

PADI
1243 East Warner Avenue
Post Office Box 15550
Santa Ana, California 92705
USA

May 27, 1988

Dr. David E. Davis,
Secretary, SPUMS.

Dear Dr. Davies:

Thank you for your letter regarding the Recreational Dive Planner dated April 15, 1988. I want to take the opportunity to respond to your letter and to provide additional information for your consideration.

There appear to be misperceptions formed on this project. The goal was simply to test some schedules which, if the testing was successful, could be utilized to develop recreational diving tables.

To begin with, the document entitled, "Recreational Dive Planning; The Next Generation", is not the archival piece of science. It does not contain all of the analysis which will be published in the final scientific document. It was intended for distribution to interested laypersons and scientists alike. PADI's interest in sponsoring this study can be found in the first two sections of its three-part format: Executive summary, history and development, and scientific data. Because of this format, confusion and misperceptions may have occurred. An individual looking for the scientific aspects could be distracted by the first two sections in the document; which may be the case in this situation.

When the final report of this first test phase is completed, I will see to it that one is sent to you. Until that time, I would respectfully request that you consider the following before forming a final conclusion on behalf of SPUMS.

It is well recognized that Australia has some of the world's foremost authorities in the sciences surrounding decompression. From your comments, it is clear that your consultants had some reservations concerning the "theory, design and conduct" of the study. We must take exception to this as, within the constraints of time and money, it accomplished its goal.

The concerns of PADI dealt little with decompression theory and were molded more by the legal climate in the United States. Indeed at times there were concerns voiced if a study even as benign as this one could be conducted in the US because of potential litigation. However, it must be noted that the study followed accepted standards of practice in the United States at this juncture in time.

I wish to emphasize that the study was a development project, not research into the limits of decompression. The parameters of the US Navy tables were taken for the basis

set. These were revised to make them more conservative using Spencer's published study as the starting point. Titrations to bends/no bends points were not performed as limits were not being studied. It was the goal of the study to perform tests of the selected dive profiles with a population of recreational divers both men and women, in the age range of sport divers. The primary reasons concerned the US federal regulations, and the litigious atmosphere which currently pervades the United States.

Doppler devices were employed because they (1) allow some degree of assessment of gas phase formation in the absence of overt decompression sickness, (2) they can be employed retrospectively to make a rough guess of the probability of decompression sickness and, (3) they are invaluable in seeking approval by human subjects' committees because there is a means of determining schedule validity without injuring a subject. These reasons are of limited scientific merit, but are very valuable in a legal sense.

We concur with your observation that Doppler devices only detect moving bubbles and not actually the tissue gas phase which is stationary. Table testing with Doppler devices is of value when the dives are of relatively short duration as in this study. This methodology has also been employed in Canada by DCIEM (Defence and Civil Institute of Environmental Medicine) in its table development program.

It is important to note that both acceptable bubble grades, and the absence of bends were used as the test criterion. No assumptions were made that the divers were free of a tissue gas phase. The data collected were indicative of these facts. Any statements concerning "minimal gas phase formation and no silent bubble carryover" are a liberal interpretation of the methodology.

It has been shown that if bubble formation can be minimised or avoided, the risk of decompression sickness will be low. That is phenomenologically the most that one can make of Doppler ultrasound. A check of Dr. Powell's publications in hyperbaric physiology and his chapter in Bennett and Elliott (3rd edition) will convince one that he indeed knows the limits of Doppler bubble detection.

Although Doppler measurements are useful, the primary indication is still a biological one of bends or no bends. This study did not have any cases of decompression sickness. Additionally, as the report shows, bubbles were detected in but a few divers. Depending upon the theoretical perspective, much or little can be made of this observation. In projects such as this, Doppler ultrasound devices serve as much, if not more, for their legal benefit as they do for the scientific information they yield. The goal was the design of reasonable decompression schedules for recreational divers. We did not expect to have any decompression sickness and that was, in fact, the experimental result. Considering the initial basis set, the number of trials (at least 15 on 17 different profiles), and the age and gender distribution of the subjects, the test series would have significant weight in a court of law.

The issue of statistical significance appears to be one which can be argued endlessly. It would be desirable to test to conventional levels of statistical reliability or higher, but the requirements of the vast number of trials makes this virtually cost prohibitive. Moreover, it has never been accomplished to date by anyone within the field of hyperbaric science. Previous testing practices in the field may reflect this difficulty. For example:

- (a) Haldane tested his schedule twice.
- (b) Initially, the US Navy tested their standard air schedules four times. During the 70s, commercial schedules were tested 12 times and more recent programs have used 20 to 40 tests.

These facts are reported in a paper written by Drs. Bennett and Vann of the F.G. Hall Laboratory in Duke Medical Center entitled "Development and Validation of Deep Bounce and Other Decompression Procedures In The Laboratory". (It is significant to note that DSAT (Duke University Saturation Diving) research tested approximately 500 manned dives, far more than any other tests of this nature.) Drs. Bennett and Vann went on to state that when few tests are conducted, it is essential to achieve the greatest assurance of safety. This can only occur when no decompression sickness incidents are allowed, such as in the DSAT study.

The testing of decompression procedures involves validation of a decompression table which contains many different schedules. It is impractical to test every profile in the DSAT table which has over 36,000 possibilities.

Decompression, as you well know, is highly complex. There are many variables to consider such as the diver himself, the patterns of diving, and the table design. These factors make table validation of a major problem; the medical community tried to address this as recently as 1987 in a UMS conference with no firm consensus.

Within the framework of the mathematical models, decompression sickness becomes a statistical phenomenon. As a result, it is not possible to design a practical table that is 100% safe for 100% of the people 100% of the time. This is commonly known.

To totally eliminate all risk of decompression sickness, one would have to avoid diving altogether or, once having descended, never surface. Obviously, neither alternative is practical. Furthermore, to design a testing process that would define limits for everyone, everyone would have to be tested. Every man, woman and child would have to be tested every day. (Obviously, this would no longer be a test. As a result, the number of test dives used by table developers can never be perfect.) Because people differ in susceptibility to decompression sickness, no decompression table can guarantee that decompression sickness will never occur, even though the diver dives within the table limits. All this is, of course, clear to you.

PADI feels that the diver education community shares a responsibility with the medical community to provide recreational divers (who now number in the millions versus commercial divers who number in the thousands) with the very best set of tables, both in terms of safety and utility, that current technology and available resources can produce, to accommodate the type of diving (ie. no decompression repetitive dives) these people are already doing.

The data resulting from the testing which produced the DSAT tables show a better approach to this problem than military or commercial tables. There was an obvious need for a better table for recreational scuba activity. The data tested at the Institute of Applied Physiology and Medicine in Seattle did not appear de novo but rather from a logical extension of earlier information.

As an additional point for consideration, this research was the first of an ongoing series of research projects DSAT has planned. DSAT, in close connection with the North American scientific community, is formulating a study that would extend the research recently completed. The study would investigate the effect of using the algorithms on which the recreational dive planner is based in situations where divers dive repetitively for many days such as during a live aboard boat vacation. This test has already been designed and is currently being submitted for review by a panel of hyperbaric experts from the United States and Canada. We expect the chamber phase of the test to begin within the next month.

Thank you again for your comments and suggestions. I'll look forward to furthering our communications on this and future projects.

Drew Richardson
Training Manager

The Christchurch Clinical School of Medicine,
University of Otago,
P.O. Box 4345,
Christchurch,
New Zealand.

9 November 1988

Dear Sir,

In recent issues of the SPUMS Journal and the UHMS magazine "Pressure" there has been passing reference to the new PADI (Professional Association of Diving Instructors) diving tables that are currently being introduced internationally. All these references appear derogatory and I am particularly concerned about David Davies' comment that both Brian Hills and Des Gorman condemned the findings of the research on which these new diving tables are based as being unscientific.