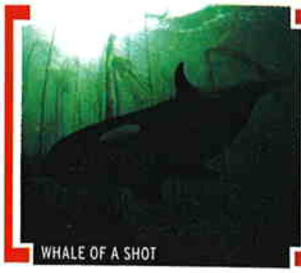
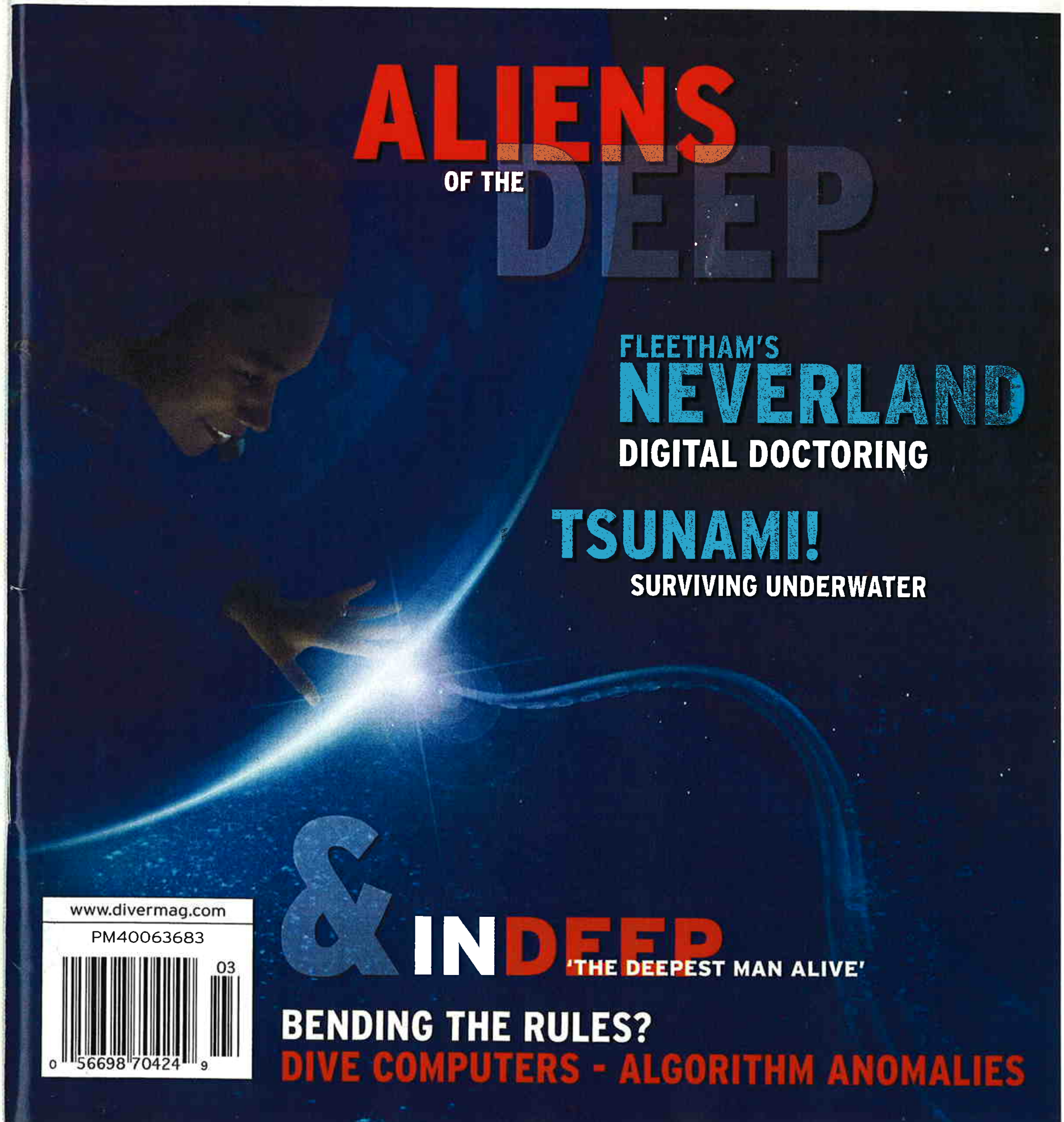
The longest-established scuba diving magazine in North America March-April 2005

DIVER


WHALE OF A SHOT

NEW - EAU CANADA, EH! STEEL REEFS - HOT NEW HABITATS DIVING ICONS MALTA - MARVEL IN THE MED A FISH STORY SHARKS IN 3D



ALIENS OF THE DEEP

FLEETHAM'S NEVERLAND
DIGITAL DOCTORING

TSUNAMI!
SURVIVING UNDERWATER

& IN DEEP
'THE DEEPEST MAN ALIVE'

BENDING THE RULES?
DIVE COMPUTERS - ALGORITHM ANOMALIES

www.divermag.com
PM40063683
03
0 56698 70424 9

SOUNDINGS

DIVE COMPUTERS, JULES VERNE CANADIAN CONNECTION

BY PHIL NUYTTEN

It may surprise you to see that the dive computers story in this issue was written by an insurance expert, not a scientist, but take note of Peter Meyer's observations: they make a lot of sense! The sidebar to that article introduces you to Ron Nishi, who is an engineering physicist, and this introduction is long overdue, in my opinion. The decompression schedules developed at Toronto's Defense R&D Canada (DRDC), formerly the Defense and Civil Institute of Environmental Medicine (DCIEM), are known and used all over the world, but Nishi, the man largely responsible for their development, remains an unsung Canadian hero.

I don't know why that surprises me, though. Consider multi-tissue decompression computers: they're absolutely everywhere, are life savers, and progenitor of a swillion dollar manufacturing industry. OK, hands up all those who don't like decompression computers! Only one hand. "And what do you do, sir? Oh, OK, ...colostomy bags - I guess somebody has to make them." Now, hands up if you know where the mulit-tissue compression computer was invented. No hands? Alright then, a piece of news for you: right here in the Great White North – Canada. The Kidd-Stubbs multi-tissue analog computer is the direct forerunner of today's chic, swatchy little wrist computers. Look for a feature on the development of this unit coming to these pages soon, as told by one of the two doctors who invented it. You'll like it, I think.

This year marks the 100th anniversary of the death of Jules Verne (March 24th). Not too big a stir over here, but in France it's a very big deal indeed. Since *20,000 Leagues Under the Sea* was largely responsible for the literary world's view of things underwater, we certainly should pay our respects. What better way than to have a bunch of cutting-edge Canadian diving technology featured in a Jules Verne tribute special as part of the popular French adventure programme 'Thalassa.' It airs in late March in 80 countries, including this one. Check local listings!

"Where the hell's the waiter?" Actor Kirk Douglas as Ned Land in the 1954 Walt Disney production of 20,000 Leagues Under The Sea. Photo: Walt Disney Pictures

Hmmm...
this 'Soundings' seems to be much more Canadian than usual – so, I'll close with a quote from Jules Verne's token Canuck, Master Harpoonist Ned Land, aboard the Nautilus: "I promise you, Professor, not a violent word shall leave my mouth, not an angry movement shall betray me, not even if we are not waited upon at table with desirable regularity!" Ah, Monsieur Verne certainly knew his Canadians! (The publishers should have spent a few more francs on translators, though.)

Regards, *Phil*

DIVE COMPUTERS BENDING THE RULES?

BY PETER MEYER

I'm not a technologically astute individual; I have no idea how to download Twisted Sister as the default ring tone on my cell phone. I am an experienced diver though and have made a living in this industry for over 30 years. In my current incarnation I provide insurance and risk management services for several major dive-training associations as well as several hundred dive retailers, resorts and vessel operators, so perhaps my thoughts on the current use of dive computers will be of interest.

My diving experience dates back to, well, let's just say I recall using a capillary depth gauge; hard breathing meant your air supply was low (no pressure gauges at the time); dive tables were plastic cards on a chain; and, also in the mists of time past, I remember using an early version of the CYBERDIVER computer, an eight pound behemoth you turned on with a sharp smack against the nearest rock.

Today, I'm happy to be diving one of several available high tech wrist mount Nitrox computers. I have assumed it makes every effort to assure my safety as I plumb the depths. But my assumption was unfounded. Recently it's come under scrutiny and using it I am no longer convinced of my safety at any depth.

In my business I have the dubious distinction of reviewing all of the incident and claim reports filed by those facilities and individuals we insure. The other day I opened file 1005: new number, familiar claim. And it was further evidence of a disturbing trend: reimbursement claims for air ambulance and recompression chamber charges are growing at a constant and alarming rate. It's a puzzling development. Dive computers are intended to prevent such claims and they're getting more sophisticated all the time.

I am amazed at the number of incident reports I review that are the result of 'safe' computer dives - i.e. the computer said the diver was well within the limits, but got bent anyway. Yes, I think we all recognize there is the possibility of decompression sickness (DCS) occurring on any particular dive, but I don't think we fully appreciate how close to the edge we may be on a fairly regular basis.

I am amazed at the number of incident reports I review that are the result of 'safe' computer dives - i.e. the computer said the diver was well within the limits, but got bent anyway.

Recently I spent 10 days diving in Papua New Guinea, making an average of five dives per day throughout the trip, which is way more than I'm used to in the colder waters of the Pacific Northwest. About half way through that adventure I came to the startling realization (for me anyway) that every dive I'd made was to a depth in excess of 100 feet (31m) with an average bottom time of between 30 and 65 minutes. A mental jump back in time reminded me that a single 'square' table dive to 100 feet (31m) had a maximum bottom time of 25 minutes and any repetitive dive to the same depth required a long surface interval or a severely reduced bottom time.

For the first time I really grasped just how significant a contribution these modern diving computers have made, providing as they do a huge (and I do mean huge) increase in available bottom time for the recreational diver. This increased bottom time derives primarily from the use of multi-level tables, or algorithms, in a modern computer to calculate simulated nitrogen absorption. It's simply more precise than using the old US Navy 'square' tables. Actually, I have understood the theory behind this all along, which is why I have used a computer for years. I just hadn't quite been able to 'visualize' the truly enormous increase in available bottom time until this last trip.

This huge increase in bottom time is a great benefit and so, along with their user friendliness, it's easy to understand the dive computer's overwhelming acceptance by the diving public. I know this all seems perfectly obvious to everyone else, but I just couldn't get over the huge difference in available bottom time when compared to the normal dives I had done in the pre-computer era. This was a major revelation! And it bothered me. I was bent once in the Bahamas on a square dive to 90 feet (28m) for 30 minutes (the allowable no-deco time according to the US Navy tables). Now I was doing multi-level dives, with no apparent ill effects, way beyond the parameters of the dive that bent me. How could that be possible?

When I returned from my adventure in Papua New Guinea I pulled several of those 'safe' DCS incident files and took another look. That's when I started to get worried. These incidents mainly involved more experienced divers - dive masters and instructors - and the symptoms generally appeared after multiple repetitive dives over several days (just like my recent holiday dives). All of the individuals involved were adamant their dives were conducted well within the safe parameters of their dive computers and the computer downloads they provided confirmed this in every case. None of these people had any idea they were bent until the onset of their symptoms and to this day they are convinced that something 'unusual' must have occurred to cause their illness.

When we discussed their personal condition and fitness at the time of the dive, some admitted to being a little tired (a little partying perhaps?) or dehydrated, but there was nothing particularly abnormal that could be pointed out as a specific causative influence. In other words, they were all pretty well normal at the time. My personal opinion is that a computer that anticipates the user being fully rested, properly hydrated and in great overall physical condition, simply

The Diving Research Facility at DRDC, Toronto, is a Canadian-designed and built deep-ocean simulator capable of being pressurized to over 5,577 feet (1,700m) below sea level. It is one component of this centre of expertise for defence research and development (R&D) in human protection and performance in extreme environments, human-systems integration, command effectiveness and behaviour, simulation and modelling and military operational medicine. The facility was formerly known as the Defence and Civil Institute of Environmental Medicine (DCIEM). Photo: Courtesy of Defense R&D Canada - Toronto

won't work for 99 per cent of the diving population. One can only hope that today's dive computer designers and engineers are of a like mind and are cutting us some slack in their modified algorithms!

Sorry for the digression; now, back to our 'safe, but bent anyway', statistics. All of these individuals accepted without question that their computers were designed to keep them safe under normal diving conditions and were completely taken by surprise when their symptoms developed. When asked how they would change their dive patterns to prevent a similar occurrence in the future there were simply no clear answers. After all, isn't the computer supposed to do that for you?

I recently reviewed a similar incident in response to a call from a dive boat operator in Hawaii who was reporting their fourth DCS incident in less than six months. The comment that stood out in the incident report was that the 'bottom time and depth were well within the safe limits.' Here we go again! I requested a copy of the computer download as well as details of the make and model used. Upon reviewing that information we were able to confirm that the diver involved had, indeed, been within the 'safe' parameters of the particular computer being used. Yes, he was safe, but he was also bent. Anyone else see the irony in this?

The model of computer used was familiar to me so we cross-checked with some of our other files and found several more incidents that involved the same brand of computer (same algorithms?). I can't reveal the name of that manufacturer because the company would likely sue me for suggesting its computer isn't really 'safe.' What's in a word anyway?

It's noteworthy that this computer provided as much as 50 per cent more bottom time than a competitor's unit on a third repetitive dive during a recent test.

The dive in question was also well outside of what us old guys would consider 'safe' diving parameters. The real profile was a 116-foot (35m) dive for 58 minutes, followed by a 1:24 surface interval and an 82-foot (25m) dive for 51 minutes. For those who don't remember (or who weren't around at the time), the single dive limit at 116 feet (35m) used to be five minutes when we used 'square' tables. So, based on those old tables, we would have assumed this individual was already over (way over) the acceptable bottom time of five minutes when he made the first dive to 116 feet (35m) for 58 minutes.

Now a few of you (alright, probably everyone reading this) may be crying foul and pointing to the scads of research out there that proves the new algorithms and computers being used are much safer than my plastic tables with rusting grommets. I don't disagree. But I also don't buy the 'safe' argument either. It seems to me that you are either 'safe' or you are not 'safe' and, frankly, I don't think anyone is technically 'safe' when diving, with or without a computer. There are inherent risks in diving and we all take them. The goal (yes I think I may finally be getting to the point) is to minimize that risk to the extent possible and that is the real reason to use a dive computer, in my humble opinion.

The simple fact that people are suffering DCS on an almost daily basis on 'safe' computer dives indicates to me that someone (those making the units?) may have overlooked this fundamental objective. Yes, increased bottom time is a really great idea, but I do have a problem with computer manufacturers purposefully maximizing bottom time via the algorithms in their computers when we know for a fact that a good number of us will get bent using these computers. Remember, I'm in the risk management business and during our waking hours we generally try to prevent injury from such obvious and repetitive risks. One would assume that the designers of these units feel the same way?

So, there I was, embarked on a new mission, determined to improve my own safety and provide my clients with a simple plan for preventing a recurrence of the newly named 'Safe DCS syndrome.' I immediately ran into a rather curious (disturbing really) complication. Virtually all of the units on the market allow for different (significantly different in some cases) bottom times for the same dives, or sequence of dives. In fact, some recent comparisons of current computers show that the allowable bottom time on an identical multi-level first dive to 100 feet (31m) varied by as much as 50 per cent between different models, and as much as 100 per cent or more on identical second or third repetitive dives. Call me old fashioned, but that seems like a huge difference for an instrument that most of us assume is based on tried and true scientific research. Well, apparently, I'm wrong about that, too. It seems that each manufacturer may use a different algorithm for their computers, and then may actually modify that algorithm so that it becomes their own unique product. The simple reality is that knowing which algorithm is being used (modified or not) will not help us identify the more conservative or safer computer models available.

As these revelations unfolded, it occurred to me that I had no idea how my own computer compared to others on the market. I was hoping I had picked (albeit inadvertently) a more conservative model and so I set out to reassure myself by reading the manual, finally! Yeah, I know you're supposed to do that before buying or using the thing, but have you ever actually looked at the manuals that come with these computers? The units themselves are relatively intuitive and easy to use. The manuals (mine anyway) are not. In point of fact they are downright complicated and unfriendly. When did you last read your VCR manual from cover to cover (sorry, I meant DVD - gotta keep up with technology)! And, it seems to me that unless you're a techno-geek manual content is mostly irrelevant to the average recreational diver. Aren't these things supposed to make diving easier? I have to admit though, being in the insurance game, I love the multiple, highlighted warnings and disclaimers that appear on virtually every page of these manuals; a welcomed respite from all that in gas/off gas stuff.

So, after my rather lengthy review of the manual, do I know if my unit provides for conservative or aggressive profiles? Simple answer: No, I have no idea whatsoever. In fact, I probably never will know because the model is no longer made, the manufacturer has been sold to another company and nobody is interested in explaining the details of my computer to me. So, is my unit one of the more conservative ones, or am I eventually going to end up as one of my own statistics? Who knows? The only reassurance I have is that I haven't been bent yet; but then again, there is that irritating pain in my right forearm that's been hanging around since my trip to Papua New Guinea.

Being mature (I'm slightly above the median age for Canada at the moment) and maybe just a little paranoid, I think I'll spring for a new computer. The question is how do I choose the right one this time around? More research, that's certain. I'll read the various comparisons available, oh and those manuals, too (I look forward to ominous new disclaimers). Or, maybe I can just ask at the dive shop. Do you think they'll know? Despite this daunting task, you can rest assured I will be buying the most conservative unit available or one that allows me to manually program an increased safety margin. I don't mind reviewing incident reports; I'm not interested in filling one out.

I was moving some stuff around in the garage the other day and found an old set of plastic dive tables (right next to my double hose regulator). A moment of contemplation was followed by the realization that the good old days are just where they should be. Those tables were just a little harder to use than I remembered.

About the author: Peter Meyer is the Senior Vice President of Willis Canada, Inc., providing insurance to a broad spectrum of dive industry constituents that include retail dive facilities; dive vessel operators and dive resorts worldwide; scuba instructors, dive leaders and the general diving population. Since 1988 he has been a leading consultant for the industry, currently managing the professional liability programs for several dive training agencies and hundreds of retailers, resorts and vessel operators.

He has been involved in recreational boating and scuba diving his entire life, having owned and operated two retail dive facilities, two live aboard dive charter vessels, and having taught recreational diving at all levels for many years. Watch for more articles by Peter in coming issues.

ALGORITHMS: Comparative Tests Needed

By Ron Nishi

The latest (2002) DAN report[1] on decompression illness (DCI) and diving fatalities shows that dive computer use grew from 60 to 70 per cent, 1998 through 2002, among those reporting accidents. In 1987, fewer than 20 per cent of the injured divers reported using dive computers. It's understandable that with the proliferation of dive computers on the market, the number of injured divers using computers will increase. Does this mean dive computers will increase risk of DCI? We can't answer that question because we don't know the number of people using computers or how they are using them (i.e., no-stop dives, multi-level dives, decompression dives. DAN's Project Dive Exploration is a great step toward getting this information). We also don't know how many are not using dive computers.

The terminology, DCI, includes both decompression sickness (DCS) and arterial gas embolism (AGE). So when the author of the accompanying article states that he reviewed "those safe DCS incident files", were some of them actually AGE and not DCS? (Editor's Note: All cases in Peter Meyer's article were DCS). Dive computers have no bearing on AGE, so divers could well be within the computer's 'safe' diving limits. Where cases of DCS are concerned, we should really know how many were diving within the computer limits and did not get DCS to see if there is a serious problem. Conversely, we should also know how many divers there were in violation of their computers and had DCS, as well as how many who did not have DCS. Unfortunately, this information is not available. It would also be interesting to see how many dive accident claimants were diving outside the 'safe' limits of their computer.

We also have to consider what is meant by a 'safe' computer dive. 'Safe' is a relative term. There is no such thing as absolute safety. 'Safe' compared to what? As the author of the article points out, different computers give different results (sometimes significantly different) for the same dives or sequence of dives. This is going to depend on two things - the basic decompression model and how it is implemented as a decompression algorithm in a dive computer. Karl Huggins, Project Manager of the Catalina Hyperbaric Chamber and an expert on dive computers, estimates that there are about 10 to 15 basic decompression algorithms. There are so many ways that the parameters of these models can be adjusted that many permutations of these models are possible. Some computers are designed for no-decompression or no-stop diving; others will allow decompression stops. Some of the algorithms used are more conservative than others and many computers are adjustable by the user. The biggest differences in calculating the remaining no decompression times or the decompression times required (once in the decompression mode) are going to show up in multilevel dives or repetitive dives.

Karl Huggins has recently tested 15 dive computers on a number of dive profiles that have been previously tested on humans[2]. One example was a multi-level dive to 130 feet of seawater (fsw) (40m) for 12 minutes, 70 fsw (22m) for 13 minutes and 45 fsw (14m) for 29 minutes. At that point, six computers showed that another nine to 11 minutes was possible before decompression was required. The other computers showed that up to 12 minutes of decompression time was required. So, the diver who had done the "116-foot (35m) dive for 58 minutes" may have been 'safe' on his computer but he could very well have been outside the 'safe' limits of several other computers. John Lippman and Mark Wellard have also compared the performance of five dive computers on five different pressure exposures consisting of repetitive dives and multilevel dives[3]. For example, on a multi-level dive to 100 fsw (31m) for 5 minutes, 65 fsw (20m) for 10 minutes, and a final level at 50 fsw (15m), the no-stop time remaining ranged from 23 to 61 minutes on reaching 50 fsw (15m). These examples show that there could be a wide variation in how different computers respond to the same dive profiles. Although these two examples are for single multi-level dives, such discrepancies may be magnified when the calculations are extended to multiple multi-level or single dives. Some of it depends on how the programmer deals with the off-gassing of inert gas during the surface interval.

So, what is 'safe'? As the author points out, dive computers are not based on "tried and true scientific research". A number of decompression tables have been tested with human subjects. But these were done under very well-controlled situations in hyperbaric chambers. Some have also had limited testing in open-water. Testing of repetitive dives is generally quite limited. However, the Diving Sciences and Technology (DSAT) tables were tested with multiple dives per day for multiple days[4]. Implementation of the decompression models underlying these tables in a dive computer, for divers who don't stick to going down to some depth, staying there for some time, and then ascending, or for divers who do multiple repetitive dives for several consecutive days, is a different matter. The manufacturers have to modify the decompression models for them to work in a dive computer. For example, a true model-based dive computer will not be able to duplicate the US Navy or DSAT repetitive diving tables because these tables have artificial rules for calculating residual nitrogen times.

There have only been a few attempts, in the early 1980s, to validate decompression algorithms in dive computers using human subjects. The Edge dive computer[5] was tested with three dives a day for three days with a single dive on the fourth day. Max Hahn in Germany also tested algorithms intended for dive computers[6]. Since then, none of the other computer manufacturers have followed suit. So there is a need for comparative tests such as the ones by Karl Huggins and John Lippman. SCUBA Diving Magazine also does an annual review of dive computers and how they perform against some standard test profiles. Information on the 2004 tests can be found at http://www.scubadiving.com/gear/dive_computers/crunching_the_numbers/.

There are a number of other factors not related to dive computers that can increase the risk of DCS. The author alludes to a few of these such as fatigue before a dive or dehydration. We can also add heavy exercise or exertion before or after a dive. Our experimental dive research