces the book's cover. Morgan's candor and humor set the pace for the lively montage of dialogues to follow with Australian couple Ron and Valerie Taylor who rose to fame in the iconic shark documentary film *Blue Water, White Death*. They are joined by others from diving's first generation including filmmaker Al Giddings (*The Deep*, *The Abyss*, *Titanic*, etc.), retail pioneer and cameraman Chuck Nicklin (The Diving Locker), manufacturers Dick Bonin (Scubapro) and Bob Hollis (Oceanic), photography masters Ernie Brooks and Paul Humann, as well as deep ocean explorer Dr. Bob Ballard who discovered the wrecks of the *Titanic*, *Bismarck*, and *PT-109*. (Hollis'

adventures as part of two saturation missions to salvage artifacts and valuables from the wreck of the *Andrea Doria* in 1973 and 1981 would make a good movie all on their own.)

Diving's second generation of innovators includes cave explorer Wes Skiles, filmmaker Mike deGruy, wreck explorer John Chatterton (of *Shadow Divers* fame), IMAX film producer Greg MacGillivray, and the dynamic husband/wife team of Howard and Michele Hall who seem to dominate the realm of documentary underwater films now (*Island of the Sharks*, *Coral Reef Adventure*, *Deep Sea 3D*). Last but not least, Stan Waterman talked Gilliam into sitting for an interview about his own amazing career and, typically, he shares a wicked sense of humor along with some biting perspective about what it was like to champion new technologies and daring approaches to diving business when the sport's ultra-conservatives wanted to suppress nitrox, liveaboards, technical diving, diving computers, training methods, and honest journalism. If you don't fall down laughing in parts of his interview, you need to seriously lighten up!

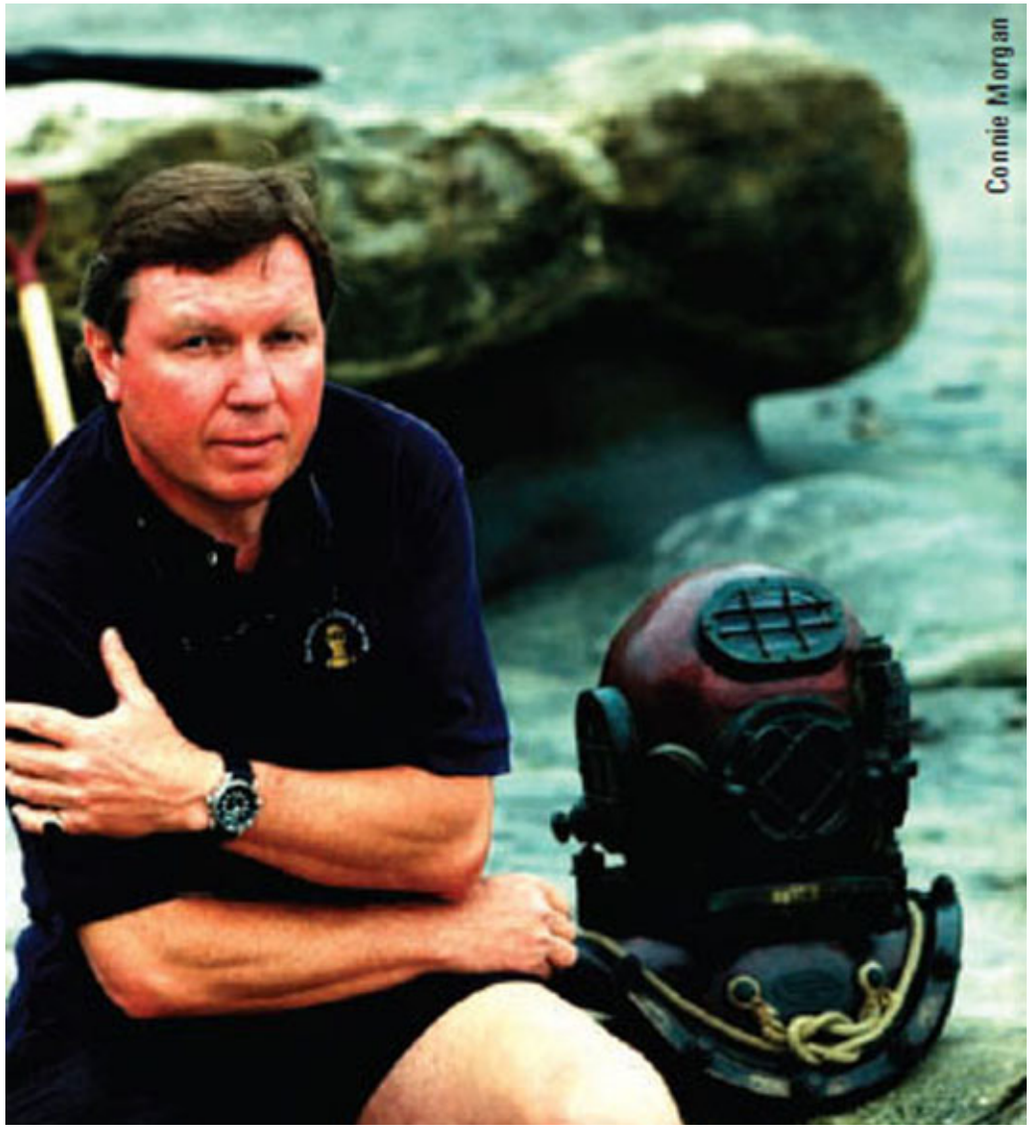
I found each chapter to be a slice of human interest that let me briefly pull back the curtain on the personal lives of diving's heroes and feel like I was part of the conversation. The full color book is lavishly illustrated with great photographs that capture each interviewee throughout their diving careers. It's a very personal journey and the reader will feel like they pulled up a chair and shared a cup of coffee around a table with each person. I came away with a new found appreciation of what the history of diving really is.

Gilliam enlisted help from other leading writers for some interviews he couldn't conduct himself and Fred Garth, Lina Hitchcock, Eric Hanauer, Douglas Seifert and Michel Gilbert & Danielle Alary all make significant contributions to round out the book.

It's a massive volume, 8x11 inches in size, 489 pages, hard bound, and weighing in at a whopping five pounds per copy! If nothing else, it will make a weighty coffee-table ornament that could survive a hurricane blast. But I predict it will become a collector's item. It already has been endorsed by no less an authority than the Historical Diving Society. Find a place in your library for this rollicking ride through diving's evolution to the present day. Straight from the mouths of those who made history.

We liked the book so much we stock it for sale with a special offer available only through the magazine: Bret Gilliam will personally sign your copy to you if you order through us (*Editor's note: that was back in 2007*).

Forward
By Leslie Leaney



Grainy black and white images flickered across the length of the auditorium. The audience fell silent as the screen showed an athletically built young man standing on the swaying deck of a small boat. With a deep tan and sun-bleached hair and beard he looked like a sea gypsy. Assisted by a bearded crewman, he placed a navy submarine escape apparatus over his head, put on his nose clip, mask, and fins. And then, without pause, he took a step off the deck of the boat, and into the sea. The images then moved underwater as the young man gleefully swam around the seabed in a lengthy series of maneuvers reminiscent of a solo aerobatic display. Somersaults, loops and rolls. Liberated in a three-dimensional world, he instantly became a fish among the fishes. He was free at last! It was a surreal moment in the sea.

In the front rows of the sold-out auditorium headliner speakers James Cameron, Stan Waterman, Ernie Brooks, John Chatterton, Bret Gilliam and others sat in revered silence. You could hear a pin drop. Seated on the auditorium stage in the silent darkness, an elegant older couple sat holding hands. The gentleman turned his head to the screen slightly and nodded as if to reassure himself of a fact. Could what he was seeing really have been 64 years ago and half a world away? Could it?

What the audience was witnessing was the original footage of what most historians consider the dive that launched scuba diving as we know it. The fact that the actual diver who made it was sitting on the stage in front of them with his wife Lotte, made the whole experience even more surreal.

The step that Austria's Hans Hass took on July 12,1942, at the Greek island of Ari Ronisi, heralded the dawn of recreational and scientific scuba diving. A threshold had been crossed. Twenty-seven years later America's Neil Armstrong stepped across another threshold. "One small step for man, a giant leap for mankind." The whole world knows Armstrong's first step. Only a handful of divers know of Hass' first step. That too was also a giant leap for mankind.

Hans Hass' 1942 step was but the first of millions that were to follow, as humans discovered the thrill of scuba diving. Less than a year later Cousteau and Gagnan invented the Aqua-Lung and full French production of the unit would follow within three years. By 1948 the Aqua-Lung was available in the United States and the sport of recreational diving started to develop.

In the years that have followed, numerous sea lovers tried to make a career out their passion for diving. Then, as now, it proved to be a difficult thing to do. Those that were able to convert the intoxication of this new adventure into a meaningful career became the pioneers of the sport. However, scant attention was given to the historical relevance of what was being invented, discovered, and photographed or filmed. Few participants thought what they were doing would qualify for the designation of "historic." But some of it was.

In 1992 I co-founded the Historical Diving Society of America to help record and preserve some of this early history, partly because the first wave of pioneers were reaching their very senior years. Even with the assistance of recognized scuba historians such as Nick Icorn, Eric Hanauer, Philippe Rousseau, Nyle Monday, Peter Jackson, Kent Rockwell, and Michael Jung, it has proven to be an extremely challenging task. This is partly because, unlike almost every other sport, we divers do not enter a competition with each other to provide a set of winners and losers. Consequently, we do not provide victors who become sports heroes, nor Most Valuable Players that are recognizable to the general public. The way divers generally get any recognition is by overall consistent career accomplishments displayed in a body of work and in service. It is here we find our heroes and MVPs.

In the pages that follow you will get to meet, via interview, a very select group whose work in the underwater realm has elevated them to MVP status. Stan Waterman gives you an introduction to these divers, but let me endorse that they are some of the most interesting creatures swimming in our oceans today. By granting practically unlimited editorial space to each, the interviews have captured not only the history of these careers but also the essence of the subject's character. Each interview provides a personal link in the chain of diving history that connects us all to the birth of our sport, and it also records some of the milestones they created along the way.

Perhaps the most appealing element of this book is that it is easy to imagine that you are actually sitting opposite the divers as they tell their story. For me it felt like I could have been relaxing on the back of a dive boat and watching the sun set listening to someone who has had a measurable influence on the overall culture of diving. Very rare air indeed.

Since Hans' early step of 1942, the world has accumulated an increasing archive of imagery and words that record many individual contributions to the culture of diving. But the pristine world that some of these pioneers have seen may no longer be available to their grandchildren. As we now all face the environmental uncertainties of the future, it is important to know from where we have come. The divers interviewed here present some illumination to that historic path which includes the discoveries of their personal journey. Theirs has been a unique experience and I am delighted that this book gives these special characters a chance to share some of their adventures, and enables them leave their indelible fin-prints in the historical sands of time.

Leslie Leaney, President of The Historical Diving Society, USA
Santa Barbara, California, June 2007

Al Giddings

DEAN OF UNDERWATER HOLLYWOOD

BY BRET GILLIAM

ALL PHOTOS FROM AL GIDDINGS COLLECTION EXCEPT AS NOTED

:: al giddings

During the last four decades, Al Giddings has earned a reputation as one of the most creative and talented filmmakers in the entertainment industry. His diversified roles have included that of director, producer, and cinematographer. Never settling for off-the-shelf technology, Giddings is constantly designing innovative camera, lighting and optical systems in all film and video formats to High Definition TV. »

He is well known for his underwater directing and shooting of such highly acclaimed films as *The Deep* and the James Bond series *For Your Eyes Only* and *Never Say Never Again*. But what many don't know is that Giddings was also a pioneer in technical diving out of necessity for his film projects. He was the first to dive with mixed gases on the *Andrea Doria* in 1969, the first to discover, dive and penetrate the Japanese *I-169* submarine in Truk Lagoon in 1973 and he's been incorporating innovative gear, such as rebreathers, in his projects for years. Giddings also pushed underwater film techniques and technology for The Abyss and the film went on to capture an Academy Award nomination for Outstanding Cinematography. More recently, he served as co-producer and director of underwater photography on Jim Cameron's spectacular *Titanic* released in 1997. The film, of course, broke all box office records in film industry history as well as dominating the 1998 Academy Awards.

Giddings has directed and filmed dozens of works for television, including his specials on the *Andrea Doria*, as well as films on the North Pole, deep-sea volcanoes, great whales and sharks. In 1996 he did *Galapagos: Beyond Darwin* for the Discovery Channel, one of the highest rated shows in its 10-year history. Three television specials, *Blue Whale*, *Shark Chronicles*, and *Mysteries of the Sea* each earned him Emmys. He also produced and directed *Ocean Quest*, a five-part NBC ocean adventure series that captured the number one slot in prime-time ratings.

For Giddings, like many other filmmakers from Cousteau to Howard Hall, technical diving has been a means to an end, whatever it takes to get the shot. Much of the technology Giddings developed, both in diving and filmmaking, opened the door for the modern diver to follow in his virgin footprints. Still, it has been his talent behind the lens, along with his willingness to push the edge of diving, that has won him great success and acclaim.

This interview actually began in 1997 and portions were used in the old Garth/ Gilliam magazine *Deep Tech*. At that time I was dispatched to track Giddings down at his lavish Montana ranch and production studio. We first met on the *The Deep* over 30 years ago then, and had continued to exchange information on emerging rebreather technology. On my first visit, Al told me that I might have trouble finding his place even with good directions, so he'd meet me at a place called the Old Saloon just off the main highway in Emigrant, Montana, about 30 miles out of Yellowstone. It was a nice fall day about 70 degrees and, of course, I'm in shorts and a T-shirt.

So I stroll into this bar and it's like stepping back in time into the Wild West. There are guys in Stetsons sipping beer who look like they just finished a cattle drive and some very friendly women eagerly attending their needs. I figured Miss Kitty was in the back somewhere. The bartender takes one look at me and says, "You gotta be looking for Giddings. He'll be coming in shortly. Sit down and have a drink." Whether a suggestion or a command, it seemed like good advice. I climbed onto a stool and he shoved over a beer mug roughly the size of Rhode Island.

Al arrived and escorted me across the Yellowstone River in front of towering mountains to his new 20,000 square foot studio. Just up the hill at his house, a friend was preparing a gourmet meal of


Filming humpback whales in Alaska

fresh salmon and pasta. We watched a herd of elk grazing in the high pastures from his back deck while a Montana sunset of impossible beauty wrapped the valley and mountain range in warm light. Over a glass of fine Chardonnay, we caught up with each other and let the tape recorder run.

Then about to celebrate his 60th birthday, Al is the consummate hard-driving professional who hasn't lost a step. We had spent some time at DEMA 1997 getting him set up with closed-circuit rebreathers and now he was eager to show me some footage from his upcoming Discovery Channel special on whales. As the sequence unfolded in the studio, I sat speechless. He had captured over 30 humpback whales in one frame as they congregated for their migration to Alaskan summer grounds. Nothing had changed. Al was still the king.

You've been in the business for nearly 40 years. When did you start diving?»Mid to late 1950s. I really loved the water. I grew up in Northern California with a fly rod in my hand, fishing and hunting. I started off shooting with a speargun as do so many people from Gustav to Cousteau. I got excited about diving and, I thought, somehow I'm going to make my living in the diving world. Probably two years into it, I became more interested in shooting with a camera. I bought an Argus C3 Matchmatic Camera and I put it in a '46 Ford oil filter with a screw down top. Then I cut some holes and came up with lens ports. I sold two pictures to *Motorland* magazine. Now I could see the possibility of earning my keep diving, but photography, that would really be the high tech way to go. So I started the retail diving operation, Bamboo Reef. Sal Zammitti got involved later, Leroy French was my partner. Al Santmeyer bought my interest out years later.

What year was that?»We started Bamboo Reef in 1961. I was teaching diving at Drake High School that I did for three or four years. So at the age of 21 or 22 I sat down and wrote this paper on "diving's physiology & practical aspects" or some zany title like that. I don't know who reviewed it, but soon I had a state teaching credential, three or four years out of high school, no college. I was back at my high school as an accredited teacher.

With Bamboo Reef you guys were classic dive retailers. But later on you went into building customized cameras.»Leroy French and I got $600 of home-improvement loans and bought $1,000 of inventory and then we took all of our personal gear and displayed it in the store. We took no salary for the first two years, then $25 a week for the second year or two. This was 1961. So I started building camera housings on the side. I was already doing stills, I could buy $20 worth of Plexiglas and a bunch of surplus store fixtures and build an underwater housing fashioned after Jordan Klein's, who was building them at the time.

I remember when you came out with the Giddings Felgen line of underwater camera gear.»That was in 1969, seven or eight years into my career.

That was really top of line. I still have a Nikomar housing and a Seastar III strobe.»You were our first dealer in the Caribbean. Because of my personal interest in photography, I would develop

these systems for my own use and then spin off a product. We really popularized motor drives and some of the first dome ports. My personal and professional interests were growing so I partnered with Mike Felgen. Even then, around '69, when I announced to the world that I was going to really earn my living just shooting underwater, they thought I was crazy. The first year I made $40,000 to $50,000 and I couldn't believe it because I had no overhead, no inventory. When I started shooting, the volume money wasn't there, but the take home money was. I would get a check for $3,000 and I didn't have to pay US Divers for all the tanks I had ordered.

What were your first underwater jobs?»I started getting involved with *National Geographic*. There was an oil spill in San Francisco Bay; I shot some stuff there. Then I shot an article for the *Geographic*, also about this time, on plankton with Bill Hammner in Bimini. I started to do motion picture film. Al Tillman had the first big underwater festival in Southern California, so I started selling some of that material. I did films with AMF Voit and US Divers: *Painted Reefs of Honduras and Twilight Reef in Cozumel*. There was just enough work to sort of pay the rent and 10 years later an event happened that really accelerated things.

Cornel Wilde (the actor) approached me and had this feature called *Shark's Treasure*. That was a real Hollywood pot-boiler. I think his budget was about a $1.8 million. So we shot on 16mm and blew it up to 35mm. I took Cornel and a bunch of people to Australia, set up cages and strategically baited the sharks. I had really great results and although it was a B-picture, a lot of people saw it, the shark material specifically, and thought it was pretty exciting. That led to *The Deep*. Columbia called me a few years later and they brought up *Shark's Treasure* and I initially backed off a bit embarrassed. But they said, "Why are you backing off? The picture did $11 million dollars gross but cost only $1.5!" At the time that was real money and they loved the images so I partnered with Stan Waterman to shoot *The Deep*.

I built the camera systems for *The Deep*, three 35mm models. That really was a remarkable project in so many ways. I was involved for eight or 10 months before we pulled the trigger. We built the housings and ran around the world trying to find the sites — Bermuda, Virgin Islands, Australia. I think that was the first time anyone hat shot underwater material in any other way than the "set-it-and-forget-it" wide angle lens approach. With three cameras, my approach was to shoot it as a creative topside Director of Photography would: with different focal lenses, three cameras shooting simultaneously, and give the editor something really dramatic to cut. Lighting was another issue. We brought in not one or two 1Ks, but 5Ks and dozens of 1Ks and built an enormous underwater set. We shot all of the master shots in open water on the 1867 wreck of the *Rhone* in the British Virgin Islands and then went to the underwater set in Bermuda. We laced the set with live eels and live fish so as the camera panned around, you really felt that you were there.

Many people have said that they can't tell the difference between the *Rhone* and the set.»Right, the biologists complimented us to no end saying they didn't know where the scene transitioned between the set and the open sea. It really made the movie. I could actually go: "stand by, roll camera one, roll camera two, and feeder." Somebody would then sprinkle the set with fish food. We wouldn't feed them for a day or so; the fish would be all over the place. There are shots of Robert Shaw lighting a fuse to blow up the wreck and as the camera backs off, fish are looking at the burning fuse. That created a production value that no one had ever seen before. Imagine too, we would shoot an extreme wide-angle lens master plus a medium close-up on Jackie Bissett or Robert Shaw or Nick Nolte or Lou Gossette

and somebody else would be running tight on the burning fuse, so the editing was really creamy. For the first time we had an underwater movie that had all the dramatic moments and the voltage of a tightly choreographed, well shot, topside film.

I remember when the movie first came out, many people critically hailed it as the most ambitious underwater project that had ever been done since *20,000 Leagues Under the Sea* some 25 years before. How did Columbia react to this whole thing when you guys pitched this and said we are going to do this thing with 60 percent of it under water? That must have been a daunting sell.»They were really nervous, and for Peter Guber, 29 years old. His first picture was *The Man Who Would Be King* with Sean Connery. Peter was a very persuasive, very high-voltage guy. We got along very well and the core and fiber of our relationship was my endless excitement over what we had set out to achieve. Peter gave me full backing and support and Columbia deferred to him as the producer. Peter Yates (the director, who had also done *Bullit* with Steve McQueen) was really excited about the ideas that were brought to the table.

It was an incredible challenge and I mixed my natural history experiences, my commercial diving experiences and the support of Columbia and Peter Guber's enthusiasm with a budget of $8.6 million. Every time we had a meeting I'd raise my hand and they would all go, "Oh my God, here he comes again." Cameras were an issue. There were no reflex systems around that would take multiple lenses and my dream and vision was to build three underwater 35mm "Stradivariuses" that would allow us slo-mo, multiple lens choices and all. Peter said, "OK, go for it."

We used hoses (surface supply) for the first time. I took the first stage from a dozen regulators and hooked them up to a master manifold and ran a dozen hoses in the water – 60, 70, 80 and 100-ft. hoses. We would go in and of course, we could stay on the bottom forever since the depth was only 30 feet or so. We covered the whole set so that it was dark as night and then we would light the interiors of the set. It was amazing, I remember, for the first time ever, looking through the viewfinder and thinking it looked like that vision of the shipwreck that I had when I first started diving. You know, you close your eyes and you think someday I'll be on a shipwreck like this. It was absolutely perfect.


Spear fishing in 1959

In addition to the technology challenge, this was the first time that anybody had really tried to put the actual actors in the water and shoot them. You had all of these non-diving actors, how did you do that?»The studio guys talked constantly about doubles. I wanted to approach this a little bit differently. I wanted to sit down with Shaw, Bissett, Nolte and Gossette, all of these people, and teach them how to dive. Of course it was, "Oh no, use doubles for that." I said, "Wait a minute, we're going to get a production value. We'll get voltage, we'll get excitement out of these people that you could never get with doubles and I'll be able to shoot all of the close ups and pull-backs and all of this on the actors and I think they are really going to love it."

You know Nolte is a very physical guy. But Jackie Bissett was a little different. She said to me, "I want to get something straight at the beginning of this conversation, not only am I not going to dive but I don't even like to put my face in the water." I took a deep breath

and waded in and said, "Well, then you are going to miss a most incredible experience. Perhaps, one of the most exciting experiences of your career." I heard her groan. She was trying to figure me out, where is this guy coming from, but I was totally serious. I left *National Geographic* magazines with her when I was finished. I did the same thing with Shaw and Gossette and all of those guys. I have never, in my career, ever worked on a film that had the unique spirit of those people. All of those people learned how to dive. They were challenged by the diving as well as their first discipline, acting and doing a movie.

Bissett was the largest name at the time with Shaw who had just finished doing Jaws. He had something of a notorious drinking habit. How did you handle that?»Bless him, I loved him. He was a great man and a wonderful artist but he did have a bit of a drinking problem, as you'll remember. In fact, on the last day of the last hours of *The Deep*, he was too much into the sauce to do his scene. I know you remember that scene where the giant eel grabs Lou Gossett by the head and drags him back into the wreck. Shaw's character is also tied up in the line from a spear gun and is being dragged toward the eel's hole. Well, Shaw showed up to the set pretty bombed, actually more than bombed. In fact, Peter Yates took one look at him and said, "Forget it, no way!"

Shaw came down, took me aside and said, "Al, I know you can get me through this."

So I went back to Yates and said, "It's going to be okay, we're going to do it." Then I got Chuck Nicklin and the rest of the crew and told them to get in the water and light the set. They couldn't believe it after watching Shaw stagger around. But in we went. Shaw somehow made it to the edge of the platform and I got in facing him. I grabbed him by the tank straps and hauled him into the water. I had to put the regulator into his mouth for him, all the while I'm looking into his eyeballs trying to read him. He just smiled, he was feeling no pain. So down we went to the underwater set, the lights came on, the cameras were ready and I jammed him into position then wrapped the line around him to set the scene. He was so out of it he kept spitting out his regulator too soon since he thought we were rolling and I'd keep jamming it back in his mouth.

I'd go, "No, not yet!" and he'd just grin at me.

Finally, I had him in position and all tied up and ready for the eel to drag him away. I grabbed my camera and had him hold still, then focused on his face. I nodded and he came alive and started acting. He spit out the regulator and I'm shaking him for effect with one arm, and he's fighting back looking pretty heroic for a guy who could barely walk, much less swim. We did about five takes, then I handed the camera back to Nicklin and swam Shaw back to the surface. I had to lift him out of the water he was so gone. Then he puts his arms around me and said, "We got her, boy!" Meanwhile Yates, the director, is in the parking lot doing laps around his limo shaking his head.

You look at *The Deep* today and you see that shot and it all worked. It looks like Shaw is in pain and struggling for his life in mortal combat with the eel. But in reality he's smashed and half-laughing at the crap he's putting us through. In hindsight I guess it was pretty funny, but at the time no one thought he was capable of getting through it.

***The Deep* was in 1976, but you did some definitive stuff years before on the *Andrea Doria* wreck that was really some of the first technical diving of the era.»**It was 1969 and I had met Bruno Vailatti


Directing Sean Connery in Never Say Never, Again, 1983

at a film festival and he was interested in doing a film project on the *Doria*. This was deep stuff, especially back then, and he talked me into joining the project. It was only about a dozen or so years since the ship went down and it had hardly been dived at all. We chartered this 85-ft. trawler *Narragansett*. In those days we were using the old SOS deco meters and we were doing two dives a day. I ended up doing 21 dives, all on air and using pure oxygen for the decompressions. I'd never done that kind of deep repetitive diving and it was pretty hairy at the time. One time Bruno and another diver got lost on the wreck, we all had less than 150 psi left in our tanks and our meters so far in the red zone that I thought we'd never come out. A year later Elgin Ciampi, got bent when a Pegasus DPV had a failure, he ended up unconscious in the boat's chamber, barely survived.

But it was an exciting time. Later we used trimix for the first time. I had the wheel of the *Doria* in my hands on dive six. I was in the chart room with all the stuff spread out all over the place and the ship's compass was still in place although it was smashed. It was the first real serious exploration of the wreck and we had a ball. But we were definitely out there on the edge at the time.

Speaking of going over the edge, you did an amazing project in the 1960s with Bob Croft.»I did Bob Croft's 240-ft. breath-hold dive and, in fact, that was the first network show I ever sold. Bob Hollis and I worked on that with Dewey Bergman.

This was a revolutionary dive for breath-holders.»Totally unbelievable at the time! Bob was doing bottom drops, 110, 120-ft. deep breath-hold dives. Croft was a chronic smoker – two or three packs a day – and I remember Doc Schaeffer told him to back off on the smoking. But Croft said his tolerance for carbon dioxide was very high when he was smoking and he didn't want to change his routine. When he quit smoking, his breath-holding capability was far less. Don't ask me to make any sense of this.

Where was the diving done?»We were in the Gulf Stream off of Fort Lauderdale. Carl Rosseler was there at the time doing stills. Dewey Bergman, myself, and Bob Hollis. I remember rigging a camera on the line. The first dive he made with the camera on the slide was a disaster because the balance was off. It wouldn't run right, so I ended up being the guinea pig. I had Hollis go to 100 feet. After we tinkered with the slide I rode to about 140 feet.

Croft was entering a zone that had the doctors concerned. They actually predicted that he was going to have a residual volume lung collapse.»Right, they were concerned about hemorrhaging and

I remember Doc Schaeffer set him up with an electronics package that would give him a readout. I remember gulping because we could watch his heart rate as he left the surface. It was a bit frightening because it looked like his heart was shutting down. Schaeffer said something about shunting blood to the extremities and at that time, a lot of this was really unknown territory. Anyway, Croft eventually got to 240 feet! I was down below him filming, slightly out of my mind from narcosis because I'm kicking like mad in the Gulf Stream trying to get the shot. At the time, his breath-hold dive just seemed impossible.

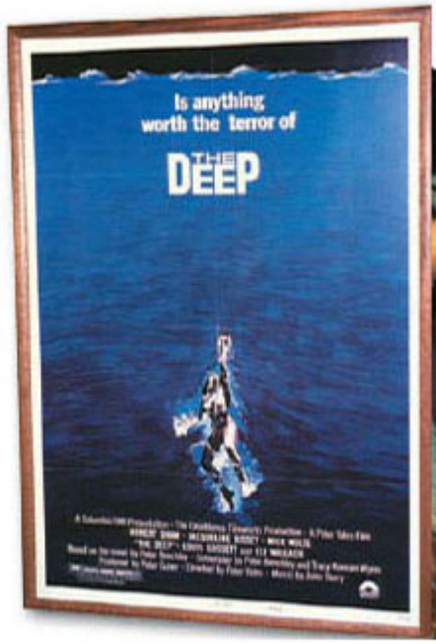
You followed that up with one of the first expeditions to Truk Lagoon.»Sometime around 1973 Paul Tzimoulis of *Skin Diver* called me and said he was trying to locate a Japanese submarine, the *I-169*, that was sunk in the Allied strike *Operation Hailstorm* in 1944. So we started systematically looking for the sub among the 60 or so known wrecks at that time. But until we actually put out the word through the Fishing Department that we'd pay $100 for any information on the *I-169*, we weren't making any headway on finding her. About three days later a man came aboard and said he had lived on the island as a child, remembered the whole attack and knew where the sub had gone down.

So we took off making passes with this little profile fathometer. Stan Berman was actually the first to see it and he came up almost choking because he was so excited to tell us about what he'd seen. I remember jumping in the water and going through that murky upper layer, my eyeballs popping out of my head, then all of a sudden, boom, the bottom opens up and there's the *I-169* stretching into infinity. It was about 140 feet to the bottom. We had a little come-along and jacked open the hatch over the engine room. The hatch opening was too small for a big American in doubles, so I had to take everything off to squeeze in. Tzimoulis passed a single tank to me along with a big light. I remember turning it on and actually hyperventilating. There were human remains on top of the engine. It was like something out of a horror movie! The clocks had stopped at 8:02 in the morning and there were personal effects and skeletal remains everywhere!

It was damn spooky. I'm walking around in the cramped compartment of the sub with no fins and about 40 pounds of weight on. I'm sinking into the muck and silt. At one point I'm nearly up to my waist in the stuff, crew remains and white skulls looking back at me everywhere. Then my light went out! I'm way in from the hatch and it's totally black. I remember talking to myself saying, "Okay, cool it, don't get excited, keep it together." I managed to turn the damn light on and turn around. Black silt pouring off me and I'm bumping into skeletal remains. Talk about a rush! It was like entering a time capsule.

Few people have even seen it since. I dove it in 1994 it was just exactly the way you left it, untouched.»After we left, other sport divers managed to find the wreck several months later. One diver ended up getting caught inside and drowned. It was a real tragedy and it scared off others. In 1974, the Japanese raised $240,000 to recover their war dead and I was invited back to film the effort. It was an incredibly moving experience that became the basis of my film, *Search For the Shinohara*. It was nominated for an Emmy.

You had a *National Geographic* cover story on Truk as well, didn't you?»Yeah, they sent me back again and a huge article was published, almost 50 pages in length. It turned out to be one of the most popular articles ever published for them. It seemed to strike a chord for everyone with ties to WWII, including the Japanese.



Bissett, Shaw and Nolteon, the underwater set of The Deep, 1976

I remember seeing pictures of the Shinto ceremony, the funeral pyre, and the religious rites that you recorded.»Yeah, that was part of the film. It was all I could do to hold it together emotionally and shoot the ceremony. There were two survivors of the *I-169* there, a Mr. Maki and a Mr. Eura, along with a throng of family members of the dead crewmen. The salvage crew brought up newspapers and magazines that were still readable after 30 years submerged. There were personal photos that hung on the bulkheads along with letters home that were never mailed. There were wooden tags from foot lockers and other personal effects that had been brought up. The image of mothers of the dead sorting through this stuff and crying was so compelling that all of us were moved to tears. At one point in the funeral ceremony Mr. Maki stepped forward and played taps, the U.S. version. Everyone was so overwhelmed by the emotions and loss of those brave men.

Following your success with the Truk expeditions, you produced another hit for ABC, *Mysteries of the Sea*.»This was the second time I had worked with Peter Guber and I really wanted to do a chronicle of undersea history and indeed that is what it became. We traveled all over the globe in 1979-80 looking at the different developments and progresses in diving techniques over the centuries. We built full-size models of gear and equipment and even did period wardrobes for the re-creations. We filmed things like treasure hunting, predators and sharks, diving research and submersibles. I wanted the film to really have wonderful moments and remembered that *National Geographic's* first grant for $1,000 was to Admiral Peary. I knew that Gilbert Grosvenor, (*Nat'l Geo's* President) had sat on Peary's knee as a young man. So I called him up and said, "Gil, I'm going to the North Pole to do this film. We're going to dive in Peary's footsteps and I'd really love to have you come." He said, "Oh my God, that all sounds incredibly interesting." He had some reservations though and wanted to think it over. I didn't know if he was going to join us. On the third day I called and I got his secretary. She said, "Al, Gil is not here, but he told me to tell you that he was at Abrocrombie & Fitch and you would know what that meant!" So Gil committed. The film team went up to meet our Canadian expedition crew. We had chartered a vintage DC3 airplane and I remember this pilot had a roll of toilet paper hanging in the cockpit between the two windows so he could wipe the frost away while searching for the Pole. It all seemed totally bizarre.

***Mysteries* resulted in an Emmy Award winning film, and also as a wonderful book.»**That's right. We were flying back after a wonderful expedition to the North Pole. Gil and I were very excited. We had shot some great stuff and had dived through nine feet of ice. Gil had walked upside down in Peary's footsteps. I was telling Gil about *Mysteries* and about how we were going to do a book and he said, "Let's do it together." In fact, at the time I was headed for my connecting point in Seattle and Gil was going east, but he said, "Don't go to Seattle, let's talk further about this."

So I changed planes and we went on from Yellow Knife in the Yukon to Washington. We talked all the way back on the plane and the result was the book, *Exploring the Deep Frontier*. Sylvia Earle was my co-author. Initially, they didn't think it would find much of a market. But the first year it did about 250,000 copies in hardback. It was a runaway bestseller for the *Geographic*.

Tell us about some of the projects that you did between that and when you jumped in with both feet to do *The Abyss*.»I have had an interesting career working in two camps, the theatrical camp and the natural history camp. So in between theatrical projects, I was doing natural history and vice versa. I went on to do *Gentle Giants*, the first real film on whales. I spent a lot of time in Hawaii and then went on to Alaska to film the first bubble-net feeding behavior on humpbacks. In fact, we were just on a piece shooting widescreen digital in Alaska last month, revisiting one of the places that I worked years ago.

I am also excited by Hollywood projects, particularly working with Jim Cameron, because I'm just so impressed with his work. That is an incredible challenge. I have really always been challenged by the natural history projects. In fact, each discipline benefits from the other. Working underwater and doing all of these natural history programs gives me a real take on how to approach theatrical programs and underwater lighting. I take those lessons and disciplines back to the natural history world.

As big of a challenge as working with natural history can be, where you have an uncontrollable "actor," if you will; the technology-driven challenges posed when you did *The Abyss* were unheard of at the time. Tell us how you conceived shooting *The Abyss*, as well as the site you chose.»*The Abyss* will be historic. It was one of those special projects that only comes along once in a lifetime. Jim Cameron was committed to doing something that was totally believable. Cameron is really an excellent diver and a consummate filmmaker. He is unlike any other director with whom I have ever worked. We used 10,640 dive tanks in 90 days on *The Abyss*. Cameron was in the water, shoulder to shoulder with me for all of it. I never expected that. My respect for him, not only as an artist, but as someone who would invest that much personal and physical effort into a project, was immense.

You weren't doing this in some small-scale set. Describe the set you were working on.»Well, like all Cameron projects, they are just sort of bigger than one's imagination and this was no exception. We went to view a turbine pit at an abandoned nuclear power plant in Gafton, South Carolina. I remember being excited about the turbine pit and the possibilities of doing shoots underwater. About a half mile away was the main containment vessel. So Cameron, young, tough, rugged, brilliant, and I climbed this abandoned crane that had been sitting there for seven years. And now we're looking down on this massive structure: four foot thick walls, 200 feet across, 55 feet deep. This great bowl would make the ultimate superset.

Anyway, about three million dollars later, we had scarfed all of the metal out of this concrete bowl that had held all of the reactor stuff and painted the entire thing with black dye. I wanted a totally black environment. Things were now set in motion for the largest, most extensive underwater set in the world. Eight million gallons of water, filled, filtered and heated to 81 degrees. We then shot for five months.

You were using full size submersibles and habitats, right?»As soon as I read the script and spoke with Cameron I knew the elements from this picture were not coming from the props department at Fox. They were coming from the commercial diving world so I called Phil

Nuytten. Soon after that Phil came to LA. We talked about everything from the helmet-like masks to beam splitters that would give some of the light on the actor's faces. Once again I took the same approach that I had on *The Deep* years earlier. I wanted to teach Mary Elizabeth Mastrantonio, Ed Harris and Michael Biehn how to dive, how to use rebreathers and all the sophisticated gear. The approach was really going to be commercial diving. When production started we would enter the tank at 6:00 in the evening and work on the bottom from 6:00 until 1:00 in the morning. We were shooting nights so we had no light leakage, no daylight. We would come out at 1:00 in the morning, have lunch, jump in a hot tub right next to the set, warm up, jump back in to the set and finish at dawn.

That movie was a success and, of course, Cameron's prior successes with *The Terminator*, established him as the leader of this film genre. You both have recently gotten back together again on a very ambitious project which will be premiering shortly. Tell us about that.»I did a show with the Russians in 1992. I went out on the *Titanic* with Emory Kristoff and Joe McInnes to shoot *Titanic: Treasure of the Deep*. Walter Cronkite hosted the show and we had a premier screening in Burbank at the Academy with about 700 people and I called Cameron and said, "Jim you should come and see this." He said, "Okay, I'll be there." He was a very busy guy, I wasn't sure he was going to make it. But that evening just before the lights went down, I looked back and standing in the doorway to the theater was Jim and his brother.

They came down and sat with me and we talked and watched the film. When the lights went up everybody was applauding, it was a very nice moment. Jim was so excited because he had been thinking about the *Titanic* and had seen *A Night to Remember*, the old black and white *Titanic* film weeks earlier. That historic night I think he saw unbelievable possibilities in the actual wreck as part of the story. Probably six months after his initial excitement at the screening, Cameron called up and said, "I've got to finish *True Lies* but then I want to dive *Titanic*." I said, "You've got to be crazy, but I love it."

So off we went to Russia to investigate the submersibles and support vessel. We spent 10 days and had some wonderful parties with the bottomless vodka-bottle tradition and all. Later we rendezvoused with the Russian ship at Halifax for the expedition. We set up one submersible and nine HMIs. The Russian submersible *Mir I* was the gun-ship and carried a 35mm deep water system with pan and tilt, and a black and white monitor inside the submersible. Our dives were 17 to 21 hours at 12,460 feet! If you really pinned me down and asked what is the most high-voltage underwater feature film ever done, I would certainly have to say *Titanic*.

The ROV footage went to Fox's prop department and they recreated the interiors of the wreck along with a 90 percent scale model of the ship. Looking through the viewfinders while shooting in the underwater set was like looking at the *Titanic*. I mean I would look through the viewfinder at night, we would have it lit, the ROV would come around the corner, into the room, flickering light off the mirrors in the Astor suites, the main ball room, the promenade decks. The set was so good. Once again, you are going to see something like

The Deep years ago, where it's a seamless setup. The audience will just freak because you are seeing the master super wide shots of the *Titanic* and we move up to the doorway, down the hall and around the corner and the set is so beautiful.

Around the corner, you enter the first-class cabin; it is the core and fiber of the story. The fireplace, the wreckage, the safe that they eventually get to. All of these things are as if I was in a wreck swimming with scuba at night. It magically transported me to the real wreck. I wouldn't really know the difference. So Cameron once again championed a whole new watermark and *Titanic* will carry a look and authentic fabric that has never been done before.

How many directors do you know who would go to the *Titanic* itself and jump into a 23-ft. long submarine with a seven foot diameter interior space, along with three guys then log 150-200 hours on the bottom two miles down?

***Titanic* will be released just before Christmas 1997. In spite of the fact that you have had a presence in Montana for a number of years, you have recently made a major commitment to this area with the film studio and production facilities.»**Well, the Montana facility is a dream come true. I have had the ranch here for 15 years; it was always my getaway place. Years ago, fax machines, Fed-Ex, UPS, all of those great services finally came into this wonderful valley 20 miles from Yellowstone and I thought, "Could I really run my business from Montana?" I had a wonderful studio in Northern California, central to the real action in LA, just down the road. At this point in my career I sort of know all the players, with these new super ways to communicate, I took a deep breath and designed this building.

This coincides with the practical reality of high definition film systems. How do you feel about this technology?»Just recently, new standards were finally realized and established internationally for high definition television. High definition has six or seven times the smack of the finest television image you've ever seen, of any size. With high definition, a little shutter dialed into the camera can capture any one of those frames and be printed on the cover of *Geographic*. I believe that the average set in America five years down the line will be 60 inches. High definition is so dramatic; a feature film in HD will be something akin to going to the theater. The marriage of images and sound in the future will be such that we are going to see a shocking new and wonderful change in home entertainment.

It is a very exciting time. Most of my friends are saying this revolution is going to be something like the change from black and white to color. I disagree. I think the change is really going to be more like to the change we realized going from radio to television!

Back in 1997, I concluded the interview with Al and eagerly awaited the premiere of Titanic. We stayed in touch and I made a couple more trips back to his Montana house and studio. Later in 2002, I went back and re-read the original interview and was amazed at how accurately Al had predicted the blockbuster success of Titanic *and the emergence of HD film systems and the popularity of home theatre including the DVD format that has replaced the VHS video tape. I thought it would be interesting to pick up where we left off and resume the interview.*

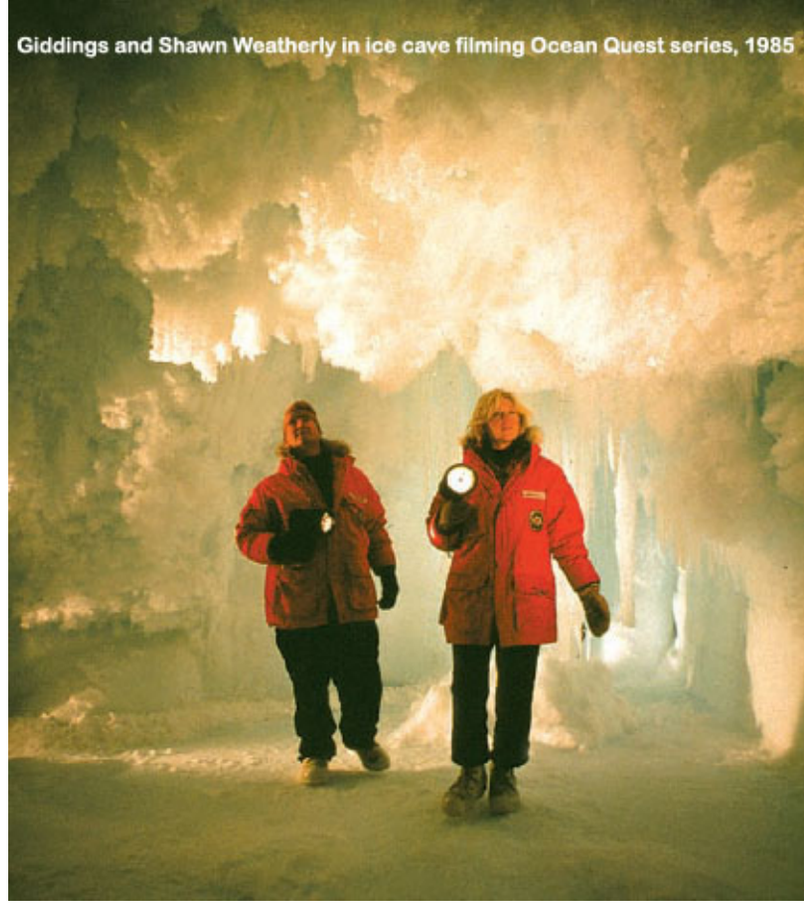
This time I brought along my publishing partner, Fred Garth. I had introduced him to Al before but he'd never had the chance to visit. After I filled Fred's noggin with glowing accounts of how beautiful Montana is in the fall, he eagerly committed to the trip. After all, an invitation to visit Gidding's private sanctum is one not offered to many

persons. So we grabbed a flight from Las Vegas at the end of the 2002 DEMA show in late October and landed in Jackson Hole, Wyoming to begin the scenic drive through the south entrance to Yellowstone Park up to Al's place just over the border in Montana. I told Fred to expect hospitable fall weather and maybe to bring a jacket in case it got cool at night. Wrong!

We landed in a driving snowstorm and had to renegotiate our rental car for an upgrade to a fourwheel drive vehicle. We got the last one in town. When we informed them that we were driving up to Montana, the clerk just kind of chuckled and said, "Have a nice trip."

We then embarked on an ethereal trip into America's wilderness. A little more than two hours north of Jackson Hole, we were detoured by a herd of snow-covered buffalo that decided to have some sort of Bison World Congress smack in the middle of the only road. After sorting ourselves through that little mess, we toured through a premature winter wonderland of snowy roads, moose, a few more buffalo who hadn't apparently heard that their convention was a bit further south, and finally an endless herd of elk feeding in the lush pastures next to the hot springs and geysers that turn Yellowstone into a spectacle of indescribable beauty. After nearly 10 hours of transit over 11,000-ft. mountains, descents through water-carved canyons, and a display of wildlife that rivaled any zoo, we arrived at Gidding's estate just as it began to snow again. We settled in at his plush log home (on the market for a cool six million as he builds something a bit grander) and grabbed a drink before touring the studio facilities just down the hill.

As always, Al was the perfect host and eagerly took off on an excited account of the system he had acquired that allows him to "up-convert" his invaluable library of film and video to the new widescreen 16x9 HD format. We sat there for hours entranced as he previewed sequences he shot decades before that now were magically transformed into images with such depth and clarity that you felt you could reach into the screen and touch a whale, a shark or actually feel the warmth of a sunset. It was mind-blowing and more than a bit surreal. Once again, Al had not only anticipated the new technology but was leading the implementation process. At 65, he had managed to turn the clock back and re-birth film he'd shot in his youth. He was as excited as if he'd been given a time machine.


Giddings and Shawn Weatherly in ice cave filming Ocean Quest series, 1985

We had to begin somewhere, so I figured a good shark story would get Fred's attention. That's where we started. »

Your partner, Leroy French, was involved in a shark attack that is worth sharing.»It was the early 1960s and we were new to the dive business. We chartered a fishing boat to the Farallon Islands about 25 miles out from the Golden Gate Bridge. We had about 12 people on the boat and it had a very high gunnel making it awkward

to dive from. We were in double 90s, which were the order of the day in that era. I was wearing a set of those doubles; Leroy had a set of triples on a la Cousteau... you know, those skinny 40s or whatever. We were both taking pictures and others were spearing fish. I was on the surface at the boat that had this very high ladder and an eight-foot climb straight up the side. Suddenly a woman started screaming. And I thought, oh my God, somebody's caught in the current.

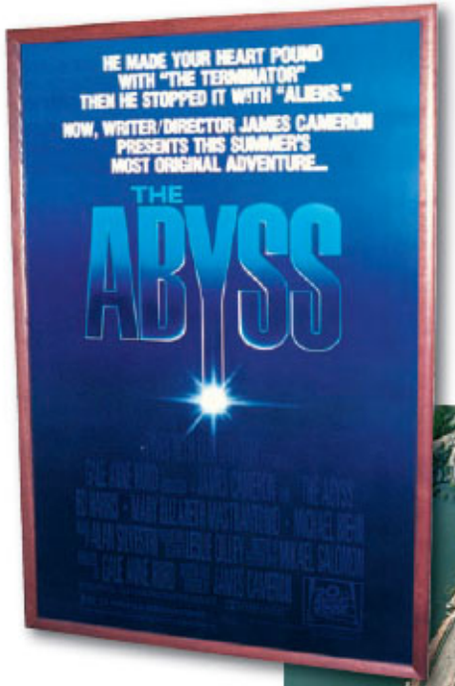
Where were you when all this started?»I was getting out of the water. I had come back to the ladder and was awkwardly handing up my camera when this woman started screaming. So I turned and looked and it wasn't a woman! It was Leroy, about six octaves above what is humanly possible. I couldn't understand what was going on. I was a competitive swimmer all through school, so I took off swimming overhand with those awkward doubles, face down with my mask around my neck. I got about halfway to him and looked up. Leroy was about 30 feet away in a huge pool of blood. A very riveting moment. There was a 12-ft. circle of blood around him. We had no sense of what was going on. We couldn't even spell White shark in those days and really knew very little about them.

Leroy later said this was his worst moment, this huge tail went up behind him and he's staring at me but hearing the rush of water. He's already been hammered terribly once (receiving 470 stitches or something later), and the shark was so huge, maybe a couple thousand plus pounds. I first thought it was a killer whale. Again, we were green young kids just getting into it, but then I knew it's no killer whale, it's a huge shark! And it took him by the legs and "glump" he disappeared - silence.

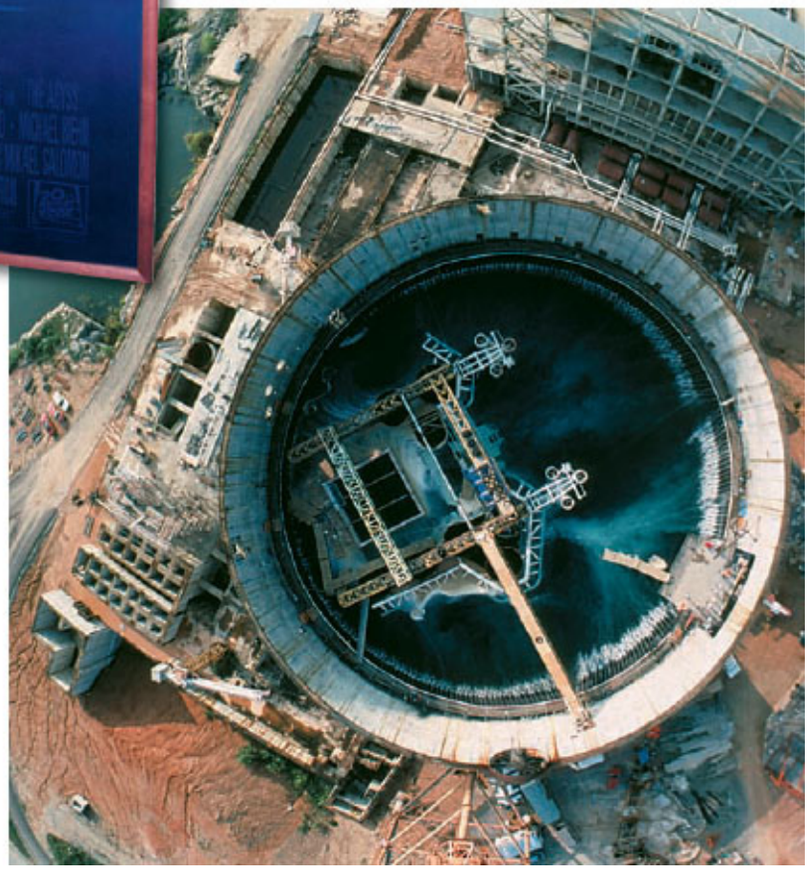
So I guess I was on automatic, as people do under those circumstances. I dropped my face in the water again, then swam to close the distance and stopped. I'm treading water and frantically looking around in the middle of this big blood ring. All of a sudden he popped up, maybe 10 feet away, screaming out of his mind. And I remember thinking this will be a total mess unless I can get him turned around. We both had on these outrageous tank systems so I sort of manhandled him so I could get a grip on the manifold. Those triples were just right. I could really grab the bar. He was just out of his mind. I mean, literally just primal sounds, as I towed him to the boat, basically waiting for the next jolt.

About three years earlier a woman had been hit at Monterey. Somebody was swimming with her and the shark continued to hit her, so I was waiting for that. The other people were climbing up anchor chains and scrambling out of the water any way they could. A guy named Joe Michato still had his tanks on and was going up the anchor chain hand over hand. People had just never experienced anything like it - total mental chaos. Anyway, Don Josslyn jumped in the water and swam to us, which I thought was unbelievably ballsy, considering what he'd seen happening. With everyone else scrambling by whatever means to get out of the water, Don jumped in to come help. What a guy, and was I glad to see him! Ironically, later on he was a victim of a White shark attack himself, less than 10 miles away. How many people have been in two incidents of that magnitude? Anyway, we towed Leroy to the boat. Then we had to get him up that ladder straight up the side of the hull.

Where had the shark gotten Leroy?»The first bite took most of the calf muscle from one leg and part of his buttocks was hinged back and flapping. The second time the shark took him by the arm and pulled him down about 20 feet. A little sidebar, he had a SportsWays vest on with the little CO2 cartridge thing. At about 10 or 15 feet down Leroy pulled that. We thought later maybe the explosive nature of the



Abandoned nuclear containment tank became the set for The Abyss, 1988



cartridge sort of startled the animal and it released him. Anyway, we were trying to get him up this ladder and I remember trying to keep my cool so that the rest of the people would not completely give way to panic. So I'm trying to hoist Leroy out of the water before the shark hits him again. People told me later it was raining blood. You can imagine. He was cut wide open and I could see blood vessels and tissue hanging. I remember this because they looked like telephone lines that had slipped through the shark's teeth.

Finally, with blood pouring all over me, we got him on the deck and radioed the Coast Guard to send a helicopter with a basket. He was then lifted to the Letterman Hospital. He was there for about two weeks then went through a long period convalescing. That experience kind of broke his spirit. Anyway, Leroy recovered and dealt with the dive shop for a while. Eventually I went to San Francisco to pursue filming and Leroy went off to the Caribbean and sort of disappeared.

How old were you guys then? What year was that actually?»I was about 25. It was 1962 or 1963 maybe.

And Josslyn?»I don't know how many years later but Don was in water 15 or 20 feet deep diving for abalone and all of a sudden, "this great head came off the bottom" and Don fended it off. The shark took his leg and lifted him completely out of the water. Don is a big, tough, focused guy, and realizing he had the abalone bar in his hand, he gripped the handle and punched it into the side of the shark's head once or twice, really hammered it, and the shark let him go. Luckily the boat was right there so he got out of the water with much less damage than Leroy. But still, to be involved in two major moments within five or six years was amazing.

Another interesting incident following that was in San Francisco when the Southern Pacific Scuba Club guys came in to the store. They were renting gear to go to the Farallons, and I said, "Listen, I'm in this business and I want to promote it, but don't go to the Farallons. It's a major breeding area for White sharks, don't do it." And this guy

said, "Yeah, yeah, we know, it will be fine." That Saturday I was in the shop when all of a sudden the radio crackles with a news bulletin: a group of divers was being attacked by a school of White sharks at the Farallons. Anyway, it was another guy, Jack Rochette, who was hit under similar circumstances.

So 12 years later when you were put in touch with Peter Benchley to preview the *Jaws* film, how did you react to the movie?»Stan Waterman and I went to the premier in New York. There were only a dozen of us attending. I thought, there was no way this film will ever approach the voltage of the real thing, so I'm going to have to think of some discreet response after this film was over. You know, "Gee, wonderful, terrific, I loved it", whatever. I remember being into the Spielberg magic when the young woman was hit at night in the sea, watching through my clenched fingers and covering my face. When it finished, my thought was how could they release this to the public? It's going to rock like Hitchcock's film *Psycho*. I thought, there's no way they can show this because filmgoers will pass out in the aisles.

One of the interesting things Spielberg did that was so effective was never showing you the shark until the third reel. That made it scarier.» It was the dramatic and skilled management of those scenes. The anticipation, the leaning eight inches forward in your seat, and just not knowing. He sold that very well in a dramatic sense. It was quite remarkable. I think it *was* the third reel when the shark came up off the back of the boat and Roy Scheider is pitching chum out the back, that's the first time you really ever got a good look at the head, and he says, "I think we'd better get a bigger boat" or something like that. And the whole audience at that point had just gone, "huhhhhhhhh!" It was crazy.

Give us some reflection on *Titanic*. Did you ever think that that film could do what it did?»No one anticipated *Titanic's* success. I think everyone agreed that it would be a remarkable film. Jim Cameron called me during the edit and said, "You must come over." I went over to a sort of inner sanctum in his house where thousands of cables literally took over like a postproduction facility. We went into the inner chamber where he had his screens and playback systems and he showed me elements, unedited but assembled, where the stern came up and people are dropping like flies and hitting stanchions. It was five times as severe as what you saw in the film. I mean, once again sort of like Spielberg, I thought, "Jim, how can you..." and he stopped me and said, "Al, I've got to cut about 80 percent of this." And he did. But if you saw six or eight shots that were originally 10s on the on dramatic scale, there were 30 shots, 50 shots, I mean again and again. I was impressed! This film would be another one of those shockers in that sense.

We anticipated a very successful film. But I didn't feel that anyone had any sense of what it would end up doing - a billion, $700 million. Unbelievable. The next closest film is probably E.T. at $400 or $500 million, and I'm not sure that's accurate. Something that no one anticipated was the fact that legions of people, tens of thousands of people, saw it four, five, six times.

The studio had to argue with Jim on the money to complete the film, right?»Well, at one point in time I sat at the Golden Laurel Awards with Jim and he leaned over and said, "Fox reinstated my deal." Because before the film was completed, the budget was running wild, $200 million plus, Jim gave up his director's fee and his points and said, "You must stay with me and back this. I'm glued to my convictions and to my excitement over this film. Here's my money, take it." It was an extraordinary gesture for a director to do that. I really respect that kind of conviction in Cameron. He is an unbelievably


Full-scale operating submersibles were used in The Abyss

capable director and will leave, in the truest sense of the phrase, no stone unturned to deliver. So the deal ultimately was reinstated. They gave it back to him, and the amount of money that represented was unbelievable. I think I said at the moment, "Jim, they love you." And he said, "Baloney, they don't want me across the street."

Earlier when we worked together on *The Abyss*, I anticipated that film doing much more because I saw so much of that material on the screen. It was really something riveting. And I thought *The Abyss* would go to the moon. I think Fox made a mistake. They pressed Jim in the end to deliver under any circumstances because of the money and interest on the money and all of that. And so Jim more or less mailed in the end because he was sick and tired of arguing with the bean-counters over the budget. I think you can make some mistakes early on in a film, but if you make them at the closing of the film, people leave with a negative impression. So *The Abyss* floundered around and did not go over the horizon financially. But no, *Titanic*, I thought wouldn't do anything like *The Abyss*. And so as Bill Goldman says in his book about Hollywood, "nobody knows anything."

How was *The Abyss* supposed to end? It was a fascinating film anyway because of all the technology you guys had going.»Technology and the pace of the film. It did not let up for a second. That's right. Just as you said, the ending originally was incomprehensible.

When they finally did release the director's cut, I know scores of people who went out and got it just to see what it was all about. And everybody had the same reaction: How in the world did they not release it this way the first time?»As it was shot and released, frankly it didn't make any sense. And when they put the extra scenes back into it on the director's cut, now all of a sudden you realize that this is an alien presence that's coming here to destroy the earth because we can't get along with each other. Jim's wonderful vision was not realized in the first release because they pressed him, so it stumbled a bit. How about this? When they came to Jim to do the DVD version he said, "I'll do it if you strike 20 release prints. I'll cut

it in my long version." He added 25 or 30 minutes to the film. And when it was released, there was a reviewer in *The Chronicle* in San Francisco who wrote, "Never in my career did I think I would say the following: the film to see this weekend is not a new release but Jim Cameron's director's cut of *The Abyss*, at 30 minutes longer. It is brilliant."

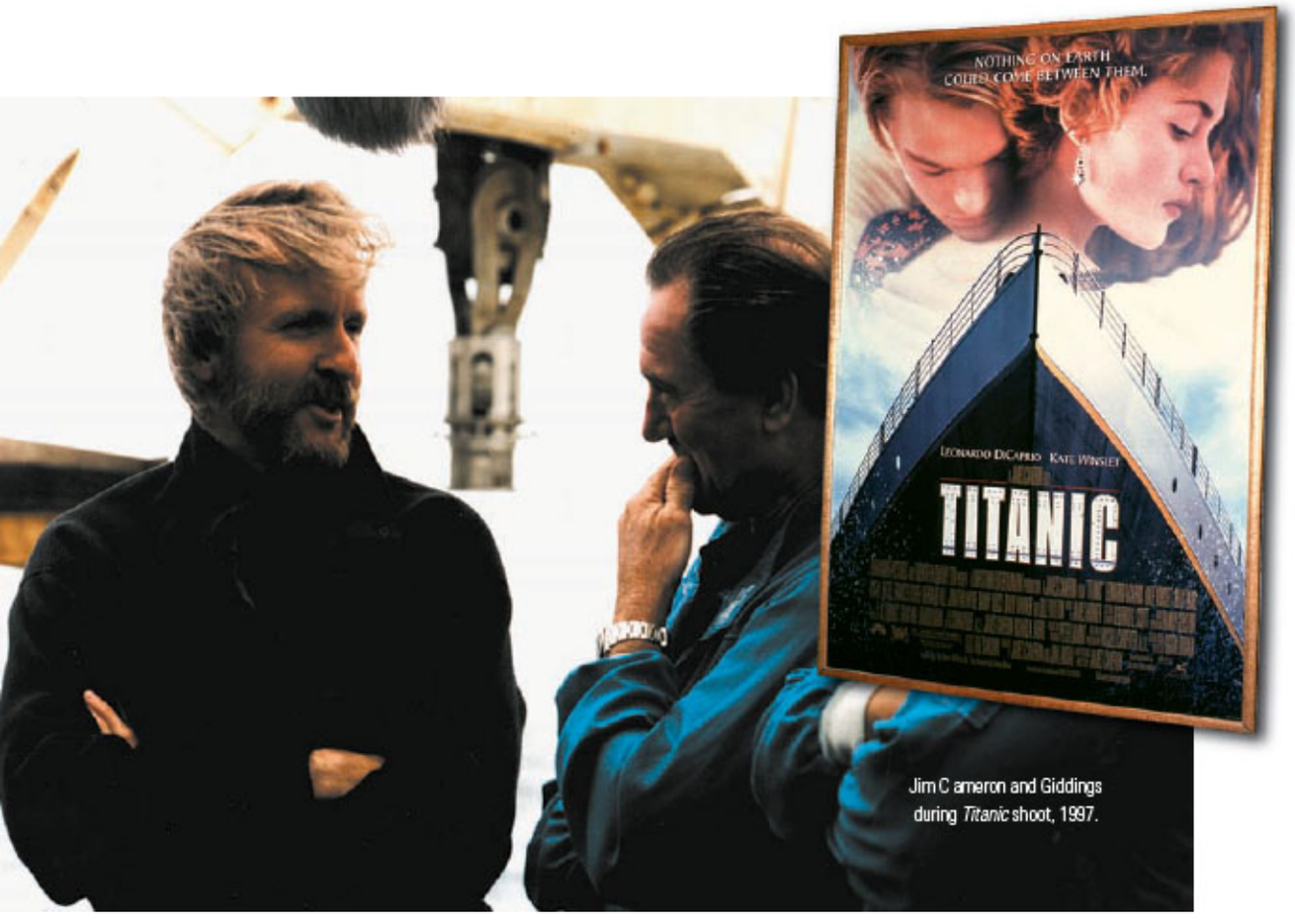
I went to the Galaxy Theatre, which is the nicest theatre in San Francisco, and couldn't get in. I thought I'd go and there would be a handful of people. Forget it. I was there with a date and couldn't get through the door. So I came a couple of nights later on Wednesday, the second showing or something, and watched it. People stood up and applauded. I think the Fox executives blew it the first time around. Had it come out of the chute in its full-length form, it would have done a few hundred million dollars at the get-go. Cameron is the most remarkable force to ever grace the halls of Hollywood.

When is he coming out with his next masterpiece?»Well, I'm curious. He's so taken with the undersea world that he's snorkeling around. That's my way of saying, he's playing around with all sorts of other things and not, I'm sure, making real money as it relates to his day job. He's driving Hollywood crazy because they would all like to see him do *Terminator XII* and *Alien VI* and *Titanic II*, you know, billion-dollar deals. But Jim is really enamored with the underwater world and would like to be Jacques Cousteau, I think, or somebody of that ilk in the historic sense.

Let's talk a bit about high-definition technology. I think it was 1997 when you shot the Truk Lagoon HD program. Give us your perspective on how that went and what it was like to shoot in that format the first time.»Well, in my opinion, high-definition television is not an upgrade. I hear people make that reference all the time. It is a new form of entertainment with seven times the resolution. I anticipate when the dust settles, considering the American appetite for entertainment, the average home will have an 80 to 90-inch screen. The images will be very refined. HD is such a visceral experience that lights will dim, the family will gather, phones will shut down, and people will be entertained by this incredible technology. This ability to give you an almost three-dimensional image will be there in a way that will make tears flow and emotions soar. Right now you can watch fantastic films like *Titanic*, on your square 19 or 20-inch television, but the film wasn't shot in a 4 x 3 aspect ratio, you miss part of the picture. And with speakers only four inches in diameter there's no horsepower behind it emotionally. So, people don't respond as they do in a theatre. When HD is full up, transmitted to everyone's home, those experiences will be unbelievable. There are people concerned now on a number of fronts over HD and its resolving powers as it relates to say a Mike Tyson fight. Its clarity combined with such graphic and brutal sights could really blow people away.

There are also concerns about models or aging actresses and how to handle that since the HD image is dead-on real. The cameras now have diffusion ability so that you can deal with skin tones to manage that. But HD is magic. What Sony, Panasonic and others are pioneering is unbelievable. Nobody, in my estimation, has a clue as to what's coming. It's an unbelievable format. And "frame-grabbing," the ability to capture a single image off the motion picture stream, is unbelievable! You really can't do that with the old technology of film or even modern digital stuff. But if you shoot with that HD camera, you dial in an electronic shutter, you're producing 30 frames a second, 108,000 frames an hour, any one of which could be frame-grabbed and printed on the cover of *National Geographic*.

What tool would be more exciting for someone in the nature world



Jim C ameron and Giddings during *Titanic* shoot, 1997.

- whether it's Jane Goodall or me - than an HD camera shooting a breaching whale and having the ability to go in at the apex of the breech and extract the most dramatic frame. Imagine model calls in the future where a model like our dear mutual friend Lauren Hutton walks in, does a shoot for 15 minutes then while the camera is still running, we're able to go through those 40,000 frames and extract only those that Revlon wants for their new magazine. Whoa, the whole photographic universe just changed!

I gave a presentation at Jackson Hole a year ago, and at the end, all of it was at this voltage. Then I said there's only one downside, and the audience got set to hear the second shoe drop. The downside is, I'm not 30 and beginning my career with this new format. Cameron is experimenting with something that the two of us looked at very carefully, and he really is pioneering this. He went to Japan and talked to Sony. Out of that came a couple of the newest F900 cameras reconfigured to allow the cameras to be close enough, that is, the two lens centers to be close enough to shoot 3D. If you shoot 3D high-definition, two cameras, you then have a universal format. You can go in any direction. You could go to IMAX and expose 70mm film for display in Japan and all over the world, Paris, Tokyo, wherever. You can go to 35mm, you can go down to television, you can go over to 35mm theatrical, anyplace, any of those entertainment formats from one particular exposure.

When we shot 16mm, we couldn't make effective 35mm slides and we certainly couldn't do IMAX. You had one relatively myopic format. An HD camera as we know them today and the HD camera that I'm talking about has three chips, part of the recording system, and each chip has about 2,200,000 pixels, bits of information. Those three chips create an imaging system, the base of which is about seven million pixels. Sony will show a new camera in Las Vegas next year. Each chip is the size of a 35mm frame, so each chip might carry 10 million pixels. I just said that the best HD cameras today that blow my mind have a total of 7 million bits of information plus. This camera will be 10 million pixels per chip for a total of 30 million bits of information. Now, do you think you can extract stills from that?

Oh, I think so.»You could – I mean they'd be the quality of something shot with a 500C Hasselbladd. Remarkable. So HD is a new form of entertainment of the most provocative nature. Imagine a format that

allows you to shoot, surface and then view it. For my whole career we've shot and then shipped film out for processing. Then we get a telex back in Tahiti or Galapagos or wherever we are, from the lab in LA saying, "no apparent technical difficulties." Well, that doesn't really tell us anything about the artistic nature. Did you like it? Was it great? Watch what this change to HD does to the shooter. Like Howard Hall, who's already a brilliant filmmaker, jumps in the water to shoot a sequence and when he comes out he can play back his material in the field! Everybody, the lighting guy, you, everybody that supports him can look at it. With the old film cameras you have two-minute and four-minute loads. IMAX is a three-minute or 16mm is a nine-minute load. I now load 40 minutes of tape!

If HD is the obvious future, let's step back to 1999 and talk about your film, Galapagos in 3D. You're talking about pushing an IMAX camera system so huge that you actually had to mount DPVs on it to fly it around. Do you think that's over with now? »The 3D IMAX camera system that Howard Hall told me about had my knees turning to jelly initially. I ended up putting four DPVs on the back and came up with a series of bolts that I could walk the propulsion package up and down on this master plate until I found the sweet spot. Then I could fly that system. Once I had it up to speed, it was very effective. I'd literally launch it, disappear for an hour with a one-ton, multi-million dollar system and come back with smiles usually. We sort of pioneered a new approach to using a blacksmith system. It was the total opposite of my comments on HD in the sophistication level. We'd shoot, store the stuff, and ship it once a week. We wouldn't hear anything for a month, so if we were out to lunch on exposure or the camera had a problem, we were effectively screwed.

And now with the two-camera HD system that, in essence, will simulate 3D, what are we talking about in size for that compared to this 3D IMAX 2,000-lb. monster?»Probably a package that would weigh 125 pounds in air that is relatively small, might be 25 inches long, 18 inches wide, 20 inches high and load 40 minutes of material. And you have the use of zoom lenses, beautiful primes - all matter of things that any creative Director of Photography would demand in any creative film project.

But HD and IMAX - and I love the IMAX format - both have their place in film. Remember, I have walked in two camps throughout my career. Half of it has been natural history nonfiction and the other half has been Hollywood. One of them is the pure art of documenting real-time, exciting natural history, and the other is the art of illusion. Here at our studio, we have all sorts of formats from 70mm to HD from HMI lighting to Motordrive Nikon still camera, all those different formats. And the reason that they're here is I don't know whether the next call is going to be 70mm IMAX or theatrical or natural history nonfiction HD. So that's really been an exciting and challenging adventure and experience, and I've carried the best of both worlds across the line. Learning theatrical techniques and approaches in lighting has really done wonders for the sort of shooting that I do underwater in a natural history sense.

That's a very good point, so much of your natural history stuff is shot with a theatrical slant.»Well, when you looked at the HD material here today, down in the editing suite, all of that was borne of an approach that nobody uses. I would go to the bottom with a couple guys at midnight in Palau with a camera that had a super-zoom ability and diopters, as well as the ability to fill a frame with a macro subject or back off to wide angle and manage it all on the bottom. So whatever we encountered we could cover. We don't use fins in 50 - 60 feet of water or with 60 - 80 pounds of weight so we

could literally tiptoe around the bottom. Your breathing rate is way down, believe me, much below what it is with fins and your balance is unbelievably enhanced.

People very often say, "Come on, this was shot in an aquarium." I mean it's too dead still perfect.

Steve Burns was here a couple of weeks ago with four executives from *Discovery*, and they said, "Nobody uses zooms like you do. Nobody racks focus and zooms at the same moment or moves in and pans to the right with focus clicked on. That's a dramatic move." I realized early on that in making images with a wide-angle, "set-it, forget-it" system is not enough because people had already been exposed to all of this. I felt we had to fill a frame with a whale's eye. We had to make it dramatic. We had to tell a story with the camera. Those are the approaches to dramatic storytelling.

I was reading that CBS is filming some of their new shows in HD and some of them in film, and some of the people were commenting that HD is still not at the level of film with certain light situations, similar to digital photography. Do you agree?»No, they're totally incorrect. I think those people are classic Hollywood or classic film people who are perhaps a little intimidated by the technological jump, the move to high definition, the move to computer systems, so to speak. All this means is that they are more comfortable with older technology. I made the move 15 years ago to tape. The criticism then was, "Al, how could you?" At the first Jackson Hole symposium, Mark Shelley was there. He was the only other tape guy and was on a panel. I walked in and Mark said, "Oh, my God, I'm saved. Al is here." And he knew that I had a hot new tape. So I screened that tape for those people, and the place went stone quiet. After I finished the first hand shot up. A guy said, "I'm really upset with you." And I thought, okay here it comes. Then he said, "You just cost me $120,000. I just bought a film camera, an Arri SR and I bought this and that. It's not going to do what you're able to do with tape."


MIR submersible hovers over Titanic, 1997

I'd seen the handwriting on the wall 15 years ago and migrated to tape for a dozen obvious reasons. Again, playback in the field, how can you put a price on that? Forty-minute load. And it goes on and on. Today, I'm really vindicated. I sit downstairs with today's latest imaging technology, pioneering a process once again as I did with Sony's cameras, changing the black levels, changing the chromo levels and really getting into those cameras, which is a part of history. When I started with video, Sony couldn't spell "natural history." They had no market there. And I said, "Listen, there's a whole other market. It's not huge, it's not like the news market but it's significant." So when Jeff Cree prevailed, put a video camera in my hand and we started shooting in Cocos, I discovered that I loved the entire system but didn't like the image all that well. Jeff just kept saying, "I can change that, I can change that", so in the field I would look at it and say, "It's not a Kodachrome look, where are the blacks?" Jeff would then get into the camera with a plastic screwdriver, open the side, and take my breath away.

You're talking about a Betacam.»Yeah, Betacam 300. He would dump the black. He had the ability to go to a part where he could back it off. Then I would shoot and say, "Oh, that's much better, a much better contrast, more like Kodachrome." Then I'd carry on about something else. I remember the third or fourth day in Cocos the camera was so dialed in that I wanted to take it to bed with me for fear the electrons would fly off in the night. They used to drift with the old tube camera. Those guys would have to dial those cameras in every day sometimes in the early news broadcast usage. I took Sony's cameras and radically changed them.

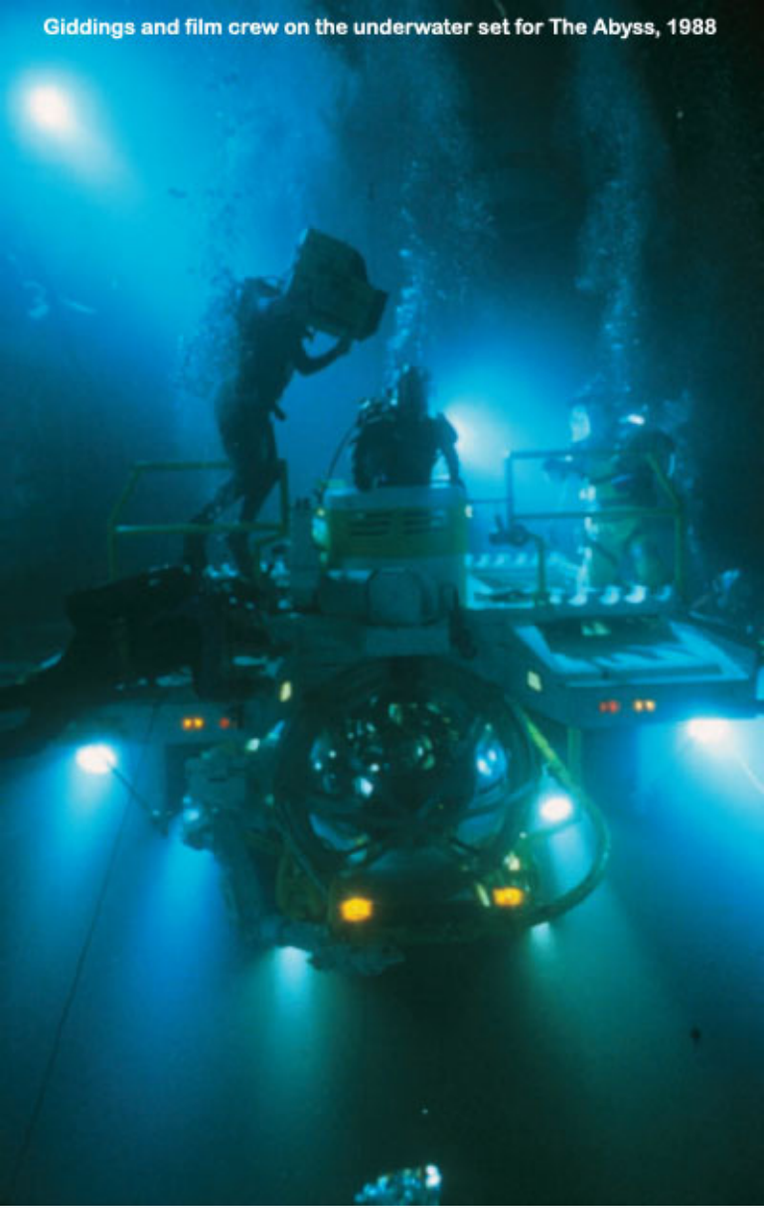
About an hour ago you said you love this new HD format, your only regret was that you're no longer 30 years old.»Right.

So, now you *really* are 30 years old again because you're taking your entire library and transferring it to this 16 x 9 aspect. Tell us about that.»It goes back to what I said previously. My first innovative technological adventure in the electronic world was to establish the black parameters of cameras. Today, Sony's cameras are delivered factory setup, but you can get into the menu and set it to your specifications. It's really wonderful. I've made deals where I would say, "Listen, I'll shoot this project for $8 instead of $10 but I want stock footage rights. I want the ability to use this natural history nonfiction material that is not dated by cars, clothes or period dress, there is no architecture, there are no straight lines, no buildings, all of that. I want to be able to store this and I want to be able to see income from the library sales. I saw natural history stock early on as something to treasure, something historic, something wonderful, the first whales, the first White sharks in slow mo, all of that stuff.

Now let me back up a little bit. Three years ago I said, "I'm a little nervous, more than a little nervous about what's going on with HD." The digital world is coming on and all of the tape that I shot over the years was analog. So my library is going to be antiquated, 18th Century Fox. All these wonderful images are not going to be applicable. So I said, "I'm either going to sell it bargain basement or I'm going to contemporize." So I started running around the world talking to everybody; and fortunately I've met the most wonderful tech people, Larry Thorpe from Sony and Michael Brinkman, president of Panasonic. I started chatting with all these guys asking, "Is there an instrument or magic box in existence that will allow me to take an analog electronic image and up-convert it to digital tape?"

It seemed logical to me, and I'm not a super tech. Could all of these millions of hours and tens of thousands of projects on tape be up-converted to digital? I'm not going to leave all of this stuff in the vault. They're going to convert it into the digital world somehow, right? I not only wanted to go to the digital world but to go to the HD world. So while in Japan with Jim Cameron, I started talking with Larry Thorpe, then with Michael Brinkman. Everybody had a neat box. Everybody said yes. I looked at the results and was not impressed. I'm really more of a nut over definition than the image. Look at the Emmys on the wall. None of them are for programming. They're all for cinematography and the art of film.

So everybody who knows me said, "Al, you'll never find anything that will satisfy you. Equipment that will effectively up-convert to HD doesn't exist." Enter Barry Clark and a couple of people said, "Are you aware of the Teranex company?" I soon found the company and talked to the various people there. They volunteered to do a demonstration. That demonstration, which included about half a million dollars worth of equipment, took place here in Montana. Sony had the feed and record machines. Teranex had the magic up-conversion boxes. My vision is to have a system that would allow me


Giddings and film crew on the underwater set for The Abyss, 1988

to take my tape images, at least, the last 15 years of my career and all those titles, *Blue Whales*, *Titanic*, *Galapagos*, etc., and up-convert that square image to wide-screen HD. The Teranex guys said, "We can do it." The Sony guys said, "You're not going to be thrilled. The resulting conversion will not be brilliant, at least to your standards."

So, anyway, the Teranex guys felt confident and came here. I gave them a copy of *In Celebration of Trees*. They put it through the process on that now-famous Wednesday two years ago, and I was speechless. The Sony guys came into the room seconds later and slumped in their chairs in total disbelief. The Teranex system had come out of the U.S. Government surveillance world. The Teranex box not only does an up-conversion to HD but it will up-convert and down-convert from any format in the world. It doesn't make any difference. Any tape will go in and out of that and make anything else. The box also deals with electronic noise reduction and refinements. I'm using five percent of its capability to do a magic process, and the machine is incredibly more capable. Anyway, that was the second innovative and ground-breaking moment, at least in my personal world. First was a camera re-management and all that I shared with Jeff Cree, a brilliant guy at Sony, and the second is happening right here right now.

I'm here in Pray, Montana, population 63 or whatever it is, with a system that is really space-age. I'm taking analog square images in today's formats and up-converting to HD with seven times the pixel count resolution. The results are stunning. I have had people from *NHK* and the *Discovery Channel* to *National Geographic* here to see this process. I can't tell you how pleased I was with their response. I am able to take all of these titles representing the whole history of my career along with a lot of the history of the undersea world and its animals and convert it all. It's a thrill to go into the vault and take the 287 hours I shot for *Blue Whales* and convert it. Imagine the process. I went out, shot it, shipped it, viewed it briefly in the field to make sure all the parameters were technologically online and forgot about it. They cut it, sent the material back and we put it in a vault. I did that title after title after title. It's so exciting to go through the material, up-convert, color-correct and reformat. I can't tell you what a good thing it is, and in thousands of shots I'm saying, "I cannot believe this."

And so this year we will up-convert 20,000 to 30,000 scenes. They represent about a 6 to 1 ratio, so within the original material is another 200,000 beautiful scenes. At the end of the year we'll have 110 or 120 categories for the library. Each one will be meticulously organized by subject matter. For instance; one tape will consist of nothing but White sharks, the next tape, all blue whales, the next, all sunsets or

rattlesnakes (because I've also done a lot of topside stuff). The library will include both underwater and topside shots.

So to wrap it up, the second exciting, innovative, ground-breaking, pioneering effort goes on downstairs. We now have the only suite of its kind in the world (*Editor's note: as of late 2002*), although other people are coming up to speed. We're taking all of that analog video 4 x 3 and converting it to widescreen, and no information is lost because of the anamorphic process whereby the image is squeezed, top and bottom slightly, to create the wide-screen format. The pixel count, the information recorded, is there in total. The Teranex system is so refined that it extracts from the tape more information than probably any other processing super box on the planet. So these are exciting times. In the end, we will take all of the HD tapes, newly rendered with seven times the resolution and frame-grab maybe 75,000 stills from the best selects to add to our still library.

Tell us about when you showed Howard Hall, who made a business decision to sell his 16mm library, the results of your magic box system.»Well, you know, Howard is a wonderful character. He and Michele were in Jackson Hole when Sony asked me to anchor their tech panel consisting of all Sony people more or less and me. It was a 90-minute panel where all the Sony guys had different facets of HD technology. At the end, they said, "Al will now blow a few minds with something that everybody has said you can't do. I spoke for 20 minutes about my up-conversion, commenting again that there was only one downside - that I wasn't 30 and starting my career. I then finished by showing projected images in HD, up-converted images on a Panasonic HD projector and people sucked their breath in. I mean how could you take material 13 or 14 years old, Betacam SP, analog square and in 2001 project it onto an HD wide screen 16 x 9 format image? It was unbelievable.

What was Howard's reaction?»He said to Chuck Nicklin, "I could throw up. Goddam. Giddings comes flying out of the weeds with another outrageous approach to video." I believe Howard knows that I have tens of thousands of hours of really well-shot material. I had Paula Lumbard in here, a very innovative pioneer in stock footage who's opened a stock footage house in Los Angeles dedicated to HD. She heard about us from the video world. We got together, made a date and she came up about six weeks ago. I know that she would agree with this word: speechless. She sat down in our suite and said, "How can this be? How can you put a cookie in and get a chocolate éclair out?" Within a week we had a contract and she's going to represent us in LA. She's really brilliant and we're sending her beautiful up-converted HD material.

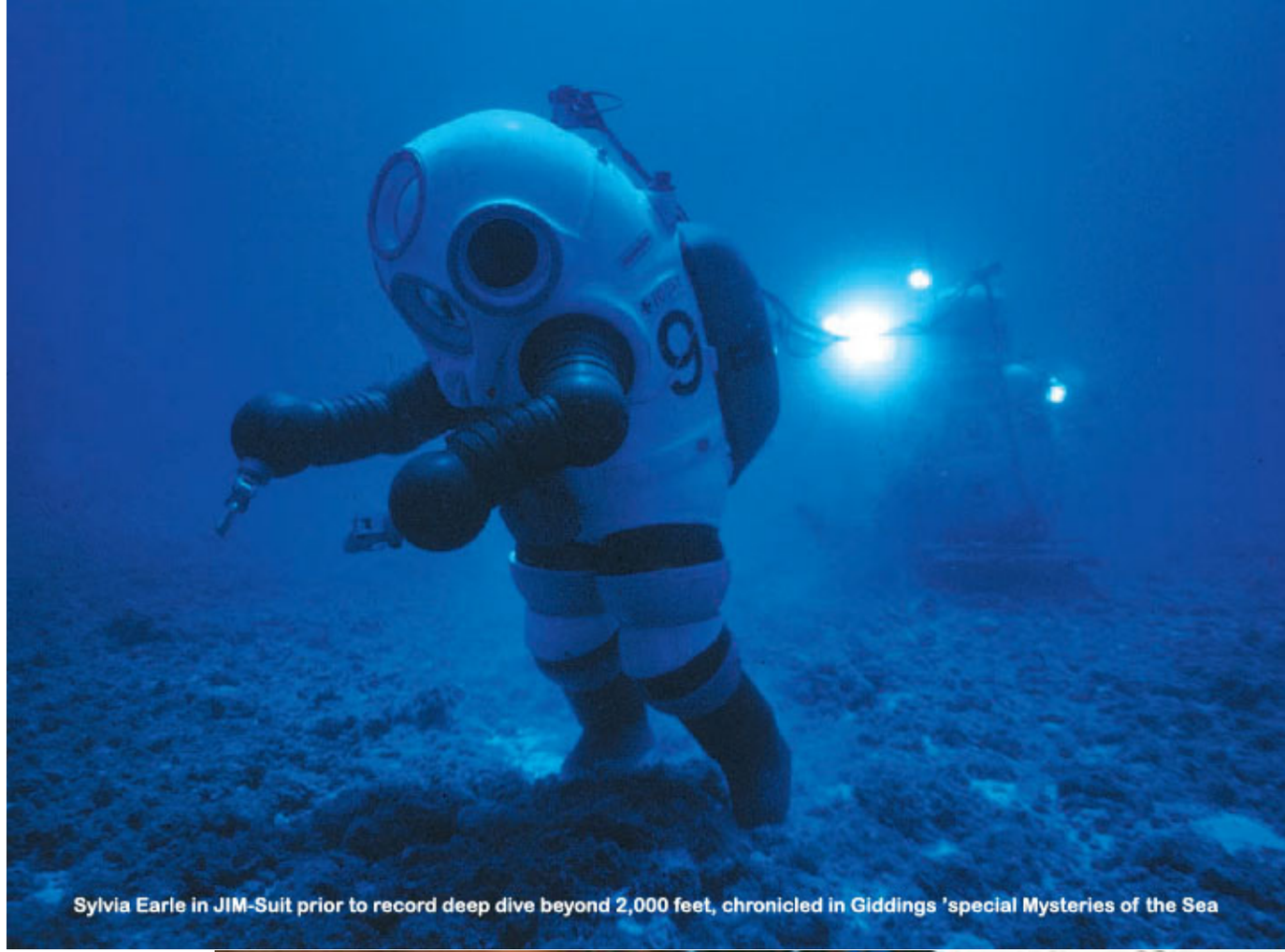
So I am bumping these images, refining them, creating a HD master, while simultaneously creating a digital 4 x 3 master for today's market. In other words, when I push go on a shot, it records it in two formats simultaneously. I would bet big money in the next five years there will be refinements in the up-conversion process. I will then take my newly up-converted tapes and refine them yet again. Teranex already has the ability to double or triple the resolution of HD.

I've always felt that any way you cut it, no one is going to leave all of the archives unused. Howard Hall's wonderful stuff and Stan Waterman's wonderful stuff, and all of the material that has been shot historically over the last 40 years in any format will be beautifully up-converted. There ain't no way *NHK* is going to leave a million hours of material in the vault and sign off on it. It's their history; it's culturally important. Every country in the world has such an archive. Are they going to leave it there? No. It's rendered in the contemporary sense, the last 30 or 40 years, in a resolution that's totally up-convertible by machines that are not even on the market yet. Do you know what I'm

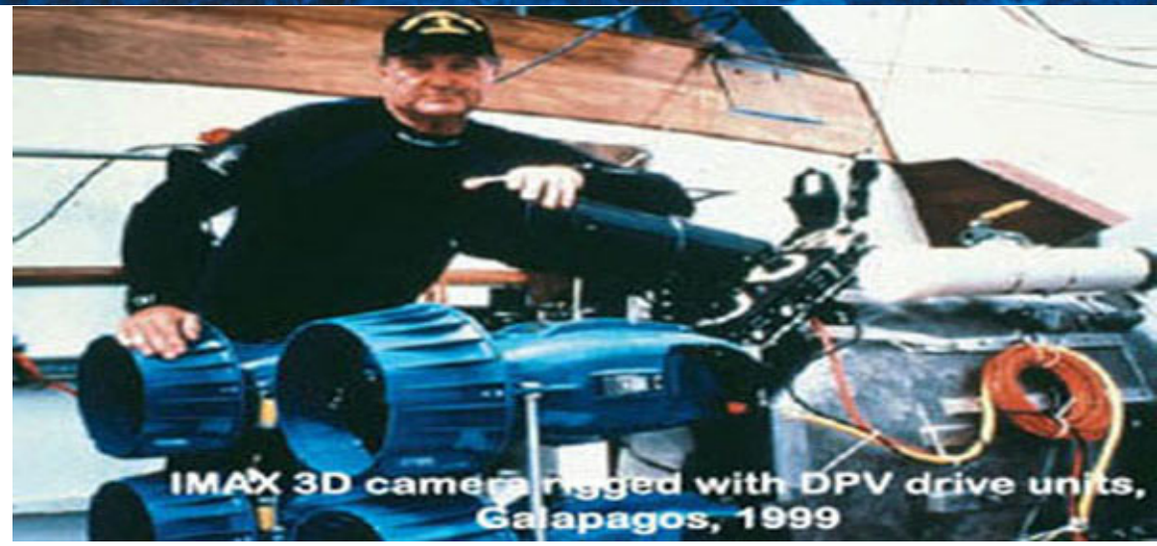
saying?

Absolutely. It's an amazing technological break.»That also applies to stills. *The Geographic's* fabulous collection will not be left on the table. I'm early in making this move, taking images to wide-screen HD, but now I'm smiling because I know that at some point there will be yet another more sophisticated box that will take what I've done and refine it again.

Fred and I left the next morning after a meal of excesses at a nearby restaurant that caters to the jet set who fly in for the food experience. We promptly drove into another premature blizzard that ultimately closed the Yellowstone roads due to the intense snow and forced us to backtrack from Wyoming to Montana through the western exit. We then slogged across the state to the other side of the Rockies and turned south in Idaho. The storm intensified and we gradually reduced speed to less than 20 mph. As we turned east again to summit the Teton Pass that would require us to climb above 10,000 feet over a road that twisted and turned next to precipitous drop-offs, the full fury of the blizzard came on us. Cars were sliding off the mountain, accidents were everywhere and when we reached the top a local cop advised us not to even attempt the descent. We shifted into the lowest four-wheel gear and fearfully creeped down the mountain while rodents passed us making rude gestures. Fred kept his door ajar and his seat belt off in case I blundered and he was forced to bail out before we plummeted to our deaths. Nearly 15 hours after we bid Al farewell, we crawled into Jackson Hole and in weary relief, began drinking… heavily. The trip was worth it. But next time we'll visit in the summer.



Sylvia Earle in JIM-Suit prior to record deep dive beyond 2,000 feet, chronicled in Giddings 'special Mysteries of the Sea



IMAX 3D camera rigged with DPV drive units, Galapagos, 1999

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