Vol 19 No. 1 JANUARY - MARCH 1989

SPUMS JOURNAL

ISSN 0813 -1988

South Pacific Underwater Medicine Society

CONTENTS

Information about SPUMS, conferences and courses is to be found on the inside of the front and back covers and on pages 38-40 and page 44.

ORIGINAL PAPERS

ARTICLES OF INTEREST FROM OTHER JOURNALS AND LETTERS TO THE EDITOR ARE DETAILED ON THE BACK COVER

PRINTED BY: K.D.COPY CENTRE, 354 Canterbury Road, Surrey Hills, Victoria 3127.

Registered by Australia Post Publication Number VBH3527

OBJECTS OF THE SOCIETY

To promote and facilitate the study of all aspects of underwater and hyperbaric medicine.
To provide information on underwater and hyperbaric medicine.
To publish a journal.
To convene members of the Society annually at a scientific conference.

MEMBERSHIP

Membership is open to medical practitioners and those engaged in research in underwater medicine and related subjects. Associate membership is open to all those, who are not medical practitioners, who are interested in the aims of the society.

The subscription for Full Members is $A35.00 and for Associate Members is $A25.00. New Zealand members' subscriptions ($NZ 50.00 and $NZ 35.00 inclusive of GST) should be sent to Dr Andrew Veale, Secretary/Treasurer of the New Zealand Chapter of SPUMS,19 Otahuri Crescent, Greenlane, Auckland 5.

Membership entitles attendance at the Annual Scientific Conferences and receipt of the Journal.

Anyone interested in joining SPUMS should write to the Secretary of SPUMS,

Dr David Davies,
St Anne's Hospital,
Ellesmere Road,
Mt Lawley,
Western Australia 6050.

AIR MAIL DELIVERY

The *SPUMS Journal* can be airmailed at the following annual extra costs.

Zone 1	e.g. Papua New Guinea & the South Pacific	$ 6.50
Zone 2	e.g. Indonesia and Malaysia.	$ 9.00
Zone 3	e.g. India and Japan.	$ 11.50
Zone 4	e.g. U.S.A. and Israel	$ 14.50
Zone 5	e.g. Europe, Africa & Sth America	$ 15.50

Those interested in having their copies of the *SPUMS Journal* 'airmailed should write to

SPUMS
80 Wellington Parade,
East Melbourne,
Victoria 3002,
Australia.

They will be advised which zone charges apply and of the appropriate amount in Australian dollars.

INSTRUCTIONS TO AUTHORS

Contributions should be typed in double spacing, with wide margins,on one side of the paper. Figures, graphs and photographs should be on separate sheets of paper, clearly marked with the appropriate figure numbers and captions. Figures and graphs should be in a form suitable for direct photographic reproduction. Photographs should be glossy black and white prints at least 150mm by 200 mm. The author's name and address should accompany any contribution even if it is not for publication.

The preferred format for contributions is the Vancouver style (*Br Med J* 1982; **284**: 1766-70 [12th June]). In this Uniform Requirements for Manuscripts Submitted to Biomedical Journals references appear in the text as superscript numbers. [1-2] The references are numbered in order of quoting. The format of references at the end of the paper is that used by *The Lancet*, the *British Medical Journal* and *The Medical Journal of Australia.* Examples of the format for journals and books are given below.

1 Anderson T, RAN medical officers' training in underwater medicine. *SPUMS J* 1985; 15: (2) 19-22
2 Lippmann J,Bugg S. The diving emergency handbook. Melbourne: J.L.Publications, 1985

Abbreviations do not mean the same to all readers. To avoid confusion they should only be used after they have appeared in brackets after the complete expression, e.g. decompression sickness (DCS) can thereafter be referred to as DCS.

Measurements should be in SI units. Non-SI measurements can follow in brackets if desired.

REPRINTING OF ARTICLES

Permission to reprint original articles will be granted by the Editor, whose address appears on the inside of the front cover, subject to the author's agreement, provided that an acknowledgement, giving the original date of publication in the *SPUMS Journal* , is printed with the article. Where the author has claimed copyright at the end of the article requests for permission to reprint should be addressed to the author, whose address appears at the end of the article.

Papers that have been reprinted from another journal, which have been printed with an acknowledgement, require permission from the Editor of the original publication before they can be reprinted. This being the condition for publication in the *SPUMS Journal*.

ADVERTISING IN THE SPUMS JOURNAL

Advertising space is available in the SPUMS Journal. Rates on application from the Deputy Editor whose address apppears inside the front cover. Deadlines are January 31st, April 30th,July 31st and October 31st.

PROJECT STICKYBEAK

This project is an ongoing investigation seeking to document all types and severities of diving- related accidents. Information, all of which is treated as being CONFIDENTIAL in regards to identifying details, is utilised in reports and case reports on non-fatal cases. Such reports can be freely used by any interested person or organisation to increase diving safety through better awareness of critical factors. Information may be sent (in confidence) to:

Dr D. Walker
P.O. Box 120,
Narrabeen,
N.S.W. 2101.

THE MARINE STINGER HOTLINE

AUSTRALIA WIDE TOLL FREE NUMBER 008-079-909

For advice about the treatment of marine stinger injuries dial **008-079-909**.

ARTICLES OF INTEREST FROM OTHER JOURNALS

LETTERS TO THE EDITOR

EDITORIAL

Readers may be suprised to find John Lippmann's paper on dive computers printed again in this issue. Unfortunately some important parts of the article were omittedin the last issue so it is reproduced here as it should have appeared in December.

The welcome response by the Professional Association of Diving Instructors (PADI) to the less than enthusiastic reception of their new diving tables and the disciplining of incompetent instructors by the National Association of Underwater Instructors (NAUI) is indicative of the responsible attitude to matters of diving safety now being adopted by diving organisations. This is a considerable advance from the days when organisations were more interested in internicine and unfriendly rivalry over the diver training market share each could gain. Some credit for this should naturally be awarded to the attitude of the legal profession, particularly in the United States of America, which has grown to expect that all save their clients are responsible for every misadventure which can befall man (or, naturally, woman). Unfortunately but naturally there is only one sure defence to such legal dangers, which is to do everything by "the book". In Australia there is a well known and highly effective trades union method of causing severe disruption. "Working to rule" could just as correctly have been called "going by the book". Unfortunately authoritative texts are not depositories of absolute truths but only the accepted beliefs of the time when they were written. This does not make it any easier to defend different actions when questioned in a court of law as instructors in New South Wales have found out in the recent past. Unsubstantiated statements of "in my experience" will carry very little weight in many instances. The answer is to collect the experiences of many. Incident reports, such as were collected at the SPUMS AGM on Mana Island by Acott, Sutherland and Williamson, are the long term answer to the danger of being locked into an inflexible frame of action where alternatives to printed opinions are actionable. Acott, Sutherland and Williamson and those SPUMS members who contributed the reports are to be congratulated on their provision of evidence about common diving problems and incidents.

Readers may possibly be bored by appeals for their support for the reporting of diving-related problems, but if they actually wrote such reports (and posted them) they would realise the value to the writer as well as to the general diving community of such reports. The Divedata Databank deserves the support of all interested in the maintenance and improvement of diving safety.

Every diver should be aware of the validity of the work by Kissell, quoted by Dr Wong Ted Min in his paper on the contribution of lack of buoyancy control to diving deaths, concerning the loss of mobility due to the equipment worn when diving. This is another example of the reality of the statement that solving any problem, e.g. heat loss, produces more problems for the diver. But although this must have been a factor in some accidents it is not one which is so recorded. It is evident that problem reporting as well as incident reporting is an important priority and probably rather more important that seeking to solve the riddle of HPNS, which can be avoided by using a 1 ATA suit.

Robert Monaghan has again demonstrated that statistics are dangerous things in the wrong hands, i.e. if the results are unwelcome and possibly suspect. As the case reports concerning diving fatalities in Australian waters have shown, diving is very safe until a number of adverse factors are collected by the victim and then tragedy strikes. If one is parsimonious and limits oneself to one error at a time one is likely to remain safe. Inexperience, underestimation of the water conditions, separation, running low on air (even by divers with contents gauges !) and solo surface returns from a dive have all been frequently identified as adverse factors. Naturally a fine spray of water with each breath or a hard-to-breathe regulator are unhelpful to anyone, but particularly to the inexperienced. Attention to such matters will spoil the joy of statisticians calculating the risks of diving and prevent any more provisional reports on diving deaths being written. Both are worthy objectives for all to seek to further.

The paper by Smart from the Royal Hobart Hospital, presented at a hyperbaric and diving medicine meeting in November 1988, draws attention to the need to recompress divers who have minimal and confusing symptoms as these may well disappear with recompression therapy. Other papers from this meeting will be published as they come to hand.

The number of Letters to the Editor in this issue is a matter for congratulation. Readers are reminded that this is their Journal and they are invited, indeed entreated, to write when they feel strongly about some matter, though the Editor reserves the right to modify comments expressed if such action is required. Although not strictly letters to the Editor the correspondence with the Standards Association of Australia about the setting up of a committee to produce a standard for recreational diving has been placed there (pages 33-34) as the best method of bringing the matter to the attention of the members of SPUMS. Those with ideas which they would like put to the committee should write to our representative, Dr John Knight.

Once again we reprint the British Sub-Aqua Club's diving accident statistics for our readers to keep abreast of the diving troubles of the other side of the world. Attending the World Underwater Federation's meeting in Martinique would allow any of our readers to learn and at the same time dive almost half way round the world.

One innovation in this issue is the inclusion of the New Zealand Letter, edited extracts from the newsletter sent by the Secretary/Treasurer of the New Zealand Chapter to members in New Zealand.

NZ NEWSLETTER

Edited Extracts from the Secretary's Newsletter New Zealand Chapter of SPUMS

13th November 1988

This time the Journal arrived on time, the Secretary was in New Zealand, and a planned weekend dive was cancelled. The Journal gets dispatched on time!!!

Dive accidents have continued over the winter period with advice and treatment being offered to accident victims from as far away as the Cook's and Fiji. There has been no apparent slackening in the mortality/morbidity rate, although final data will not be available until the next newsletter. One disturbing trend has been the blind reliance on dive computers of different brands, and the increased number of experienced divers being bent. One factor would appear to be multiple ascents during otherwise "safe" dives. As many of you will know, during most ascents, even from 12-15 msw (40-50 fsw), micro bubbles form, this changes the physical characteristics of the gas phase/dissolved gas relationship making it easier for nitrogen uptake into the bubble, ie. the micro bubble acts as a nucleus for bubble growth, hence increasing the bends risk.

Project Stickybeak

Members are reminded that any dive related incidents should be reported to Dr Douglas Walker, P.O. Box 120, Narrabeen, New South Wales, 2101, Australia. All incidents are of interest. A Report Form for ENT disorders (which can be photocopied) will be finalised and posted out with the next Journal. (Prepared by Noel Roydhouse.)

It would be very useful if SPUMS members knowing of deaths or near deaths in their locality, could forward details to myself or Dr Mark Fraundorfer, NZUA (New Zealand Underwater Association) Accident Recorder, C/-Tauranga Hospital. Often details are published in local papers and much knowledge is available locally at the time of the incident, later forgotten, and certainly never making it into the inquest report which may simply record "death by drowning. We urgently need good data, particuarly relating to serious or potentially sreious diving related disease.

Well, for those not active over winter (and missing great diving) it is time to go out and regain past diving fitness before attempting that deep dive on your favourite pinnacle in a 4 knot current. Remember the risks for a dive accident, obesity, lack of fitness, increased age, poorly maintained equipment, etc. Take it easy out there !

New Zealand Chapter 1989 Conference

Planning for this is proceeding in the able hands of Beris Ford, Wayne Dalley, Rees Jones, and Peter Chapman-Smith. It is to be held in the Bay of Islands (Piercy/ Dog, Cavallis/ Rainbow Warrior) Labour Weekend 21-22-23 October. **Note this date in your Diaries NOW**.

1989 Diving Medicine Course

This course mentioned briefly in the last newsletter is sponsored by NZUA and held in conjunction with New Zealand Chapter of SPUMS. In 1989 the course will be organised and run under the able stewardship of Mike Davis, an experienced Diving Medicine specialist and long time SPUMS Member. The course is designed to increase the pool of doctors competent in the assessment of intending divers, the management of common diving illnesses, and in the assessment and first aid management of Dysbaric illness.

Doctors attending the course become a part of the Diver Emergency Service (DES), which is centered on the 2 Hyperbaric treatment centres, (Christchurch, RNZN Devonport) and involves DES doctors in many parts of the country.

Doctors interested in taking this course in the last week of September 1989 should note the date, and keep watch for further information as it comes available from Mike Davis and NZUA. See page 40.

New Zealand Chapter of SPUMS Library

13 books are now available. Books may be borrowed by writing to:-

SPUMS(NZ) Library,
4 Dodson Avenue,
Milford, AUCKLAND. 10.

Books will be lent for 3 weeks only, after which a penalty will apply, renewals will not be allowed until I can assess demand.

Books should be posted back with stamps enclosed to the value of the outward postage. This will fulfil RogerD's "user pays" philosophy, and ensure there is no continuing drain on SPUMS funds.

The titles, authors and brief reviews appear below.

Atlas of Aquatic Dermatology
Alexander A. Fisher
Written and photographic guide to the diagnosis and management of common skin conditions.

Decompression / Decompression Sickness
A.A. Buhlmann
Description of experimental and theoretical work abnormal atmospheric conditions, increased and decreased pressures. Involves discussion of different gas mixes.

Diving and Subaquatic Medicine
Edmonds, Lowry, and Pennefather
A clear practical guide to dive instructors and diving doctors. Based on extensive clinical experience. Highly recommended for inclusion on the shelf of every doctor dealing with divers.

Diving Medicine
Richard H. Strauss
A similar practical guide to diving medicine, covering diver medical evaluation, management of common diving related disease and mangement of dive accidents.

Marine Animal Injuries to Man
Carl Edmonds
Comprehensive review of problem bites, stings and poisonings which may present to doctors in the South Pacific. I have found it useful in the telephone diagnosis of Ciguatera poisoning, hence saving a $10,000 evacuation from the back of beyond. Remember that when NZ divers go to the South Pacific, they come home again to see their friendly GP!!!

Medical Examination of Sport Scuba Divers
Jefferson C. Davis. 2nd Edition
A superb cookbook guide to the diving medical examination. A book that ALL family doctors performing medical evaluations of intending divers should have access to.

Safety in Manned Diving
Eric Jacobsen et. al.
Produced by the Norwegians on the basis of Northsea experience. Discusses current methods and risks of offshore diving. Covers certification, Government and industry regulations.

Stress and Performance in Diving
Bachrach & Egstrom
Covers physical, physiologic, environmental, and mental stress involved in diving. Useful reference for teachers and instructors. Systematic and readable.

Subsea Manned Engineering
Gerhard Haux
Covers many aspects of the design and methods of diving, both under pressure and 1 atmosphere systems.

The Deep Sea Diver
Robert C. Martin
A very readable historical guide to diving and the methods and equipment used to overcome the rigors of the underwater environment.

The Underwater Handbook
Charles W. Shilling
Another of the complete guides to the physical, physiologic and engineering problems of diving. Readable.

The Physiology and Medicine of Diving
Bennett & Elliott
A well known standard text of diving. Covers scientific theory and indepth background to issues of diving physiology. Recommended text for those with a thirst for more knowledge about the 'Why' of diving medicine.

Underwater Ear and Nose Care
Noel Roydhouse
Essential reading for those doctors seeing divers. Covers the most common source of divers misery, the nose, sinuses and middle ear. Offers practical solutions. There are few books which collate these disorders in such an easily read manner.

If you wish to purchase one of these titles, I can obtain these from the publisher at a small discount.

Good (safe) Diving,

Andy VEALE
Secretary/ Treasurer

STOP PRESS

COLLAPSE OF THE NATIONAL SAFETY COUNCIL OF AUSTRALIA (VICTORIAN DIVISION)

John Knight
Deputy Editor

The financial collapse of the National Safety Council of Australia (Victorian Division) (NSCA) during the preparation of this issue has changed the diving scene in Australia very considerably. No longer can Robert Monaghan envy us "with your co-ordinated chamber and rescue operations".

The NSCA provided a hyperbaric rescue service which ceased with the closing down of the company's activities. The chamber operators at the hyperbaric facilities at the Alfred Hospital in Melbourne and at the Royal Adelaide Hospital were paid by the NSCA as were some at Townsville. I understand that temporary arrangements have been made to keep the Melbourne and Adelaide chambers operating and I presume that something similar has happened in Townsville. I understand that commercial firms are negotiating with the liquidator of the NSCA to purchase the hyperbaric facilities of the NSCA and that these negotiations are unlikely to conclude rapidly.

Sports divers will appreciate the continuing service offered by the fixed chambers, although this is dependent on the chamber operators staying in what must appear to them to be uncertain employment in the face of firm offers from a resurgent diving industry. Of equal importance to sports divers is the hyperbaric retrieval service which was operated by the NSCA. My information is that the commercial operators are not eager to acquire this expensive service.

The SPUMS Executive Committee, at its meeting in Adelaide on April 1st instructed the Secretary to write to the Premiers and Ministers of Health of Queensland, South Australia and Victoria requesting that they take all possible steps to maintain the hyperbaric units in their states and to preserve the hyperbaric retrieval service. These letters are reproduced on page 4. In my opinion all members and associate members of SPUMS should be writing to these gentlemen, or at least to their own Premier, about the need to maintain these services.

The Diver Emergency Service (DES) of telephone advice and coordination of treatment and transport is also at risk. Not only did the NSCA contribute to the costs of running DES but the Royal Adelaide Hospital, which has been paying the costs of the DES number, 008 088 200, has acute financial problems and may not be able to continue to fund the incoming calls which run at four or five a day. I invite all readers to emulate the Executive of SPUMS and send a donation, as I have already done, earmarked for the DES telephone costs, to the Chief Executive Officer of the Royal Adelaide Hospital, North Terrace, Adelaide, South Australia 5000. Donations of over $ 2.00 to Public Hospitals are tax deductible.

No one knows what the outcome of the various negotiations will be but we, as individuals, can help to provide political pressure if we are willing to write, along the lines of the letters sent by the Secretary of SPUMS, to the relevant politicians. As we are asking for a financial commitment from a government that means writing to the Premier. If we, and as many other divers as we can reach and motivate, do not act we may lose the hyperbaric lifeboat completely.

LETTER SENT BY THE SECRETARY OF SPUMS TO THE PREMIERS AND MINISTERS OF HEALTH OF QUEENSLAND, SOUTH AUSTRALIA AND VICTORIA.

I am instructed by the Executive of the Society to write to you expressing our grave concern over possible interruption to the hyperbaric and diving medicine services following the collapse of the National Safety Council of Australia (Victorian Division).

Any loss of retrieval and treatment facilities will have economic, medical and industrial implications, and possible political concern.

Contracts with the National Safety Council of Australia (Victorian Division) have provided support for all government diving activities as well as for civilian diving accidents and increasing numbers of patients requiring hyperbaric oxygen therapy.

If these facilities are not maintained, the police, Ports and Harbours, Fisheries and other government departments will need to provide the necessary hyperbaric facilities and trained staff themselves, just to conform with State and Federal Health and Safety regulations. This will incur much more expense than the cost of maintaining current services and may necessitate the cessation of all government diving activity until such facilities become available.

This Society feels it is imperative to maintain the existing hyperbaric therapy and retrieval services in each capital city as the alternative is the highly expensive interstate transfer of such patients. In this situation, the only two centres capable of treating these patients will be Fremantle and Sydney and it is obvious that this would lead to grave inadequacies of management.

In view of our concern over the need to maintain this vital service, this Society has already contributed funds to ensure that the Diver Emergency Service section remains in a fully functional capacity.

Yours faithfully,

David E,Davies,
Secretary,SPUMS.

LETTER FROM SECRETARY OF SPUMS TO THE CHIEF EXECUTIVE OFFICER OF THE ROYAL ADELAIDE HOSPITAL.

Dr B.Kearney,
Chief Executive Officer,
Royal Adelaide Hospital,
North Terrace,
Adelaide,
South Australia 5000.

Dear Dr Kearney,

I am instructed by the Executive of the Society to write to you expressing our grave concern over the possible disruption to the Diver Emergency Service following the collapse of the National Safety Council of Australia (Victorian Division).

Your hospital has played a pivotal role in the maintenance of this essential service and the Society is most anxious that it can continue to serve the diving community. That there are around 1,000 calls each year to the service from all parts of Australia reflects the real need for its continuation.

The Executive requests that the enclosed donation of $ 500.00 be used specifically to support the telephone costs of the Diver Emergency Service. We hope that this token will help to maintain a service that Australian divers and diving doctors have come to rely upon.

Yours faithfully,

David E,Davies,
Secretary, SPUMS.

We are reprinting this article, which appeared on pages 126-133 of Volume 18, No 4, October to December 1988 as the figure, one table and some text were omitted. We apologise to John Lippmann and to our readers for our mistakes.

DIVE COMPUTERS

John Lippmann

Since decompression sickness in humans first reared its ugly head back in the mid-1800s, scientists and others have sought ways to improve and simplify decompression calculations and procedures.

Haldane introduced his model and schedules at the beginning of this century, and since then many decompression tables have been published. Although some of the very latest tables include methods for compensating for parts of a dive spent shallower than the maximum depth, most tables require a diver to choose a no-decompression or decompression schedule according to the maximum depth and bottom time of a dive. The calculation assumes that the entire bottom time was spent at the maximum depth, and that the diver's body has absorbed the associated amount of nitrogen. However many dives do not follow that pattern. A scuba diver's depth normally varies throughout a dive, and often very little of the bottom time is actually spent at the maximum depth. In this case a diver's body should theoretically contain far less dissolved nitrogen than is assumed to be present when using the tables in the conventional manner. Some divers feel penalised for the time of the dive not spent at the maximum depth.

The ideal situation is to have a device that tracks the exact dive profile and then calculates the decompression requirement according to the actual dive done. Such devices have emerged since the mid-1950's, some gaining some notoriety.

Probably the best known of the early decompression meters is the *SOS decompression meter* which was designed in 1959 and emerged in the early 1960s. The meter, which is still currently available, appears to represent a diver's body as one tissue. It contains a ceramic resistor through which gas is absorbed before passing into a constant volume chamber. Within the chamber is a bourdon tube which bends as the pressure changes, and the pressure level, which represents the amount of absorbed gas, is displayed on an attached gauge. On ascent gas escapes back through the resistor and eventually, when enough gas has escaped, the gauge will indicate that a safe (supposedly) ascent is possible. A number of problems arise with the use of the SOS meter. Individual meters often vary greatly, and the no-decompression times for dives deeper than 60 ft (18 m) exceed the US Navy no-decompression limits (NDLs). The meters give inadequate decompression for repetitive dives when compared to the USN and most other tables. In 1971, the first six divers requiring treatment at the Royal Australian Navy School of Underwater Medicine chamber were divers who had ascended according to SOS decompression meters.[1]

The Defence and Civil Institute of Environmental Medicine (DCIEM) of Canada developed a decompression meter in 1962. It utilised four resistor-compartments to simulate nitrogen uptake and elimination in a diver. Initially the compartments were set up in parallel so that each compartment was exposed to ambient pressure and thus absorbed gas simultaneously. When tested, this configuration produced an unacceptable bends incidence. The four units were then re-arranged in a series arrangement, so that only the first was exposed to ambient pressure and gas passed from one compartment into the next. This configuration was tested on almost 4,000 test dives and produced a very low incidence of bends.[1]

The meter gave effective half-times from five to more than 300 minutes, and it indicated current depth and safe ascent depth. The DCIEM unit never became available to sport divers as it would have proved to be very expensive and would have required extensive and costly maintenance.

In 1975 Farallon released its *Multi-Tissue Decomputer* which was designed to be a no-decompression meter. It consisted of four permeable membranes, two of which absorbed gas and two which released it. The Royal Australian Navy tested two meters in 1976 and found them to give very divergent results. One became more conservative while the other became more radical. In addition, various mechanical problems eventuated. Tests done in the USA confirmed that the NDLs given by the meter often greatly exceeded those of the USN tables.

Over the past ten years or so, various methods of extrapolating the USN (and some other) tables to credit a diver for the shallower portions of a multi-level dive have emerged. These methods require manipulations that are too complex for many divers and require the dive plan to be known in advance and rigidly followed. They are generally unvalidated, and their safety is a subject of dispute. In addition, if time is spent at more than two or three levels the calculations become prohibitively complex.

By the mid-1970s with the advance in microprocessors (a chip which can contain a series of pre-programmed instructions) it became possible to construct a small computer capable of doing very complex multi-level calculations. Recent technological innovations have overcome some of the early technical restraints and the scuba diver now has access to the convenience of automatic and more accurate depth and time recording, together with accurately computed multi-level decompression schedules, at far more affordable prices.

A microprocessor is capable of reading a pressure transducer (which converts pressure into electrical impulses) very rapidly and can apply nitrogen uptake and elimination algorithms (the mathematical equations which represent gas uptake and release) to this information every few seconds. These computers can therefore track a diver's exact profile and calculate decompression requirements according to it, rather than by the "rounded-off" profile which is used with decompression tables.

Despite, and in some cases because of, these features, some reputable diving scientists, doctors and educators remain very critical of these devices. Some argue that a diver will become too machine-dependent and would be at a loss and in a potentially dangerous situation if his computer failed while in use. However some diving instructors feel that modern decompression computers are less likely to fail than divers are while reading the tables and that there are some reasonable bail-out procedures in case of meter failure. *Probably the major fear of the computer critics is that some computers bring a diver far too close to, or beyond, the limits of safe diving, especially during repetitive dives.*

The decompression models programmed into the model-based computers are designed to simulate nitrogen uptake and release in a diver's body. However they are just models and cannot completely predict the gas flow in and out of our actual tissues. Our physiology is not always so predictable as many factors influence the rate of gas uptake and elimination and the possibility of consequent decompression sickness. So even though the computers follow their models exactly and the theoretical tissues programmed into the computer load and unload as expected, our bodies might not be behaving quite so predictably. There is no safety margin built into most computers which substantially compensates for this difference. Tables, on the other hand, usually contain an inherent safety margin and, in addition, since we must "round-up" any intermediate depth and/or time to the nearest higher or longer tabled depth and/or time, we partly, but not always fully, compensate for our own body's deviation from the model.

A table-based non-multi-level computer retains any inherent and/or "round-up" safety margin of the table, a table-based multi-level computer retains a small amount of the margin and a model-based computer retains no margin at all unless it is built into the model itself.

Comparing computers to tables for no-decompression dives

When no-decompression times allowed by various computers are compared to those allowed by various tables (even those based on the same model) for the same dive, vast differences often appear. These differences become greater for repetitive dives. Tables 2 and 3 compare the times allowed by various computers and tables for two series of repetitive dives that I carried out in a water-filled pressure chamber. I have conducted a variety of other simulated and real dives with similar results. Some of the reasons for these differences will be discussed in this section.

SINGLE DIVES

Table 1, below, compares the single dive NDLs of various computers to those of the USN and Buehlmann (1986) tables.

TABLE 1

COMPARISION OOF NO-DECOMPRESSION LIMITS OF VARIOUS COMPUTERS AND TABLES

Depth m	feet	USN	Buehlmann	Aladin (Guide)	Datamaster 2	Edge	Microbrain	SME-ML	Skinnydipper
9	30	-	400	-	220	234	199	215	234
12	40	200	125	125	120	136	113	132	136
15	50	100	75	75	70	77	65	74	77
18	60	60	51	51	50	53	46	53	53
21	70	50	35	35	40	40	30	38	40
24	80	40	25	25	30	31	22	29	31
27	90	30	20	20	25	24	17	23	24
30	100	25	17	17	20	19	13	18	19
33	110	20	14	14	15	13	10	13	13
36	120	15	12	12	10	11	8	11	11
39	130	10	10	10	5	9	7	9	9

SINGLE RECTANGULAR DIVES

It can be seen from Table 1 that the single dive No-Decompression Limits of the computers are more conservative than the USN limits and are generally similar to the limits of the Buehlmann Table. Therefore *for a single rectangular dive these computers will usually give a more conservative no-decompression time than the USN Tables.*

It has been shown experimentally that divers who dive right to some of the USN NDLs will be quite likely to bubble during or after the ascent. By shortening the initial NDLs and in some cases slowing down the ascent, these computers (and modern tables) attempt to minimise bubble formation during or after a dive.

SINGLE MULTI-LEVEL DIVES

On a multi-level dive the computers will normally extend the allowable no-decompression dive time far beyond that allowed by the tables.

This occurs because the computer constantly calculates the (theoretical) gas uptake or release at all levels of the dive, rather than just at the maximum depth as tables do. This function is demonstrated in Figure 1 which shows a dive profile allowed by a Suunto SME-ML. At each level of the dive there was one minute of no-decompression time left when the ascent was commenced to the next level.

This single dive required no decompression according to the computer, but required decompression of 15 minutes at six metres and 31 minutes at three metres according to the USN Tables.

On a single multi-level dive of 30 m for five minutes, followed by 20m for 10 minutes, followed by ascent to 15m, the Suunto SME-ML allows a further 46 minutes of dive time at 15m before a decompression stop is required. The Huggins table allows 25 minutes at the 15m level before requiring decompression.

REPETITIVE DIVES

The dives shown in Tables 2 and 3 were rectangular dives so that the multi-level capability of the computers was minimised and the times allowed by the computers could be compared to the times allowed by the tables.

It is obvious that the computers allowed substantially more time for these repetitive dives than the tables would give. We know that it is unwise, and at times hazardous, to dive the USN Tables to their limits, especially on repetitive rectangular dives. How then can the generous times given by these computers be justified?

As previously mentioned, divers who dive right to some of the USN limits will be quite likely to bubble during or after the ascent. Some of these divers will develop manifestations of bends, but most will be asymptomatic. In either case these bubbles will slow down the out-gassing process and give rise to more residual nitrogen for repetitive dives than there would be if no bubbling had occurred.

By shortening the initial NDLs and slowing down the ascent rate, these computers attempt to minimise the bubble formation after the initial dive. This should enhance out-gassing, reduce residual nitrogen and thus enable longer no-decompression bottom times for repetitive dives. The Buehlmann Table works on this premise. It utilises shorter initial NDLs than the USN Table, followed by a slow ascent, and this is why it sometimes allows longer no-decompression bottom times than given by the USN Table for repetitive dives. However, as you can see from the examples, using the Buehlmann Table for repetitive dives is still more conservative than using most computers.

Figure 1. Dive profile allowed by a Suunto SME-ML. At each depth there was one minute of no-decompression time left when the ascent was commenced to the next level

TABLE 2

The times given are in minutes unless otherwise specified.

Dive 1

Depth	36 m
Allowable no-decompression bottom time	
Aladin	8
Microbrain	8
Edge	11
Skinnydipper	10
SME-ML	10
USN Table	15
Buehlmann Table	12
Bottom time (actual)	10
Decompression time required	none
Ascent time	1.3 minutes

Dive 2.

Surface interval	60
Depth	30 m
Allowable no-decompression bottom time	
Aladin	14
Microbrain	13
Edge	19
Skinnydipper	19
SME-ML	19
USN Table	11
Buehlmann Table	8
Bottom time (actual)	18
Decompression time required	
Aladin	40 seconds at 3 m
Microbrain	2 min at 3 m
Edge	none
Skinnydipper	none
SME-ML	none
USN Table	15 min at 3 m
Buehlmann Table	2 min at 6 m and 7 min at 3 m
Ascent time	2.3 minutes

Because most tables are based on the off-gassing of a single slow tissue during the surface interval they often have a safety margin built into them, whereas the computers carry no such margin. Repetitive Groups and Residual Nitrogen Times given in tables are designed to account for the highest gas loading that is theoretically possible and are usually based on a single tissue compartment only. Since this tissue is a "slow" tissue it out-gasses slowly on the surface. The tables assume that all of the tissue compartments are unloading at this rate and so may over-estimate the theoretical gas loads of the faster tissue compartments. This results in shorter repetitive dive times than would be allowed if the actual (theoretical) gas load in the faster compartments was considered. So this crudeness of the table's calculations may lead to longer surface intervals than are required by the model, but introduces a margin of safety by assuming the

TABLE 3

The times given are in minutes unless otherwise specified.

Dive 1

Depth	27 m
Allowable no-decompression bottom times	
Aladin	19
Microbrain	18
SME-ML	22
USN Table	30
Buehlmann Table	20
Bottom time (actual)	18
Decompression time required	none
Ascent time	3.5 minutes

Dive 2

Surface interval	32 minutes
Depth	30 m
Allowable no-decompression bottom times	
Aladin	14
Microbrain	14
SME-ML	16
USN Table	3
Buehlmann Table	6
Bottom time (actual)	16
Decompression time required	
Aladin	4 min at 3 m
Microbrain	4 min at 3 m
SME-ML	none
USN Table	15 min at 3 m
Buehlmann Table	2 min at 6 m and 7 min at 3 m
Ascent time	2.5 min to 3 m
Decompression done	4 min at 3 m

Dive 3

Surface interval	32 minutes
Depth	36 m
Allowable no-decompression bottom time	
Aladin	7
Microbrain	8
SME-ML	10
USN Table	none
Buehlmann Table	none
Bottom time (actual)	10
Decompression time required	
Aladin, decompression was indicated but cleared during (rapid) ascent	
Microbrain	5 min at 3 m
SME-ML	none
USN Table	15 min at 6 m and 31 min at 3 m
Buehlmann Table	4 min at 6 m and 9 min at 3 m
Ascent time	1 minute

diver has more residual nitrogen than the model dictates. However many depth and time combinations may lead to the same Repetitive Group although, in reality, the nitrogen contents in the various body tissues are quite different.

Computers calculate repetitive dive times according to the exact (rather than the maximum possible) gas loading given by the model, taking into account all the tissues used in the model. This usually allows more dive time for repetitive dives than is allowed by tables. However in some situations the times can be similar. The deeper NDLs are determined by fast tissues which absorb gas rapidly and which off-gas rapidly at the surface. Repetitive Groups are based on slower tissues. If repetitive dives are compared for NDLs in the depth range where the Repetitive Group tissue controls the NDL (i.e. shallow to moderate depths), then the limits given by the tables and the computer should be close.

On some long dive sequences or in situations where repetitive dives are done over many consecutive days, the computers are sometimes slower to unload as they are programmed with slower tissues than are used to determine the repetitive groups in tables. This may lead to the situation where the tables will allow you to begin a new days diving without considering residual nitrogen from the previous day's diving, whereas a computer may still carry over a penalty. *This will normally only apply to the first dive of the day and the computer will then allow longer bottom times for the following dives that day.*

Are the computers safe ?

The safety of these devices is still the subject of many a heated debate.

The main criticisms focus on the following arguments:

1. The models on which the computers are based are not completely accurate. Decompression computers will retain inaccuracies until the devices can directly measure an individual's actual tissue nitrogen levels.

2. The inherent safety margin of the tables as well as the extra security gained by "rounding-off" the tables is lost in the computers. This will give a diver more time, but will at times put him more at risk.

3. Although some of the models on which the tables are based have been well-tested for fixed-depth dives, there have only been a few well-controlled, documented tests of the validity of the multi-level applications. The number of these tests has been insufficient to determine the validity of the multi-level applications with any statistical significance.

Before releasing the *Edge* in 1983, Orca Industries conducted a study to evaluate the safety of the algorithm programmed into the *Edge*. Twelve divers did a series of ten "chamber dives". Nine of the profiles were multi-level no-decompression profiles, and the tenth required decompression. The divers were monitored with Doppler bubble detectors. In the 119 profiles completed, bubbles were detected in one diver and were the lowest grade of bubbles.[2] None of the divers showed definite signs of bends. Two divers were slightly fatigued, one had some skin itchiness (which often occurs in chamber dives) and another had slight tingling in one leg. Tingling was a condition this subject often had after diving but it was reported as it was stronger than usual. No conclusions could be drawn as to whether the manifestations of fatigue and tingling were due to decompression stress or other factors. However significantly more dives are needed to establish the risk of decompression sickness for the various schedules. For example, for each schedule a minimum of 35 dives without bends is needed before a bends rate of less than two per cent can be claimed with 95% confidence.[3]

Orca Industries report that more than 500,000 dives have been done by divers using the *Edge* (to my knowledge at the time of writing, the vast majority of these dives have not been documented or validated) and that 14 cases of bends in divers "properly" using the *Edge* had been reported to Orca and the Divers Alert Network (DAN) by the end of 1987.[4]

Uwatec, the manufacturers of the *Aladin (Guide)*, report that between 50,000 and 100,000 incident-free dives have been done using the *Aladin* (to my knowledge at the time of writing, the vast majority of these dives have not been documented or validated) by the end of October, 1987. These dives included 290 documented dives done, by a British scientific expedition, in Lake Titicaca, 3,812 m (12,580 feet) above sea-level.[5]

With well over half a million apparently safe dives carried out by computer-users, it might appear that the computers are indeed safe devices. However, as with tables, it is difficult to determine whether it is the computers themselves that are safe, or if the apparent safety lies in how divers are using them and the type of dives that they are normally using them on. Since most of the 500,000 plus dives were undocumented, it is not known whether or not the divers dived to the limits given by their computers. If the units are not dived to their limits then we still do not know how safe the actual limits are. This is especially relevant to multi-level and repetitive dives.

More than 200 divers were treated for bends in Australasia in 1987. The vast majority of cases displayed neurological effects. These cases often arose after dives, often repetitive dives, that were conducted in accordance, and at times well within, conventional tables. Some had done a multi-level dive but had surfaced within the no-decompression limits specified by the table for the maximum depth.[6]

With such a high incidence of bends when diving within conventional limits, some fear that more cases might be expected to occur when the limits are extended, especially for repetitive dives. As computers become more and more common a better understanding should emerge.

By mid 1988, 79 cases of bends in divers using computers had been reported to DAN. In England in 1987, 16% (11/69) of the divers treated for bends had been using a diver computer.[7] Recent (as yet unpublished) figures from Aberdeen show a substantial bends incidence in divers who used computers for multi-day repetitive diving.

I believe that to a large extent the bends rate in dive computer users will depend on how divers dive when they use their computers, on the type of dive profile and on their rate of ascent.

It appears that a diver who ascends slowly will have less chance of getting bends, especially neurological bends, than one who ascends more rapidly. I believe that a diver should ascend no faster than about 10 m/minute when shallower than 30 m. Many computers include a warning to tell a diver when he is exceeding the recommended ascent rate. The rate varies between computers, but I believe it should roughly equate with the above recommendation. This function is a highly desirable, if not essential, function of any dive computer.

If you exceed the recommended ascent rate at any stage during a dive, especially at or near the end of a dive, reduce your dive time substantially from that given by the computer for the rest of that dive and for repetitive dives. If bubbles form as a result of the faster ascent, they will slow down out-gassing and make the times given by the computer far less realistic.

I also highly recommend that a diver goes to the maximum depth early in the dive and then gradually works shallower. If a diver begins a dive in the shallows and then progressively gets deeper and deeper before ascending to the surface, the nitrogen load in the "slower" tissues is likely to contribute more than usual to bubbles which are subsequently formed in the "fast" or "medium" tissues during or following ascent.

If you are using a dive computer I believe that you should:

Ascend slowly. Never exceed the recommended ascent rate and generally ascend at about 10 m/minute or slower.

Go to the maximum depth early in the dive and progressively and slowly work shallower. End the dive with at least five minutes at 3-6 m. *Avoid rectangular dive profiles.*

Do not dive right to the limits given by the computers. They do not cater for individual susceptibility to bends.

Avoid using the computer for deep repetitive dives, especially those with rectangular profiles (in fact avoid doing deep repetitive dives!).

In the event of a computer failure, ascend slowly to 3-6 m (nearer to 6 m if possible) and spend as much time as possible there before surfacing.

The future

It appears that dive computers are here to stay and they will develop enormously as knowledge and technology advance. The current models are based only on depth and time, but future computers might be programmed to include other variables such as degrees of individual susceptibility to bends, exertion, water temperature and delayed out-gassing due to a rapid ascent. I am told that a computer which will do the latter is currently nearing completion and I believe this to be a large step towards improving computer safety.

The ultimate computer would measure the nitrogen level within an individual diver's tissues. I have put my order in already!

Summary

Dive computers are designed to calculate the decompression requirement for the actual dive profile, rather than for the "rounded-off" profile which is used with tables.

Most current computers are programmed with an actual decompression model rather than with tables.

Computers eliminate errors in table calculations, and usually provide much more bottom time than is given by the tables.

Tables include inherent or added margins which provide a degree of safety if our body absorbs more nitrogen than predicted by the model. Computers do not include such margins as they follow the model exactly.

For single rectangular dives the computers usually give more conservative NDLs than the tables.

On a multi-level dive the computers will normally extend the allowable no-decompression bottom time far beyond that allowed by the tables.

The computers usually allow far more time for repetitive dives than is allowed by tables. This is an area of risk for the computers as is multi-day diving.

The safety of dive computers has not been determined as too few validated tests have been done to determine the bends risk associated with their use. However, this is also true for most decompression tables!

The computers generally rely on a slow ascent rate and the times given are less valid if a diver has ascended faster than recommended.

Computers can and do fail and the diver must have an appropriate back-up procedure.

If using a computer it is important to:

Go to depth early and then work shallower throughout the dive. Ascend at the appropriate rate. Do not dive right to the limits. Allow for predisposing factors of bends. End all dives with a few minutes at 3-6 m.

For multi-day diving rest every third day.

The above article is taken from a book relating to various aspects of diving which John Lippmann is currently finalising for publication in 1989. No part of this article may be reproduced without the prior consent of the author.

REFERENCES

1. Edmonds, C., "Bendomatic Decompression Meters". *SCUBA Diver*; October 1987: 22-27.

2. Huggins, "Microprocessor Applications to Multi-Level Air Decompression Problems". *Michigan Sea Grant College Program Report No. MICHU-SG-87-201*. Michigan Sea Grant Publications; 1987.

3. Shields, T., "Re-trial at sea of 70 and 80 metre 15 minute Trimix decompression schedules", *AMTE(E) R82-409*; 1982.

4. Barshinger, C., "Decompression Computers". Skin Diver; 1988; 37(2): 32.

5. Buehlmann, A., "Diving At Altitude and Flying After Diving", UHMS Symposium, The Physiological Basis of Decompression, Duke University Medical Centre, 1987.

6. Gorman, D. and Parsons, D., "Decompression Meters - Philosophical and Other Objections". *SPUMS J* . 1987; 17(3): 119.

7. Shaw, D., "NDC Diving Incidents Report". *Proceedings of Diving Officers Conference*. BSAC, London, 1987.

Other Sources

Chadwell, C., "Multi-Level Diving - Instructor Guide". Sea Quest, California, 1988.

Divers Alert Network, "Preliminary Report on Diving Accidents". Divers Alert Network, 1988.

Douglas, D., "Time to reflect on diving in the computer age". *Diver;* 1987, 32(7): 5.

Edmonds, C. and Anderson, T., "Assessment of the Orca EDGE Dive Computer". SPUMS J;. 1987; 17 (3): 119-127.

Ellerby, D., "Decompression Computers - Their Use". P*roceedings of Diving Officer's Conference.*. BSAC, London, 1987.

Ellerby, D., "Decompression - BC and AC". NDC B*ulletin*. 1987; 11: 1-3.

Ellerby, D., "Budget Brain". Div*er*. 1987; 32(7): 24-25.

Ellerby, D. and Todd, M., "Which Dive Computer?" Dive*r*. 1988; 33(3): 15-17.

Fulton, J., "Orca Industries stands by its EDGE". *SCUBA Diver*. October 1987: 22-27.

Graver, D., "Electronic Dive Monitors" NAUI *News*. May 1988: 33-37.

Huggins, K., and Somers, L., "Mathematical Evaluation of Multi-Level Diving". *Report No. MICHU-SG-81-207*. Michigan Sea Grant Publications. 1981.

Huggins, K., "Doppler Evaluation of Multi-Level Diving Profiles". *Report No. MICHU-SG-84-300.* Michigan Sea Grant Publications. 1983.

Huggins, K., "Multi-Level Diving, How Safe Is It?". Proceedings of International Conference on Underwater Education,. I.Q. 85, NAUI, California. 1985.

Huggins, K., "History of Decompression Devices". NAUI News;. May 1988: 22-30.

Huggins, K., "History of Decompression Devices - Part 2". *NAUI News*. July 1988: 49-51.

Murphy, G., "The SME-ML". *Skin Diver*. 1987; 36(6): 37.

Murphy, G., "Datamaster 2". Ski*n Diver*. 1987; 36(7): 101.

Murphy, G., "The GUIDE". Skin Div*er.* 1987; 36(8): 57.

Murphy, G., "Skinnydipper". *Skin Diver.* 1987; 36 (9): 56.

Murphey, M., "Subaquatic Computers Compared". *NAUI News.* May 1988: 31-32.

West, D. and Edmonds, C., "Evaluation of the Farallon Decompression Meter". RAM SUM Report. 1976; 1.

Personal Correspondence

Bennett, P., Personal Correspondence, 1988.

Buehlmann, A., Personal Correspondence, 1987, 1988.

Hahn, M., Personal Correspondence, 1988.

Hermann, J., Personal Correspondence, 1988.

Huggins, K., Personal Correspondences, 1987, 1988.

Moody, M., Personal Correspondence, 1988.

Nikkola, A., Personal Correspondence, 1987.

Vollm, E., Personal Correspondence, 1987.

John Lippmann's address is P.O.Box 381, Carnegie, Victoria 3163, Australia.

BUOYANCY AND UNNECESSARY DIVING RELATED DEATHS

Wong Ted Min

Introduction

Man emerged from the prehistoric seas 350 million years ago. Throughout the ages, he still found it necessary to return to the sea and dive for subsistence, for recreation or out of curiosity. The early dives have been limited by his inability to remain underwater for long, a skill which he had lost an aeon ago when he traded his gills for air breathing lungs.

In the attempt to prolong his endurance underwater, various techniques of prolonging the air supply have been tried. Diving bells, helmets, surface supply equipment and various contraptions have been used but all of them required manpower and large unwidely equipment. It was not until 1943 when Jacques-Yves Cousteau and Emile Gagnan developed the modern demand intake valve that the sport of scuba diving became assessible to the general public.

Today, there are dozens of diving organisations and even more diving schools all over the world teaching the more adventurous the skills of scuba diving. With the exception of some of the more dubious characters conducting the 1-day "Introduction-type" diving courses, most reputable dive organisations have a reasonably comprehensive diving course. There are many books available which give the potential divers information on the dangers of decompression sickness, air embolism, barotrauma, nitrogen narcosis, hypothermia and dangerous marine animals. Often, diving techniques, buddy breathing, emergency ascent drills and basic resuscitation are included.

It is therefore of great concern that many divers still die every year of problems related to scuba equipment. Many of these divers have little or no previous experience with scuba equipment and are totally ignorant of safety procedures.

Diving Related Deaths

A study of the statistics on diving fatalities have revealed that in New Zealand in 1983, five out of six scuba-related deaths involved inexperienced or untrained divers. All these six dead divers were found with their weight belts on, although they might have survived if the weight belts had been removed. Three deaths can be directly attributed to poor buoyancy control and being overweighted at depth[1].

In 1985, ten diving related deaths occurred in Australia[2]. Five out of these ten were untrained or newly trained divers. Of the newly trained divers, two deaths occurred due to problems with buoyancy compensators (BCs) and another two had medical conditions which should have rendered them unfit for diving.

The statistics for diving fatalities from the United States National Underwater Accident Data Centre (NUADC) between 1970 and 1982 revealed that 42.5% of diving fatalities occurred during the first few dives[3]. Investigations revealed that in 80-90% of these cases the weight belts were not removed by the victims and this may be a major contributory factor to the fatalities[4]. A large proportion of these deaths were reported to be due to drowning or asphyxiation (about 65%), which should not have occurred if there had been a good understanding of the principles of buoyancy. The San Diego City Lifeguard Service published statistics for the period between January 1975 and June 1975 which revealed that only twelve weightbelts had been abandoned, in seven hundred and seventeen diver rescues, prior to the lifeguard arriving at the scene[5].

These deaths are largely preventable. Although most aspects of diving are taught in diving courses and information is easily obtainable in many diving manuals, an area which does not have sufficient practical information is the topic of buoyancy. The US Navy and the RN Diving manuals as well as several other dive manuals explain aspects of positive, neutral and negative buoyancy and Archimedes' Principle. However, the practical implications of the actual amount of buoyancy lost at depth by a wetsuited diver have not been discussed, nor has the ineffectiveness of BCs at low tank pressures at depth been explained.

This information is important for all divers, especially novices. When diving deep for the first time, the novice may find it impossible to overcome the negative buoyancy due to wetsuit compression. This can lead to a situation where the diver is unable to swim back to the surface, unless the weight belt is dropped. This problem was recently illustrated in a tragic accident, where a prominent barrister was drowned.

CASE REPORT

This sport diver was a forty year old man. He was 20% overweight for his age and height. Prior to his death he had only done eight previous dives, all conducted by his diving school. Most of the dives were between 4 to 12 m (15 and 40 feet), with only one dive to 24 m (80 feet) for 5 minutes. This 24 m dive, according to the diving instructor, was to "check" if the victim was susceptible to nitrogen narcosis.

With only the experience of these 8 shallow dives, the victim and his buddy decided to explore a famous wreck, the "Anne Miller", which lies in 42 metres (140 feet) of water off Sydney. Both men used identical equipment, 7 mm wetsuits and weight belts of 14-16 kg (32-36 lbs). They dived to the wreck and spent 7 minutes looking around. At the end of 7 minutes, they had reached the red sector of their pressure gauge and they decided to ascend. By this time, the ascent line was nowhere to be found. Two minutes were spent on looking for the line and by this time, both had reached the limits of their air supply and were forced to begin their ascent. The buddy inflated his BC and began to ascend, venting his BC as the ascent became more rapid. The men became separated and the victim failed to surface. The buddy, on the other hand, ascended uncontrollably, and ran out of air before breaking the surface. On surfacing, the buddy was found to be in a confused state by his rescuers. He was rescued by the dive boat but the victim never surfaced. Later, the victim was found near the wreck in 42 metres of water. The search divers were unable to raise the body by inflating the BC. It was only wehn the weight belt was released that the body was noted to ascend rapidly to the surface.

A number of mistakes were made by these divers:-

a The victim was inexperienced at deep diving, having only done 8 previous dives, mostly at a shallow depth. The effects of nitrogen narcosis during his last dive, would certainly have clouded his ability to assess the situation, ditch his weight belt and activate his BC.

b There was a gross miscalculation of the amount of weight required to overcome the buoyancy of the wetsuit on the surface. With the descent to 140 feet, the amount of buoyancy in the wetsuit would have been reduced to less than one-fifth the surface buoyancy (by Boyle's Law). This reduction in buoyancy plus the excessive weight carried prevented the diver from surfacing even wit hthe BC inflated as described by those who recovered the body.

c The dive was not properly planned. The divers spent too much time looking for the ascent line, thus consuming the remaining air in their tanks.

d Separation of the divers occurred during the ascent.

e The victim did not drop his weight belt, despite being grossly overweight and facing the prospect of running out of air.

The death of this diver was most certainly preventable if he had gained more experience in deep diving. He should have gradually increased the depth of his dives, a procedure which will gradually enable him to experience the effects of nitrogen narcosis. This may have allowed him to achieve greater awareness of the reduced mental and motor coordination, and thus enabled him to voluntarily restrict his depth.

Neither diver should have dived until he ran out of air, especially at such depths, when the rate of air consumption is very rapid. If they had completed their dive earlier, then they would have had enough air to ascend comfortably and overcome other problems which might arise. The victim's BC should have been properly inflated if he had adequate air in his tank. There was certainly no reason for both divers to wear 32-36 lbs (14-16 kg) of weight under these circumstances and it showed clearly that both men did not consider the effects of proper buoyancy control.

Proper Buoyancy Control

Buoyancy was first defined by the Greek mathematician, Archimedes, who established that any object wholly or partly immersed in a fluid is buoyed up by a force equal to the weight of the fluid displaced by the object.

The buoyancy of any object is determined by its density and that of the liquid it is immersed in. The buoyancy of a diver is determined by his density and the equipment he wears. This buoyancy varies with time, as air is being consumed from the tanks, and with depth, when the volume of the wetsuit and of the air in the BC will vary according to Boyle's Law.

THE COMPONENTS OF BUOYANCY

Davey and Williams[6] found that sixteen of ninety-six college males were unable to float even with a full inspiration. Seventeen of one hundred and ten teenagers, of both sexes, were also similarly found to sink even at full inspiration. Tests done by Behnke et. al.[7] in 1942 showed that the specific gravity (SG) of normal males between 20 to 40 years fell between 1.021 and 1.097. Osserman et. al.[8] reported a somewhat similar range between 1.022 and 1.100 (with a mean of 1.068) and Howell, Moncrieff and Morford[9] had values of SG between 1.022 to 1.110 (a mean of 1.061) in 133 unselected male subjects. These values were corrected for residual lung volumes. In real terms, most people are positively buoyant at full inspiration and only 10.6% of subjects exceeded 1.000[9].

Behnke's subjects had a mean SG from 1.049-1.058 at full expiration and 0.990-0.998 at full inspiration. At full expiration, all would exceed an SG of 1.000, and so are negatively buoyant in fresh water. Only a few would remain positively buoyant in seawater (SG 1.025) at full expiration.

For a buoyant diver to descend, his buoyancy should be adjusted so that he is neutrally buoyant at the surface at full inspiration, with his eyes at the water level. Initially, the diver should put on his wetsuit and his tank, and the weight belt with what he assumes is adequate weight. He should then enter the water and see where he floats. If he is positively buoyant additional weights will have to be added to the weightbelt so that neutral buoyancy is achieved and vice versa. When weighted in this manner, remaining afloat will require only a minimal effort. If necessary, the weight belt and tanks can be ditched to give added buoyancy so that the diver can remain afloat indefinitely with the aid of his wet suit and BC.

To descend, the diver initially exhales, thus reducing his buoyancy. At this stage, he will start to descend, which may be aided by finning. With the compression of his wetsuit, the diver becomes progressively more negatively buoyant. An alternative method is to follow the anchor line of a boat down, pulling oneself downwards for the first few metres until wetsuit compression allows further descent without any further effort.

A diver wearing a wetsuit should normally put on an equivalent amount of weight to neutralise the buoyancy exerted by the wetsuit. This will pose possible problems when the diver proceeds to dive to a depth where there is compression of the bubbles trapped in the neoprene. He will experience a progressive increase in negative buoyancy. As the density of the soft rubber in neoprene is 1.1, almost all the upthrust provided by the wetsuit is provided by the air trapped in the neoprene. The air in the neoprene becomes progressively compressed at depth with the resultant fall of buoyancy. (Table 2.)

TABLE 1

BUOYANCY OF DIFFERENT TYPES OF WETSUITS

Type of Wetsuit	Dry Weight	Buoyancy
Civilian 3 mm	1.136	1.081 kg
Civilian 5 mm long johns	2.381	4.776 kg
Civilian 5 mm full suit	3.017	5.341 kg
RAN 7 mm full suit	2.910	7.410 kg

TABLE 2

BUOYANCY OF WETSUITS AT DEPTH

Type of Wetsuit	Buoyancy of Wetsuit at Depth (kg)				
	Surface	10 M	20 M	30 M	40 M
Civilian 3 mm	1.1	0.6	0.4	0.3	0.25
Civilian 5 mm long johns	4.8	2.4	1.6	1.2	0.96
Civilian 5 mm full suit	5.3	2.7	1.8	1.3	1.06
RAN 7 mm full suit	7.4	3.7	2.5	1.9	1.5

THE WETSUIT

A wetsuit is commonly worn by divers for thermal production. It is made of closed cell neoprene rubber to which two layers of synthetic fabric are usually bonded. The thickness, and therefore buoyancy, varies between 3 mm to 1.2 cm. The commonest wetsuits in use are 3, 5 and 7 mm in thickness. Thermal protection is afforded by the insulating layer of air trapped inside the neoprene. Different wetsuits have different buoyancies at the surface and these values also change with depth.

Four different types of wetsuits were tested in a saltwater pool to evaluate the amount of postiive buoyancy each exerted at the surface. The results are in Table 1.

A neutrally buoyant person diving with a 7 mm full suit will have to weigh himself down with 7.4 kg of weight on the surface. The actual weight required is slightly less than the calculated value as the scuba tanks are somewhat negatively buoyant. The diver's buoyancy at 40 metres will be one-fifth of 7.4 kg or 1.48 kg. He will be therefore overweighted by 5.92 kg. In the case of the barrister, he started off overweighted by about 8.5 kg. At the depth of 42 metres (140 feet), he would have been overweighted by (8.5 + 5.9) kg which is 14.4 kg (31.68 lbs)! This accounted for the fact that the rescuers were unable to raise the body until the weight belt was released.

Besides alteration of buoyancy at depth, wetsuits also limit the mobility of the diver. Mobility is important because if a diver is restricted in his range of movement, he may not be able to reach for the various buckles, straps and power inflators in order to save himself in an emergency. This ergonomic factor was previously studied by Egstrom et. al.10. In a comparison of three wetsuit configurations, he found significant differences in the loss of range of motion with wetsuit design, zipper placement and the type of material used. In some wetsuits, as much as 95 degrees of motion are lost.

A comprehensive analysis by Kise[11] in 1977 showed that a diver wearing a swimsuit, tank and a backpack with a deflated flotation vest had losses in range of motion of 17% for hip extension, 20% for trunk extension and 21% for trunk rotation. With a wetsuit, this diver would have lost another 43% of trunk rotation, 34% of trunk extension, 31% of hip extension and nearly 31% of neck movement. Thus the effects of reduced mobility must always be borne in mind. It is vitally important that all straps, release buckles, reserve levers, and emergency air bottles should not shift during the dive and that they are within easy reach.

WEIGHT BELTS

Weight belts have been introduced to counter the effects of positive buoyancy. More weights are required for thicker wetsuits and the risks increase proportionally. Weight belts frequently rotate during dives making them inaccessible to the diver or his buddy. Weight belts may be trapped by tank straps, leg knives, crotch straps so that if the buckle were released, the weights fail to fall away cleanly. Egstrom1[2] performed a number of tests with wetsuited mannikins to demonstrate how easily or not, weight belts fall from the diver. He found that no weight belts fell off when a wetsuited mannikin was placed between 30 to 90 degrees from the vertical. Between 10 and 30 degrees, most belts did not drop clear, owing to friction between the suit and belt material. This was largely caused by weight placement and/or failure of the buckle to completely release the belt. He also found that to drop the release belt by rolling, it was necessary to roll between 100 and 120 degrees from the horizontal. Release tensions for buckles varied from 0.7 to 7 kg of force depending on the tension of the belt.

BUOYANCY DEVICES

Buoyancy compensators have been introduced to enable the diver to adjust his buoyancy irrespective of depth. They come in various configurations and generate different amounts of lift, varying from 5 kg to 25 kg, proportional to the internal volume of the BC.

The basic BC consists of an oral inflation valve as a basic inflation system and a power inflation system of either a CO_2 cartridge or an inflation hose connected to the first stage of a regulator or to a small auxiliary air tank. The safest BCs are those with auxiliary air tanks as they provide a spare supply of air independent of the main breathing tanks. These small cylinders hold a larger volume of gas than the CO_2 devices, and are more reliable in service. The main drawback of the auxiliary air tank is the price. Power-inflators connected to the main tanks obviously have the advantage of reduced bulk but they cannot be relied upon to inflate the BC rapidly when the tank pressure is low. Having a power-inflator without an additional backup air supply is dangerous especially in an emergency. It is noteworthy that the British Sub-Aqua Club (BS-AC) strongly recommends the use of an independent air source for the BC. Few people nowadays depend solely on the CO_2 cartridge because of the poor reliability of the firing mechanism.

SCUBA TANKS

Scuba tanks have a negative buoyancy of 1 kg to 7 kg in water, depending on the configuration. There is a slight increase of the scuba tank buoyancy as air becomes consumed by the diver during the dive. The reduction of buoyancy in a 70 litre steel tank is about 3 kg. Hence, the scuba tanks do play a role in determining the buoyancy of a diver.

A more important practical factor, however, is the ability and speed in which a tank at its "reserve" pressure fills up a BC at various depths. In an experiment performed in a recompression chamber, the speed of inflation of a BC was tested. The tank used had a pressure of 35 bars gauge, which is the point where most divers begin to start their ascent to surface. The tests revealed that it required 46 seconds for the BC to inflate maximally at a depth of 30 metres. It was not possible to inflate the vest maximally whilst simultaneously respiring from the regulator at this reserve pressure, as the tank was emptied before completion of inflation. A carbon dioxide cartridge was also discharged into an empty vest at 30 metres to assess the degree of BC inflation. The amount of gas contained in the CO_2 cartridge was not enough to inflate the vest maximally at this depth.

The findings (Table 3) showed that it required about 57 seconds to inflate a BC at 30 msw with a power-inflator. It was not possible to completely inflate the BC at 30 msw if a diver continued to breathe from the regulator during the inflation. Secondly, a CO_2 cartridge recommended for this particular vest did not supply enough gas for an emergency ascent as the vest did not fill up adequately. Thirdly, if a diver had been negatively buoyant at depth, the BC will not likely overcome the negative buoyancy unless the weight belt was dropped.

Naturally, should the diver begin to ascend after ditching the weights and adequately inflating his BC, the rate of ascent will increase as the air in the BC expands. The ascent rate must therefore be controlled. The recommended rate of ascent is generally 18 msw a minute, but a rate as slow as this is usually difficult to achive in practice. Divers have been taught to follow the "smallest bubbles", but these bubbles gradually expand and accelerate with ascent. Therefore, divers must be taught to consciously look for new "smallest bubbles" during ascent, in order to minimise the risks of pulmonary barotrauma and air embolism. With an inflated BC at depth, the best way to control ascent speed is to continuously but gradually vent the BC during ascent. This avoids the pitfall of overventing the BC, which reduces

TABLE 3

TIME REQUIRED FOR INFLATION OF BC AT DEPTH WITH A POWER INFLATOR ATTACHED TO A TANK AT RESERVE PRESSURE

Depth (metres sea water (msw))	**0**	**10**	**20**	**30**	**40**
Duration of BC Inflation without simultaneous respiration (seconds)	12	25	39	57	78
Duration of BC Inflation with respiration at 15 breaths a minute (seconds)	18	40	(50)*	**	**

* Unable to fully inflate BC before tank emptied

** Tank emptied before adequate inflation of BC

its buoyancy resulting in the diver sinking, following the initial ascent.

Another technique which the diver may use to reduce his rate of ascent is to increase the drag on his movement by presenting a large surface area to the vertical plane of movement. This may be achieved by spreading his arms and extending his body backwards in a horizontal manner.

For these manoeuvres to be successful, divers should begin their ascent before they run out of air. It is extremely difficult to ascent properly with an empty tank as then the BC cannot be inflated. The hypoxic diver will find it nearly impossible to remove his weight belt and his chances of a successful ascent are exceedingly slim. The tragic consequence of this is death.

DIVER ENDURANCE

An experienced swimmer attempting to keep afloat on the surface, can usually keep his head above water for a fairly long time (exceeding 15 minutes). This ability allows rescuers sufficient time to reach him, for example, after falling overboard. This contrasts significantly with the time an overweighted diver can achieve. In a pool test, 3 male swimmers were made to keep their heads out of the water, while wearing a 5.47 kg weight belt (equivalent to 4.818 kg of submerged weight). The duration in which the swimmers were able to remain afloat was between 2 minutes 15 seconds and 6 minutes 21 seconds. Thus, when theire is a failure of his flotation device, an overweighted diver will not be able to remain afloat for very long.

Discussion

By looking at the causes of diving fatalities, common patterns are seen. Nearly all diving fatalities are preventable. The case report presented earlier illustrated that inexperience and miscalculations result in diving fatalities. Panic is a common denominator in almost all diving fatalities. It precedes the phase where consciousness is lost and the diver drowns. A proficient diver will not allow himself to reach the point of panic. The diver must concentrate on his equipment, air-supply, degree of buoyancy, onset of early narcosis, in order to take preventive measures.

A proper pre-dive assessment of the environmental conditions, limitations of equipment and personal endurance is necessary. Diving in foul weather, rough surf and extremes of cold should only be undertaken if adequate justifications prevail and precautions are taken.

Equipment limitations should be realised, especially at depth and when the air supply becomes low. Regulators generally require more effort to breathe from at low tank pressures. The BC requires proper training to maximise its effectiveness. Obviously, it will not perform its role if CO_2 cartridges are not installed, or if the power inflator hose is not connected. BCs are prone to degradation and leak when exposed to the sun and they require proper handling, maintenance and storage. They do not inflate enough to provide adequate lift at depth with the CO_2 cartridges. At low tank pressures in 30 msw, the power inflator attached to the low pressure port takes almost 1 minute to inflate a BC to its maximum capacity. In this situation, if air is continually utilised by the diver, the tank becomes empty before the BC achieves adequate inflation. Divers should be neutrally buoyant during all phases of their dive, unless they require to be negatively weighted in order to remove abalone or other embedded objects. In this situation, the diver should always be prepared, and able, to jettison the excess weights immediately should the need arise.

Wet suits become progressively compressed at depth and are, therefore, less buoyant. The thicker the wetsuit material, the more weight one requires to put on at the surface to counteract the buoyancy. This excess weight increases as one descends, and it may not be possible for the overweighted diver to ascend from depth.

Dropping the weight belt at depth results in an immediate positive buoyancy to the diver, which may enable him to ascend to the surface. Divers must be taught that at the hint of the slightest emergency, the weight belt should be unlatched and held at arm's length. In this way, should the crisis pass, the weight belt may be put on again. If the diver passes out, the weight belt will then fall out of his hands and the unconscious diver has a chance of being rescued. In addition, he is more likely to float to the surface unaided where his chances of rescue are far greater than if he should remain submerged.

Untrained divers should not be allowed to dive, unless doing a proper instructional course. Inexperienced divers must not attempt to exceed their own limits, until more dives have been logged. No one with a scuba certificate must agree to rent scuba equipment for his untrained friend. Diving should be treated as a dangerous sport. There are many instances where a diver finds himself in potential difficulties. A novice diver will be hopelessly lost with the amount of gear, hoses, gauges and buckles that make up the equipment used in scuba. All it takes is a simple mistake, a lack of understanding or inexperience to cause a loss of life. A person making a mistake or suffering an asthmatic attack or an epileptic fit on land does not drown. A similar misfortune occurring whilst diving inevitably leads to drowning and death.

Acknowledgements

I wish to thank Dr Carl Edmonds, who was instrumental in encouraging me to embark on this project, and Mr John Pennefather who provided information about some of the technical aspects of the various experiments carried out.

References

1 Walker D. New Zealand diving deaths 1983, *SPUMS J*. 1984, Vol. 14, July-Sept, 5-7.

2 Walker D. Provisional report on Australian diving-related fatalities, 1985. *SPUMS J*. 1986, Vol. 16, 35-43.

3 Anon. Why divers die: Part 1. An analysis from the University of Rhode Island. *Undercurrent*, June 1985, Vol. 10, No. 6, 10-12.

4 Schinck Hilbert V. and McAnniff John J. United States underwater fatality statistics, 1973. NOAA Grant No. 4-3-158-31, Univ. of Rhode Island, May 1975.

5 Bruton Al and Fead Lou. The lifeguard's headache. Proceedings of the Seventh International Conference on Underwater Education, Sept. 26-28, 1975, NAUI, Colton, California.

6 Davey W. and Williams B. The centre of gravity in the human body in relation to floatation. Unpublished study undertaken as a part of the Supplementary Teacher's Certificate and Diploma Course, Loughborough Training College, 1955-56.

7 Behnke A.R, Feen B.G, and Welham W.C. The specific gravity of healthy men. *J. Amer. Med. Assoc*. 1942. 118: 495-98; February 14.

8 Osserman E.F, Pitts G.C, Welham W.C. and Behnke A.R. In vivo measurement of body fat and body water in a group of normal men. *J. Appl. Physiology* 1950. 2: 633-40.

9 Howell M.l , Moncrieff J. and Morford W.R. Relationship Between Human Buoyancy Measures, Specific Gravity, and Estimated Body Fat in Adult Males. *The Research Quarterly*, Vol. 33, No. 3. pp. 400-405.

10 Egstrom G.H, Hager C.L, Cooley J, Walker D, and Kise B. Comparative Mobility in various Dry Suits. UCLA Report N61331-76-M-4166, (1976).

11 Kise B.J. Anthropometric Analysis of the Restrictions in Scuba Device Mobility. Master's Thesis. (1977). Los Angeles, Univ. of California, Dept. of Kinesiology.

12 Egstrom G.H. Diving Accidents, In *Diving Medicine*. ED. R. STRAUSS, (1976), New York, Grune & Stratton.

Dr Wong Ted Min's address is Naval Diving and Hyperbaric Medical Centre, Sembawang Road, Singapore 2775, Republic of Singapore.

BLEOMYCIN
A RARE ABSOLUTE CONTRAINDICATION TO DIVING

John Knight

In the August 20-27th issue of the British Medical Journal there was a leading article on the rising incidence of decompression sickness in the UK[1]. A follow-up letter[2] drew attention to an absolute contraindication to diving that most people are not aware of.

Bleomycin is an anti-cancer agent which has among its effects the sensitisation of the lung to raised oxygen partial pressures. Bleomycin causes lung damage, which governs how much of the drug can be used in treatment. Mostly the damage resolves with the passage of time. But sensitisation to raised partial pressures of oxygen is long lasting. Deaths from pulmonary fibrosis have occurred after anaesthesia, where increased partial pressures of oxygen are normally used. Anaesthetists know that patients who have had Bleomycin should never be exposed to more than 0.3 ATA of oxygen, and preferably less.

Why should diving doctors worry about Bleomycin? Bleomycin is often used for the treatment of testicular teratomas. These tumours occur in the age group who dive and after successful treatment the diver may wish to return to diving. If he does he will be at risk of developing pulmonary fibrosis if he breathes an oxygen partial pressure of more than 0.3 ATA. Using compressed air, 0.3 ATA partial pressure of oxygen is reached at a depth of just over 4 m!

Obviously anyone who dives should give up diving after treatment with Bleomycin. It is an indictment of our compartmentalised thinking that I, an anaesthetist who has known for years of the danger of giving higher than normal partial pressures of oxygen to people who have had Bleomycin, never moved this information sideways into my diving medicine memory banks. I am grateful to Drs Hamilton, Williams and Wilmshurst for pointing out the relationship to diving.

REFERENCES

1. Sykes, J.J.W., Pearson, R.R., and Edmonstone, W.M. The Bends. *Brit. Med. J.* 1988, 297, 509.

2. Hamilton, D., Williams, M. and Wilmshurst, P. The Bends. *Brit. Med. J.* 1988, 297, 793.

Dr John Knight's address is 80 Wellington Parade, East Melbourne, Victoria 3002, Australia.

ANONYMOUS REPORTING OF DIVING INCIDENTS: A PILOT STUDY

Chris Acott, Allan Sutherland and John Williamson

Abstract

Current recreational diving safety practices in Australia and New Zealand leave much room for improvement. Incidents with the potential to reduce safety in diving are constantly occurring, and the vast majority result in no harm to anyone. Based upon techniques in current and successful use in civil aviation and anaesthesia practice, we suggest that the recreational diving industry should adopt an on-going, bi-national, Diving Incident Monitoring Study (DIMS), with the aim of improving sport diving safety and training standards. The proposed study could usefully supplement the existing morbidity and mortality data collection that is the present province of "Project Stickybeak". The results of such an incident study, conducted during the 1988 Annual Scientific Meeting of SPUMS, at Mana Island in Fiji, are presented and illustrate the power of this voluntary incident reporting technique for the objective identification of recurring human errors in sport diving practice. Analysis of the 65 reported incidents revealed unsatisfactory diving safety standards among medically qualified divers who might be considered to be safety leaders in the sport! Fifty-five per cent of the potentially harmful incidents occurred during the dive itself, but a quarter occurred during preparation for the diving. An important advantage of the incident analysis technique is its ability to suggest corrective strategies (specific improvements in training, practice, supervision and equipment design), which are directed effectively against the most commonly occurring and recurring hazards and errors among sport divers in Australia and New Zealand.

Introduction

Unsatisfactory safety standards in the practice and supervision of recreational scuba diving in Australia, and other countries, are shown by the steadily increasing clinical work load of Hyperbaric Medical Units[1], by regular medical publications[2,3], and also by a plethora of popular press reports, albeit some of the latter are sensationalised and ill-informed. Any considered effort to improve this state of affairs warrants attention and trial. A method is presented of incident reporting and analysis the efficacy of which for safety improvement has been established in civil aviation[4] worldwide, and which is directly applicable to sport scuba diving. The same technique is also currently being applied, with exciting early promise in human medicine, to improving the safety of anaesthesia[3,4].

Such constantly recurring errors during the supervision and practice of anaesthesia lie at the heart of most (at least 80%5,6) of the accidents that happen. The same is probably true of recreational diving and the analysis of such errors enables the recognition of the more common patterns, e.g. inadequate buoyancy control, and the development of *effective* corrective strategies, e.g. improvements in the design of buoyancy control devices (BCD) and weight belts, and in the training for, and practice with their use during diving.

The reporting and analysis of scuba diving "incidents" is quite simply a method of analysis of human error! Divers, just like the rest of the human race, err constantly and naturally, despite their repeated attempts (again just like the rest of the human race) to deny the fact! As a British aviation psychologist has so eloquently put it[7] ".. all human beings, without any exception whatever, make errors and .... such errors are a completely normal and necessary part of human cognitive function."

The interesting aspect of this aproach to safety improvement is that it is all "old hat". This error analysis technique, originally called the Critical Incident Technique, was invented by Flanagan in the 1940s for application to United States military aviation[8] and even then he was acting upon a suggestion from Britain in the 19th century[8]. As a technique for safety improvement it works, but it will depend for its success in the diving upon the *voluntary* participation of all recreational divers and instructors.

An initial pilot study of such diving incident reporting was conducted by us at the recent Annual Scientific Meeting (ASM) of SPUMS at Mana Island in Fiji. About 50 divers (most with medical qualifications) dived from small boats, once or twice a day, over a period of 6 days. Fourteen of these divers voluntarily reported a total of 69 incidents.

Methods

The proposed study was introduced to those attending the ASM at an informal meeting. Emphasis was placed upon the potential value for such reports to improve diving safety, with the consequent benefits to everybody in diving, including the reporter him(her)self. The totally anonymous nature of the reporting was also carefully emphasised, and a prepared statement was circulated. This is reproduced as Figure 1 below.

As with the introduction of the incident concept in other such studies6,[8], it was necessary to present a definition of just what a "diving incident" was. This definition is given in Figure 2. The intention by the authors to publish the anonymous results of this pilot study, in the SPUMS Journal, was also declared. Although the study was conducted using the reporter's own words, an existing written incident questionnaire, already in use by anaesthetists in Australia and New Zealand6, served as an illustration. This questionnaire formed the basis for a specific diving incident report form (Figure 3, page17), which we have designed for future preliminary trial among recreational divers.

The 69 incidents that were reported anonymously in writing were collected by us over the weeks following the Mana Island ASM. These were subjected to detailed analysis along the now well established lines developed by the pre-existing aviation and anaesthesia critical incident protocols5,6,[9,10].

FIGURE 1

DIVING INCIDENT MONITORING STUDY

This is a prospective, long-term study which asks recreational scuba divers to record, in an anonymous fashion, untoward incidents that occur to them or their companions, during diving activities. The study is an attempt to investigate the factors which predispose recreational divers to err. It is focused on the process of error, r*egardless of the final outcome of that error* (most incidents cause no harm to anyone). The study has no interest in culpability or criticism of individual divers. The study is anonymous and totally impartial, and we invite all scuba divers of all levels of experience to participate.

Filling out the brief questionnaire may at times prove tiresome, but we urge you to do it as soon as practicable following the dive. If you participate you will assist in improving the safety of diving for everyone, and you may well learn something about yourself. Thank you.

This study will form part of, and indeed is an extension of, the data that already exists in Australia and New Zealand for the study of diving safety known as "Project Stickybeak".

FIGURE 2

DEFINITION OF A DIVING INCIDENT

1. An error by a diver, or a failure of his or her equipment to function properly.

2. The error or failure could have led to more serious consequences, had it not been detected or corrected in time.

3. It was an error by yourself, or one which you witnessed di*rectly.*

4. It occurred during the dive, or associated preparation and/or exit and recovery time.

5. It was clearly preventable or avoidable.

Results

Fourteen divers reported 69 incidents. These are detailed in Figure 4 on page17.

Associated Negative Factors[5]

(i.e. factors considered by some of the respective reporters as predisposing to the occurrence of their incident.)

1. Strong current
2. Inadequate safety line facilities (i.e. absent, too short)
3. Poor equipment maintenance
4. Absence of learned or written check protocols (e.g. gear check list, lost contact drill)
5. Too much equipment carried during the dive
6. Lack of familiarity with the dive site by dive leaders
7. Failure by dive leaders to match the dive site to the experience levels of divers present
8. Concealment by individual divers of inexperience with conditions at the dive site (e.g. ocean swell, boat diving)

FIGURE 3

SCUBA DIVING INCIDENT REPORT FORM (Mark 1)

1. Describe in your own words the incident you wish to report.

2. Whose incident/error was it?
Yours? Your buddy's? Someone else's?

3. When was it detected?
Preparation? Entry? Descent?
During Dive? Ascent? Exit?
Following entry?

4. Who first detected it?
You? Your buddy? Someone else**?**
Who? ———————— (no names)

5. What action was taken to deal with the problem?

6. Who took this action? (no names)

7. What influence did it have upon:-
a the dive plan?

b your state of mind?

8. Did any harm result? Yes No
Specify (optional):

9. What in your opinion was the basic cause of this incident?

10. What factors do you recognise as contributing to the occurrence of this incident?
(e.g. inexperience, unfit, etc.)

11. How many dives have you performed in your diving career to date?

12. Did your diving training:-
a) make you aware of the potential for this incident to happen? Yes No
b teach you to deal with it? Yes No

13. Have you a suggestion as to how such an incident may be prevented from recurring, either in your hands, or any other diver's?

14. Any additional relevant comments?

FIGURE 4

INCIDENTS REPORTED

DURING PREPARATION	**15**
Forgotten gear	4
Unsafe practice	4
Faulty assembly	3
Gear breakage	2
Lost items	1
Free-flowing regulator	1
ENTRY	**5**
Air not turned on	3
Gear misplaced	1
Gear dislodged	1
DESCENT	**7**
Underweighting	4
Equalisation failure	2
Snorkel in mouth	1
THE DIVE	**36**
Equipment misuse/misassembly	6
Equipment fault	4
(Maximum Depth Indicator faults = 3)	
Lost buddy contact	4
Lost diver (temporarily)	4
Out of air	3
Equipment dropped	3
Buoyancy control loss	3
Coral abrasions	3
Overweighting	2
Vision intereference (mask)	2
Unsafe practice (tables)	2
ASCENT	**4**
No reference point	4
(boat, Jesus/shot lines unseen)	
EXIT	**2**
Dropped Weight	1
Inadequate buoyancy control	1
TOTAL INCIDENTS	**69**

Associated Positive Factors[6]

(i.e. factors considered to contribute to the earlier detection and correction of some incidents.)

1. Carrying spare equipment
2. Carrying emergency safety gear
3. Carrying written gear check lists
4. Experience and patience

Discussion

ANALYSIS OF THE PILOT STUDY RESULTS

Equipment problems predominated in this relatively small series of diving incidents, either absence, misassembly, misuse, failure, or excessive amounts of it. Maximum depth indicator failures stood out. More emphasis on predive checking and calibrating of these devices should occur. Failure to connect the scuba-feed to the buoyancy compensator during preparation was also notable. This is an omission which threatens buoyancy control and the success of any rescue techniques! Diving is an equipment orientated sport, and it seems necessary to keep emphasising that good maintenance and regular familiarisation with one's own, and one's buddy's equipment, is fundamental for safe diving.

Buoyancy problems were prominent, and are always a threat to divers' safety. Allied to this, familiarity with, and the ability to test for, correct weighting were clearly lacking among some. Uncontrolled or unplanned alterations in depth carry most serious potential consequences[2].

It is distressing that absence or failure of air supply also feature in these reports. It is clearly not a rare event in recreational diving, despite the emphasis given in most reputable training programmes to turning on the cylinder before entering the water and to checking one's contents gauge regularly. Further research into these dangerous habits among recreational divers is warranted.

It is also embarrassing to report the high incidence of clearly unsafe practices among this so-called informed group of recreational divers! Loss of buddy contact, ascent beyond the reach of the "Jesus line", perching on the edge of the dive boat at sea with weight belt on, but no buoyancy device, diving beyond so called "no-decompression-limits", or without a timing device, or when not completely well, are all invitations to trouble. A prominent Australian diving medical physician was startled to see one of his dive party happily self-administering several puffs of salbutamol prior to entry! Lost contact drill is tending to become a forgotten protocol. All dive leaders must formally rehearse this protocol with all divers, prior to commencement of divng.

Despite the accepted medical importance of "slow, careful ascents" in the prevention of both decompression sickness and cerebral arterial gas embolism, here we had some divers ascending in open, and sometimes rough water, without even visual reference! The reporters of such incidents felt that the dive organisation predisposed to thse events by the inadequate provision of shot lines. Once again it is necessary to emphasis that one has to plan the EXIT, before one BEGINS the dive. It is not good enough to start thinking about the exist after one is in the water.

Happily, no one was underneath the diver who dropped his weight belt during exit!

The majority of reported incidents in this study (55%) occurred during the dive. the next most hazardous period for incidents was during preparation. Interestingly, this is similar to incident occurrence patterns in anaesthesia5,6.

On a positive note, the study also bears out the results of other such studies of human performance[6,8,9], by showing the value of experience, and check lists, for safety.

THE REPORTING OF DIVING INCIDENTS

It is important to appreciate that most diving incidents cause no actual harm to anyone. They occur repeatedly because all humans err repeatedly, but most are recognised and corrected before they progress to the accident stage (e.g. entry with an uninflated BCD, which is rapidly inflated by scuba-feed without fuss, provided the scuba-feed is connected!!). However, the written reporting of such incidents (which have until now been passing unnoticed and "unused") is a most important contribution to the build-up of a body of data which forms a powerful means of developing corrective strategies[9] (see below), for the improvement of diving safety for everyone.

Such incident reporting, being entirely voluntary, can never reveal the *absolute* incidence of any error among divers. This would require that every single incident that occurs be reported, an unrealistic expectation of human behaviour! However the data, provided enough divers participate in returning completed reports (Figure 4), will tell the *relative* incidence of errors and incidents. This will enable the most effort to be logically directed towards the most common and/or the most potentially dangerous recurring incidents in sport diving practice. The data is also reasonably objective (Figure 2), and is thus difficult for the irresponsible diver, or dive charter operator, or the ignorant bureaucrat, to refute once it is published.

An important consideration for those considering participating in such a Diving Incident Monitoring Study (DIMS), is the assurance of confidentiality, as well as anonymity, of the data supplied. This is ensured both by the totally anonymous design of the questionnaire (Figure 4), and the built-in security of the central data-collation bank, which would be a specially designed computer programme, operated and accessed by only one or two trustworthy members of the South Pacific Underwater Medicine Society. The blank forms could be made widely available at all recreational diving outlets across the two nations. Posting by divers of their completed questionnaires could be either direct to a central SPUMS data facility (hopefully post free), and/or by handing to the senior, and trusted, dive supervisor at the end of a diving trip. The latter would then despatch the completed forms to the central SPUMS facility. Such a supervisor would also be available for advice concerning the filling in of any such report form.

It is planned that the important feed-back of the Australasian data, once enough has been collected to make it meaningful, will occur on a regular, perhaps annual, basis in the pages of the SPUMS Journal, and will be available to the principal sport diver training facilities in Australia and New Zealand.

Conclusions

Corrective strategies suggested by the anonymous reporting of diving incidents pilot study conducted at Mana Island in 1988:-

1 Carry a gear check list in your dive bag
2 Ensure regular, at least annual, gear maintenance
3 Practice regularly with one's own gear in the pool. Buoyancy control takes in-water practice. Consider the use of safety straps on extra gear (e.g. camera)
4. Routine with a new buddy:-
 4.1 Discuss and agree upon underwater signals and lost contact drill to be used.
 4.2 Inspect and test your buddy's gear, especially inflation, releases, and safety items.
 4.3 "Plan your dive, and dive your plan".

It is also suggested that the adoption of an on-going Diving Incident Monitoring Study (DIMS) may be a fruitful approach to the improvement of the inadequate existing safety standards among recreational divers.

Acknowledgements

It is a pleasure to thank our colleagues from the SPUMS 1988 ASM diving group, who submitted the incident reports which made the small pilot study possible. In particular, we acknowledge the informed input of Professor Bill Runciman of Adelaide, Dr Bob Thomas of Brisbane and Dr Elizabeth Clark of Sydney, in the design of our "Mark 1" questionnaire (Figure 4)

REFERENCES

1 Williamson J., Orton J., Callanan V., Ellery W., Hardman J., Palmer R. The Townsville diving medical, and aeromedivac system: experience, lessons, and the future. *SPUMS J* . 1988; 18: 82-87.

2 Williamson J. Arterial gas embolism from pulmonary barotrauma. What happens in the lung? *SPUMS J.* 1988; 18: 90-92.

3 Davis J.C. Decompression sickness in sport scuba diving. *Physician and Sports Med.* 1988; 16: 108-121.

4 Lee R.B. Evaluating the performance of flight crew; in Safety in the operating theatre: the human factor (Crankshaw D.P., ed.). Faculty of Medicine, University of Melbourne 1983: 19-30.

5 Cooper J.B., Newbower R.S., Long C.D., McPeek B. Preventable anaesthesia mishpas: a study of human factors. *Anaesthesiology* 1978; 49: 399-406.

6 Williamson J.A., Webb R.K., Pryor G.L. Anaesthesia safety and the "critical incident" technique. *Aust. Clin. Rev.* 1985; 5: 57-61.

7 Allnutt M.F. Human factors in accidents. *Br. J. Anaesth.* 1987; 59: 856-864.

8 Flanagan J.C. The critical incident technique. *Psychol. Bull.* 1954; 51: 327-358.

9 Cooper J.B., Newbower R.S., Kitz R.J. On analysis of major errors and equipment failures in anaesthesia management: considerations for prevention and detection. *Anaesthesiology* 1984; 60: 34-42.

10 CAIR (Confidential Aviation Incident Reporting) Brochure and Report Form. Bureau of Air Safety Investigation. Canberra. 1988.

Dr Chris Acott's address is Department of Anaesthesia and IntensiveCare, Rockhampton Base Hospital, Queensland 4700, Australia.

Dr Allan Sutherland's address is Diving Medicine and Assessment Centre, Milford, Auckland 10, New Zealand.

*Dr John Williamson's address is Department of Anaesthesia , Intensive Care and Marine Medicine, Townsville General Hospital, Queensland4810, Australi*a.

DIVEDATA DATABANK INTERNATIONAL UPDATE

Douglas Walker

The proposal to set up a databank to service reports concerning all types and severities of diving-related problems has been raised for discussion in these pages previously.[1] There are two major questions which must be answered in connection with any project such as this. The first is, is the objective worth achieving? The second is, is the plan practical ? There is clear evidence for answering "Yes" to both questions.

To justify the need for such a project requires no more than to refer to the history of diving medicine, which developed slowly as reports were published about the problems affecting caisson workers and divers. None of the problems had been predicted. Though the information came from caisson workers, divers, employers, engineers and physicians it was the analysis of the information by physiologists and physicians which pointed out the probable causes and the necessary actions to reduce risks. Nowadays it is so difficult to obtain information concerning military or commercial diving accidents that it is obvious that self-regulation by interested parties does not work for the general benefit of the diving community. Of course medical opinions are not always initially correct[2] but the publishing of opinions and the free discussion of matters is the method most likely to reach the truth about any problem. In these days of litigation it will be impossible to reach the degree for freedom of correspondence enjoyed in the last century by Paul Bert,[3] though even he was careful to retain confidentiality where this was appropriate.

Computer programs can store, and allow analysis of, vast amounts of data far more simply than can any card index system. They also allow data to be updated and corrected with ease. Thanks to the number of persons and hyperbaric units which now record their information using computers the sharing of information, and in particular the ease of accessing material, has improved immensely over recent years. There are, of course, problems with accessing computer stored data. The data is usually only accessible to the user of another computer if that computer has exactly the same program as was used to enter the data. On occasions a later version of a program will not read what was entered with the earlier version ! Such are the trials of the user of a computer. Such problems need not provide a bar to the efficient working of the Divedata Databank. The simplest way to make a data bank accessible to all potential users is for all users to have the same program. However the rapid spread of the Apple Macintosh has meant that there are now two "industry standard" personal computers which until recently were unable to communicate except by laboriously entering the contents of a printout from one system into the other. It is now possible to transfer information between IBM compatible computers and Macintosh computers, but at a price. Additional processing units have to be used to transform the original data into ASCII format which can then be read by the other computer's programs. If only a limited number of data storage programs is used by correspondents who choose not to interact on paper documents the problems can be contained. It is much cheaper to post a few floppy discs than a bulky package of documents. Safeguarding confidentiality is no problem as critically identifying particulars can be omitted from the exchanged data.

A divedata databank is now close to becoming a reality. The intention is to obtain reports from as wide and diverse a range of sources as possible. This will both increase the chances of becoming aware of rarely occurring events and make the creation of anonymity concerning the incidents easier to obtain and maintain.

That the time has arrived for a scheme to exchange information is shown by the willingness of other workers, who already collect data on diving problems and hyperbaric treatments, to join. The National Safety Council of Australia (Victorian Division) has offered the facilities of its mainframe computer to store the information. The data will be available to anyone who has a research need for it. As the data has been supplied through the filter of a medical person it will be free from confidential identifying details. It is the possibly unique feature of this project that it will be in medical hands, quite independent of government, diver organisations or diver employers. It will be open to all to supply confidential information, with no risk of it being traced back to source and used in legal action against them. The objective is to be non-judgemental and non-punitive.

The initial management of all reports will be entirely under medical control in order to maintain, at all times, the anonymity of all those involved in the incidents reported and to make the promise credible. A similar proposal for a medical filter has been made by Acott, Sutherland and Williamson[4] in their paper recording non-fatal diving incidents during the SPUMS meeting at Mana Island in 1988. Information, after the removal of identifying details, will be stored in two formats, as coded data using an agreed data key and as a descriptive summary. This method of double recording has been thoroughly tested and found to be highly effective during the management of data on fatalities in Australia and New Zealand (Project Stickybeak).

It is proposed to have separate datafiles for specific areas of study, such as input from hyperbaric units, ENT surgeons, diving medical technicians etc., in addition to a general file for all dive related problems. Should some problem requires special study, such as equipment problems, it will be easy to identify such cases from the general file and write them into a special interest file. Expressions of interest in becoming involved in the project have been received from the USA (Divers' Alert Network (DAN) and the Cave Diving Association) and the UK. Australian and New Zealand hyperbaric units are involved in this project already, as are some ENT surgeons in New Zealand.

Only if there is an input of reports concerning the multitude of minor problems experienced by divers, which are generally adequately managed so that they never progress to the stage of causing a major problem, will the full potential benefits be achieved. The aim is to create a scheme which will not only monitor diving problems and so lead to the early recognition of danger areas before a serious incident occurs but will also provide a database for the retrospective investigation of problems not at present under investigation. Merely to investigate diving fatalities and serious decompression sickness, while useful, is to omit to learn from the far more common lesser problems.

It is requested that anyone with suggestions to offer or information to submit will accept this invitation to contribute to the project. The Divedata Databank project is dedicated to improving both safety and knowledge concerning diving and hyperbaric matters and is not restricted to a self selected group of doctors or divers. Everyone is invited to become involved. Safety, like liberty, demands eternal vigilance.

References

1 Walker D.G, Diving safety will compute. *SPUMS J* 1986; 16: (1) 17-18.

2 Hills and Phillips, Deep sea diving. *J RN Med service* 1932; 28: 157-175.

3 Bert P, La Pressure Barometrique. Paris: 1878.*

4 Acott C, Sutherland A and Williamson J, Anonymous reporting of diving incidents: a pilot study. *SPUMS J* 1989; 19; (1) 15-19.

* This book was translated into English in 1943. A 1984 reprint is available from the

Undersea and Hyperbaric Medical Society,
9650 Rockville Pike,
Bethesda,
Maryland 20814, USA,

for $ US 50.00 including postage.

For Further information about the Divedata Databank project write to

Dr D.G.Walker,
P.O.Box 120,
Narrabeen,
New South Wales 2101,
Australia.

TABLE ONE

DIVING DEATH RATES

USA

PADI Australia uses an NUADC estimate of 2.6-2.8 diving deaths per 100,000 "active" divers.

AUSTRALIA

PADI Australia reports 2.4 deaths per 10,000 PADI Australia certifications, which equals a rate of 24 deaths per 100,000 PADI Australia certifications.

JAPAN

PADI Australia reports 20 diving deaths per 100,000 "active" Japanese divers.

Source: PADI Australia's *Diving Accident Management in Australia* pp. 53, 76, 99.

AUSTRALIAN DIVING DEATH RATES COMPARISONS WITH USA AND JAPAN

Robert Monaghan

Is the diving death rate in Australia really ten times higher than in the US? A recent PADI Australia publication titled "Diving Accident Management In Australia" suggests that the answer is yes. My models, republished in the "SPUMS Journal"[1,] suggests otherwise.

Table one shows PADI Australia's reported statistics[2]. By comparison, my article calculated 16.7 diving deaths per 100,000 divers was a minimal estimate for the death rate among US divers. If the NUADC estimate is correct, then the diving death rate reported by PADI Australia is really ten times that of the US! If my models are correct, then the Australian diving death rate is roughly comparable to the US figures.

We should start by converting the PADI Australia reported death rate, which is expressed as 2.4 deaths per 10,000 PADI Australia certifications, into a directly comparable death rate per 100,000 divers. Clearly, there are more certifications than there are divers, since one diver can hold several PADI certifications. I have held over 30 leadership level PADI ratings and certifications myself! "Skin Diver" magazine reported that out of circa 250,000 PADI certifications, some 50,000+ or 20% were issued at advanced diver and leadership levels. This statistic implies that 100,000 PADI certifications represents 80% entry level divers and 20% upper level diver ratings. In other words, we expect 100,000 PADI Australia certifications to represent 80,000 divers who also hold 20,000 upper level diver certifications. A death rate of 24 deaths per 100,000 PADI Australia certifications therefore represents 24 deaths per 80,000 divers. This rate is mathematically equivalent to 30 Australian diving deaths per 100,000 divers based on PADI Australia's figures.

I believe this figure can be applied to the overall Australian situation simply because PADI Australia dominates 65% of the Australian diving instruction market[3]. Further, we can calculate the number of deaths among PADI Australia certified divers. We know the rate (2.4 deaths per 10,000 PADI Australia certifications) and the number of certifications (33,000 certifications annually)[3]. We can easily calculate that roughly 8 diving deaths occurred among PADI Australia certified divers. As expected, this represents the major fraction of the reported Australian diving deaths.

Does it make sense that PADI Australia should have a tenfold greater rate of diving deaths than the US? I believe this conclusion is absurd. After all, we use similar or identical equipment and techniques. The same PADI program dominates both markets, representing at least 72% in the US[4] and 65% in Australia. Finally, the same instructor training and store programs, using the same materials and philosophies, are employed in both countries. Why then should there be such a huge difference in diving death rates between Australia and the US?

My models suggest that it is not that Australian death rates are too high, but rather that the claimed US death rates are much too low. Naturally, this has raised a storm of controversy in the US, particularly amongst those who prefer to remain complacent about diving safety based on the low claimed death rates. My calculations suggest there is no room for complacency and instead I make a call for action on improving diving safety now.

My article found that the National Underwater Accident Data Center (NUADC) figures utilized an excessive number of "active" divers. I argued that there were fewer divers, making fewer dives, but at more risk than the NUADC rosy safety statistics would suggest. Since the publication of that analysis, "Underwater USA" has quoted new NUADC figures which greatly reduce their "active" diver population estimates, e.g. by over a million divers. Even PADI's own US diver estimates are substantially less than the NUADC figures. A recent Diagnostic Research Inc. (DRI) survey commissioned by the Diving Equipment Manufacturer's Association (DEMA) reported only 2 million US divers. My model estimates were for experienced divers only. What if one adds in resort course divers (400,000+ per NUADC) and student divers (500,000+) to my updated model estimates for experienced divers? You get a figure which is close to the survey results for all divers reported by DRI/DEMA. I would therefore argue that the inflated "active" diver population figures of NUADC should be rejected. Similarly, we have to abandon all those rosy US diving safety statistics based on NUADC figures.

Is the death rate among Japanese divers really lower than the death rate among Australian divers? I think not. The Japanese diving deaths are reported by an official government agency. However, PADI Australia has estimated an "active" diver population among Japanese divers by using a process similar to that employed by NUSADC. The result has been similar, namely, an inflation in the number of "active" Japanese divers. This leads to a substantial underestimate of the true Japanese diving death rate, just as happened with the NUADC figures. As further evidence, I point to the precipitous drop in Japanese diving death rates from over 50 to just 20 per 100,000 divers in just a few years. I doubt such a large drop could occur so rapidly among so many divers. Using a more reasonable dropout rate estimate, my models suggest the true Japanese diving death rate is substantially above that calculated for Australia here.

I must admit I was very glad to see these Australian diving statistics because of the support they lend to my models and estimates. My models estimated a minimum US diving death rate of 16.7 diving deaths per 100,000 divers. But I believe the true rate is considerably higher than this minimum figure. I further feel that the US and Australian diving death rates are roughly comparable, although I believe that both the Australian and especially the Japanese diving death rate are still higher than the US figures based on my models.

If PADI US wishes to continue to claim such a low death rate among US divers, then they need to explain the tenfold higher death rates among PADI Australia certified divers, and do something about it! PADI Japan, which dominates the Japanese market and is the world's fifth largest training agency, also has some work ahead of it. I presume both entities would prefer to abandon the low US death rates and accept my models and conclusions as reported here. I think it is past time that the US diving industry accepted the conclusion that diving is not as safe as the NUADC figures would suggest. My models and estimates suggest that diving is not getting any safer, either. I believe there is plenty of room for improvement in how we teach diving and in how we dive. That's my primary message here.

I am understandably envious of my Australian colleagues, with your co-ordinated chamber and rescue operations and your independent diving statistics collection efforts, particularly Project Stickybeak. I am hopeful that the US diving community will see fit to follow your example. I have called for an independent US entity to collect not just diving mortality data but also diving injury data as well. My viewpoint is that such an entity will need to be financially independent of interested parties in the diving industry, including diving equipment manufacturers, trade associations, and diver training agencies. I agree with your ideas that such a morbidity and mortality database will enable us to improve diving safety. Using it, we can determine where and how we can make effective safety improvements in diver training and diving operations. Thanks to your efforts, Australia enjoys what is undoubtedly the world's best program in this regard. Your efforts provide compelling proof that such a program is both possible and very worthwhile. Keep up the good work!

REFERENCES

1 Monaghan R., The risks of sport diving: just how many divers are there ? *SPUMS J.* 1988; 18 (2): 53-60.

2 Diving Accident Management in Australia. North Ryde: PADI, 1988. 76.

3 Diving Accident Management in Australia. North Ryde: PADI, 1988. 77.

Robert Monaghan's address is P.O.Box 2182, Southern Methodist University, Dallas, Texas 75275, USA.

THE EQUIVOCAL BEND, SHOULD WE TREAT WITH HYPERBARIC OXYGEN?

David Smart

SUMMARY

Three case histories of divers presenting to the Royal Hobart Hospital (RHH) with minor symptoms and signs after diving have been retrospectively examined to assess the effect that treatment with hyperbaric oxygen (HBO) had on their condition. Hyperbaric oxygen produced complete amelioration of almost all symptoms in each of the three cases. The problems in interpreting the data relating to

equivocal decompression sickness (DCS) were examined. A thorough neurological and psychometric assessment should be performed in all cases to detect possible neurological involvement which occurs in a significant proportion of these minor syndromes. Treatment of less serious decompression sickness with hyperbaric oxgyen is justified.

Introduction

Much has been written about decompression sickness (DCS) since the link between gas bubbles in the body and the clinical syndrome was first described by Paul Bert last century1. In recent years greater emphasis has been placed on the more serious syndromes which present to the diving physician. The efficacy of hyperbaric oxygen (HBO) in these situations is well established.

Less has been written about the patient who presents with more diffuse symptoms after diving, not classically identifiable as DCS. Many of these symptoms are without signs and could represent a multitude of ills, the only common factor in their aetoiology being that the patient has recently dived and claims that the symptoms were not present before diving, or that diving made the symptoms worse.

Should all patients with suspected DCS be treated aggressively with hyperbaric oxygen? Traditionally only those with definite DCS (e.g. localised pain or neurological bends) have been treated with HBO.

In this study the case histories of three patients with atypical symptoms after diving were examined retrospectively to assess the effects that HBO treatment had on their condition. The patients were selected from 27 total divers treated at the Royal Hobart Hospital Hyperbaric Unit since August 1984. These cases are representative of six divers presenting with similar syndromes during the same period.

Case reports

Case 1

A 30 year old male abalone diver with 4 years' experience as a professional diver and a past history of an arthroscopy of his right knee for a meniscal lesion. No surgery was performed during the arthoscropy. He also had similar problems with his left knee but no orthopaedic intervention.

Three days before presentation he dived for six hours to 18-24 m of sea water (msw) then "decompressed" for one hour on the anchor line at 3.5-4.5 msw. After leaving the water at 4 p.m. and feeling slightly lethargic he cleaned his gear and went home. At 12 midnight (8 hours post dive) he noticed the onset of pain in his left calf, left knee and general fatigue with headache. His symptoms worsened over one hour then gradually improved. He was almost pain free when he saw his local doctor the following day. He had full range of movement both knees with neurological examination normal. Detailed sensation testing was not performed. He was prescribed oral fluids and 12 hours of 100% oxygen. By day three all of his pain had resolved except for a dull ache in his left knee exacerbated by movement. He still felt generally lethargic and his headache had not improved.

He was transferred to the Royal Hobart Hospital 82 hours post dive still complaining of a dull ache in his ledt knee despite full range of movement. Neurological examination was normal. He was recompressed using USN table 5, 84 hours after initial symptoms began. At 18 msw the patient was symptom free and remained so for the remainder of the treatment. After decompression a slight ache (less in intensity than before HBO treatment) had returned in his left knee. His constitutional symptoms had disappeared. After further 100% oxygen at one atmosphere absolute he returned home much improved. By one week he was symptom free.

Case 2

A 36 year old abalone diver had an influenza-like illness with cough, coryza, myalgia and vague fleeting polyarthralgia for a number of weeks. His general practitioner treated the productive cough with antibiotics and terbutaline with no response. The worst affected joints were his knees, elbows and shoulders.

He had dived six and five days prior to presentation for 8 hours each day to approximately 9 msw, however he did not use a depth guage. He did not decompress. The day after these dives the pains in his knees, elbows and shoulders became more severe. He presented 110 hours after his last dive because the pains had not improved. Examination revealed a neurologically normal man with full range of movement and power in all joints which had pain, the elbows, knees and shoulders.

He was recompressed using USN table 6 and during the second oxygen period at 18 msw noted that all symptoms had gone apart from slight left elbow and shoulder pain. This pain persisted when he was decompressed to the surface. After overnight oxygen, symptoms were still present and the patient was further recompressed for 60 minutes at 18 msw breathing 100% oxygen, with resolution of his symptoms. However, on decompression he complained of pain in his right knee. This had gone after further 100% oxygen at one atmosphere absolute for 12 hours but he had more pain in his elbows and upper arms.

Investigations performed were as follows:

FBC. Hb 15.1. WCC 6.8, normal differential. Platelets normal. ESR 1.

CT scan Brain normal

ASOT - Negative

Antinuclear antibodies positive 1:20 litre (non specific equivocal result).

After a further 24 hours, the patient was discharged home with fleeting minor symptoms, far less than at presentation and free of systemic symptoms. Subjectively he felt better. At follow up at one month he was asymptomatic.

Case 3

A newly qualified 21 year old female scuba diver with two months' experience had recently recovered from a viral illness. She had completed 12 open water dives since starting her course and the two days prior to her presentation dived the following profiles:

Day 1 15 msw for 60 minutes exit 1730

Day 2 15 msw for 60 minutes exit 1130
20 msw for 30 minutes entrance 1500

She had a rapid ascent at the end of this dive due to buoyancy control problems.

No decompression stop was performed after the second dive. No symptoms were noticed after the final dive. Three hours afterwards, whilst travelling home over hills at an altitude of 300 metres, she noticed the onset of headache, nausea, vomiting and vertigo.

These symptoms continued overnight with further vomiting. She presented 18 hours after her last dive with general fatigue, headache, myalgic pains in her neck, back and knees, and vertigo.

She was febrile (38.1 ^{0}C). There was no skin rash. Cardiovascular system, respiratory and gastro intestinal tract examinations were normal, as was neurological examination apart from falling to the left on sharpened Romberg test (standing with the feet one behind the other, arms folded and with eyes closed). There was no nystagmus and detailed sensation testing was normal.

Treatment consisted of recompression using USN table 6. This resulted in a marked improvement in her headache and lethargy. Her nausea still remained. After a night on 100% oxygen she was symptom free and her sharpened Romberg test was normal. Her fever had also gone. Electronystagmogram just prior to discharge was normal.

Discussion

The above cases illustrate some of the problems encountered by the diving physician when assessing divers who present with atypical symptoms after diving.

Common to the cases were:

1. Delayed onset in symptoms up to 8 hours post dive.
2. Minor non-specific symptoms.
3. Intercurrent illness or pre-existing complaints which clouded the presenting picture.
4. Delays in treatment of up to 110 hours.
5. All responded to HBO therapy with a significant reduction in constitutional symptoms.

It may be easy in retrospect to attribute all of the symptoms described in the case studies above to DCS, however the diagnosis was by no means clear at presentation. Attitudes of divers towards DCS play a role in clouding the picture at presentation and result in delays in seeking treatment. There is a tendency to rationalise symptoms and attribute them to a recent event or illness (e.g. a hangover, diver fatigure, or influenza). There is also a real fear amongst divers that to get bent will result in them being prevented from diving again or is a reflection of their inadequacy as a diver. Fear of losing their livelihood is understandable with professional divers, but should not be the case with sport divers. Injuries in other sports are only regarded as a temporary setback in their training and playing schedule, and perhaps DCS in divers should be regarded the same way.

These fears combined with the minor nature of the symptoms described in the case histories above probably accounted for the delay in seeking medical advice. It was only the persistent nature of the symptoms that led to the divers seeking medical advice.

The pattern of DCS resembling a viral illness with lethargy, nausea, light headedness and malaise has been described before alone or in association with more serious DCS2,[4]. In particular, headache is now recognised a very common finding in divers with DCS and occurred in 19 out of 27 divers treated at RHH since 1984. Fever has also been described[2]. In case 3, this fever apparently responded to HBO treatment.

Case 1 demonstrates the recurrence of symptoms in an old injury following diving, which was an isolated event on this occasion. Exacerbation of pain in a pre-existing injury after diving has been documented in the literature, possibly due to local changes in tissue perfusion and vascularity[2].

The patient in case 2 had significant symptoms for a number of weeks prior to diving. If these symptoms had not been documented prior to his dives there would be no hesitation in attributing the post-dive picture to DCS. In retrospect his earlier symptoms may well have been pain due to DCS. He responded to treatment with HBO but each time he returned to the surface symptoms recurred in different parts of the body. Due to the systemic nature of DCS, the pains can be migratory.

Case 3 demonstrated a similar systemic pattern of illness to case 2 with two important differences. Firstly, there was the description of vertigo, dizziness and vomiting and slightly abnormal findings on neurological examination. Secondly, the patient developed her symptoms on ascent to altitude with its concomitant changes in ambient pressure. The resultant effects on bubble formation within the body are well known. Many cases of DCS precipitated by flying in aircraft after diving have been documented. Two patients treated for DCS in the unit at the Royal Hobart Hospital and discharged symptom free actually relapsed on ascent to 200 metres when travelling home and required further recompression.

In all cases above, treatment with HBO resulted in clinical improvement or complete abolition of symptoms. This provides further strong evidence that the symptoms were due to mild DCS. The milder DCS syndrome correlates with later onset of the symptoms. The earlier the onset of symptoms after diving, the more severe is the clinical picture2,6.

SHOULD THESE PATIENTS RECEIVE HBO ?

If it is assumed that symptoms result from bubble formation, then treatment can be justified to reduce bubble size, to increase the pressure gradient pushing nitrogen back into solution from the gas phase, and to reduce distal tissue hypoxia. Venous gas emboli have been demonstrated by doppler techniques in a majority of patients being exposed to shallow air saturation at 7.7 msw and 8.9 msw for extended periods of time7. The duration that bubbles were present in veins correlated with symptoms. Symptoms noticed by these patients included fatigue, limb and joint pain, headache, myalgias and pruritis. Except for pruritis, these symptoms occurred in the divers described in this paper. Hence treatment with HBO to reduce the bubble load may be justified even in minor cases of DCS. It results in improvement in up to 95% of cases[8]. In many studies less severe cases of DCS have been found with more detailed assessment to have neurological involvement[9]. This provides additional weight in favour of treatment of the more ‘minor’ syndromes.

SHOULD LESS SEVERE CASES OF DCS WITH DELAYED PRESENTATION BE TREATED ?

The cases presented here had delays of up to 110 hours before treatment was initiated. Some authors regard the potential seriousness of DCS to be so significant that they advocated treating even factitious cases until full particulars were obtained[10]. There is considerable evidence in favour of the efficacy of delayed treatment of DCS with hyperbaric oxygen in all degrees of severity[2,4,5,11,12,13,14,15]. The persistence of symptoms is thought to result from continued presence of gas bubbles in the tissues, and activation of haemostatic mechanisms[15,16].

There are many difficulties in interpreting data from retrospective case analyses when patients are treated with HBO.

Firstly, the placebo effect of HBO is not known. No data exists on the effect of HBO on symptoms described above in patients who have not dived. It is not possible to generate a control treatment when constructing a clinical trial because the pressure effects of hyperbaric therapy are difficult to mimic. In generating a controlled study, the ethical problems of not treating patients with DCS are also encountered. Non diving controls in such a trial would be at greater risk of barotrauma if subjected to HBO.

A high percentage of divers with cutaneous and musculoskeletal DCS have been shown to have detectable deficits when given more thorough neurological, EEG and psychometric testing[9]. A recent report from the Royal Navy demonstrated frequent frontal lobe perfusion defects in patients with DCS[17]. Considering this evidence and data presented in Eckenhoff’s study[7], it is apparent that this form of DCS is not as benign as was previously thought. A strong argument can be made in favour of HBO treatment of divers with more minor DCS syndromes. More detailed assessment including psychometric testing and single photon emission computerised tomography (SPECT) scanning (if available) should occur at presentation. The natural history of DCS is for gradual remission, however the long term effects of not treating minor cases are not known.

Conclusions

Presented here are three case histories of divers who developed minor or non-specific symptoms after diving and which initially caused some difficulty in diagnosis. All were treated with hyperbaric oxygen and all responded to treatment. It is likely, in retrospect, that each had symptoms which could be attributed to DCS. In view of the relative safety of treatment, and the fact that HBO acts partially to correct the underlying initial pathological event, treatment with HBO is justified in “equivocal” cases of DCS even after delayed presentation. Further studies combined with psychometric testing, electroencephalography and SPECT scanning are needed to ascertain the natural history of the syndrome of myalgias, fatigue, headache and non-specific symptoms, with and without HBO treatment.

REFERENCES

1 Bert P. Barometric Pressure. Translation by M.A. Hitchcock and F.A. Hitchcock, Columbus, Ohio 1943. College Book Co.

2 Edmonds C., Lowry C., Pennefather J. Diving and Subaquatic Medicine. Diving Medical Centre 1984.

3 Erde A., Edmonds C. Decompression Sickness: a clinical series. *J. Occup. Med.* 1975; 17: 324-328.

4 Robertson A. Treatment and results of thirty hyperbaric cases at the recompression facility HMAS Stirling. *SPUMS J.* 1986; 16(4): 141-143.

5 Miles S., MacKay D.E. Underwater Medicine. Granda 1986.

6 Macfarlane C.G. "Doc, it's about a sick diver...". *Aust. Fam. Phys.* 1983; 12(12): 873-5.

7 Eckenhoff R.G., Osbourne S.F., Parker J.W., Bondi K.R. Direct ascent from shallow air saturation exposures. *Undersea Biomed. Res.* 1986; 13(3): 305-16.

8 Marroni A., Catalucci G., Dal Fanet M., Frattini C. Evaluations of 169 cases of decompression sickness treated in Italian hyperbaric centres 1980-1981. *Minerva Med. J.* 1983; 74(35): 2009-14.

9 Gorman D.F. et. al. Neurological sequelae of decompression sickness: a clinical report. Proceedings: Bove A.A., Bachrach A., Greenbaum L.J. (Eds.). Underwater and Hyperbaric Physiology IX p.993-98. *Undersea and Hyperbaric Medicine Society*, Bethesda, Maryland 1987.

10 Murphy B.P>, Davis J.C., Henderson D.L. Factitious decompression sickness. *Aviat. Space. Environ. Med.* 1984; 55(5): 396-7.

11 Myers R.A., Bray P. Delayed treatment of serious decompression sickness. *Ann. Emerg. Med.* 1985; 14(3): 254-7.

12 Bruce D.G., Fox M.J. Spinal decompression sickness with delayed onset, delayed treatment and full recovery. *Br. Med. J. (Clin. Res.)* 1982; 285(6348): 1120.

13 Kizer K.W. Delayed treatment of dysbarism: a retrospective review of 50 cases. *JAMA* 1982; 247(18): 2555-8.

14 Butler F.K. Jr., Pinto C.V. Progressive ulnar palsy as a late complication of decompression sickness. *Ann. Emerg. Med.* 1986; 15(6): 738-41.

15 Philip R.B. A review of blood changes associated with compression-decompression. Relationship to decompression sickness. *Undersea Biomed. Res.* 1974; 1(2): 117.

16 Eckenhoff R.G., Hughes J.S. Haematologic and Haemostatic changes with repetitive air diving. *Aviat. Space and Env. Med.* 1984; 55: 592-7.

17 Adkisson G., Pearson R.R., McLeod M.A. SPECT scanning and decompression sickness. *(In press).*

Dr David Smart's address is GPO Box 463 E , Hobart, Tasmania 7001, Australia.

MINUTES OF THE MEETING OF THE EXECUTIVE COMMITTEE OF SPUMS HELD AT MANA ISLAND ON 11TH JUNE 1988

PRESENT

Drs A.Slark, C.Acott, G.Barry, J.Knight, A.Sutherland (NZ Representative), and (by invitation) J.Williamson .

APOLOGIES:

Drs D.Davies, C.Lourey, P.McCartney, and D.Walker.

1. The meeting of the Executive Committee was declared open at 1200 hours.

2. <u>MINUTES OF THE LAST MEETING:</u>

The minutes were read and are to be amended to include discussion of the article in "Chest".

3. <u>MATTERS ARISING:</u>

3.1 The President will write to the various registration bodies in Australia and New Zealand informing them of the existence of the Diploma but specifically pointing out that SPUMS is not seeking registration of the Diploma.

3.2 The next AGM will be held in Vila as previously decided in Adelaide. It should be timed to finish prior to the 5th of June, 1989 so that members can also attend the Undersea and Hyperbaric Medical Society (UHMS) meeting in Honolulu from the 7th to the 11th of June, 1989. It is hoped that UHMS members will attend the SPUMS meeting. Insurance arrangements should be made such that a refund would be available if the meeting should be cancelled for any reason.

4. <u>NEW BUSINESS:</u>

4.1 Dr Williamson raised the matter of insurance to cover sickness, diving accidents and retrieval. Allways Travel had informed him that there was a Group Insurance Policy with GRE Insurance, however, GRE (Brisbane) could not confirm the existence of this policy. The policy issued by GRE to Dr Williamson did cover the costs of retrieval but the company was surprised at the suggested costs that would be involved. Dr Acott will investigate further.

4.2 Dr Peter McCartney is holding a seminar in Hobart in early November. Several Executive members will be giving papers. It is suggested that the next Executive meeting is held at that time.

5. The meeting closed at 13.15 hours.

LETTERS TO THE EDITOR

DIVING DEATH RATES

P.O.Box 2182
Southern Methodist University
Dallas, Texas 75275
U.S.A.

December 21, 1988

Dear Sir,

I enjoyed reading the issue of SPUMS Journal you sent me, especially as it contained my reprinted article. I also enjoyed both your editorial and Mr Horne's cover issue cartoon !

I thought you might be interested in the enclosed draft as a possible follow-up article. I think the latest PADI Australia publication statistics are very interesting when compared with the USA and Japanese experience. Naturally, I was gratified to see the relatively close convergence between my models and the reported statistics from Australia.

I hope this article will prove useful to your readers by placing the Australian diving death rate figures into a context, e.g. between those of the US and Japan. I also believe that this article will show how the Australian data can be used to decide between my models and those of NUADC, that is, to help resolve the controversy over diving safety statistics.

Finally, I believe that the call for greater diving safety precautions can now be related to a more realistic view of the actual risks associated with sport diving. I feel fully justified in my calls for greater diving safety. To the extent that these articles call for more careful training and diving operations, I think we will have further served the cause of diving safety.

Thank you again for your interest in my articles and your on-going support for safer diving!

Robert Monaghan

COST OF AMATEUR DIVING MEDICALS

Diving Medical Centre,
66 Pacific Highway,
St. Leonards,
New South Wales 2065.

Dear Sir,

I keep getting requests from various doctors to advise on the proposed cost of an Amateur Diving Medical examination. It seems as if there is no real problem with the professionals, as most doctors do not do them.

I would think that any "recommended fee" should come from a reputable body, not mine. How about SPUMS?

With this in mind I would request that the topic be discussed at the next annual general meeting and a realistic fee be proposed and promoted in the SPUMS Journal.

My own personal viewpoint is that I have tried to keep the cost of an amateur diving medical (but including both lung function tests and pure tone audiometry) to maintain parity with that of an insurance medical examination. I do not wish to imply equality as regards the skill and knowledge needed.

The extra expertise and increased skill needed for a diving medical examination, compared to an insurance medical examination, are donated by diving physicians to the diving public. In return, the reputable diving instructors tend to advise their students to consult physicians who are knowledgeable in this field.

Currently the price for an insurance medical report is $ 55.00, but the relationship could be reconsidered at each annual meeting of SPUMS.

The recommendation of a price for professional diving medicals will be much more difficult, as various professional diving groups do have different requirements.

Thanking you for your consideration of this request.

Carl Edmonds
Director
Diving Medical Centre

AID TO THE REPUBLIC OF MALDIVES

"Wynlorel"
145 Wattletree Road
Malvern, 3144.

15th November, 1988

Dear Sir,

The SPUMS Annual General Meeting was at Bandos in the Republic of Maldives in 1985. At that time I had an opportunity, with the help of the Health Department in that Republic, to be conducted over the hospital at Male, and discussed help in a very general way.

Over the last three years we in Australia have been able to assist the people in Male with medical and surgical supplies which they sorely need and greatly appreciated.

The responses to my request have been most satisfying but now their needs are presumably far greater, due to the unrest and attempt to destabilize the country.

There are many surgical supplies and medications which we discard each day, such as antibiotics which are marked with a "use by" date prematurely, and these are very valuable extras to supplement the scanty regular supplies obtained from Sri Lanka.

Current journals may also be of value but I believe we have saturated their library requirements at the present.

Any contributions of drugs, dressings, and small operating theatre equipment and instruments can be directed to:- "Wynlorel".
Suite 3, 145 Wattletree Road,
Malvern,
Victoria 3144.
Phone No.: (03) 500-0879.

Thank you in anticipation.

Douglas M.Druitt.

THE NEW PADI TABLES

Professional Association of Diving Instructors (PADI),
1251 East Dyer Road, #100, Santa Ana,
California 92705-5605
USA

December 6, 1988

Dear Sir,

Earlier this year Dr David Davies contacted PADI International on behalf of SPUMS regarding the Recreational Dive Planner. I feel that it would be of interest to the readership of SPUMS to benefit from Dr. Davies letter and PADI's official response. I have enclosed copies of these two letters for publication in the next available SPUMS Journal. Would you please consider reprinting them in this regard?

In addition to this, PADI in conjunction with the Diver Alert Network has commissioned a new test series comprising of several weeks of trials of four dives per day for six consecutive days. The researcher is Dr. Michael Powell of The Institute of Applied Medicine and Physiology in Seattle, Washington, USA. At this writing over two hundred man dives have been conducted in this continuing study. Additionally, we are exploring the expansion of the planned number of trials because of extremely generous offers from two Australian Hyperbaric Medicine Units, those at the Royal Adelaide Hospital and Sydney's Prince Henry Hospital

Drew Richardson
Director,
Training and Education

We publish below the two letters mentioned above.

South Pacific Underwater Medicine Society,
Suite 6, Killowen House, St. Anne's Hospital,
Ellesmere Road, Mount. Lawley,
Western Australia 6050.

15th April, 1988

Mr Drew Richardson,
PADI Training Manager,
P.O. Box 15550, Santa Ana,
California 92705,
USA.

Dear Mr Richardson,

This Society is grateful for the opportunity to examine the document "Recreational Dive Planning, the Next Generation" and we congratulate the Professional Association of Diving Instructors (PADI) on its work in attempting to introduce new tables for recreational divers.

I asked two independent experts to examine the document and make their comments so that an unbiased assessment could be made. Unfortunately, both experts were scathing in their comments. These comments centred on the few numbers in each trial and the fact that the divers were not titrated to a bends point. There were not enough dives done on each profile to form a sample of sufficient statistical weight.

If a bends trigger point is not reached then the assumption is that the diver is bubble-free. This assumption is obviously incorrect since in the trials many asymptomatic decompressions produce bubbles detectable by Doppler. In addition it must be remembered that the Doppler only detects moving bubbles, not stationary ones.

Both experts agreed that the study was deficient in its theory, design and conduct and was spoiled even more by the frequent grammatical and typographical errors and the frequent use of confusing jargon.

One of the positive aspects of the manuscript is that it encourages continuous rather than stage decompression which certainly appears to be a logical approach to recreational dive planning.

This Society is concerned that, if these recommendations are published by PADI then PADI will be leaving itself open to possible litigation should a diver injure himself when following the tables recommended here.

SPUMS congratulates PADI on its endeavour to introduce new diving schedules for recreational divers but suggests that this document be used as the first draft of a pilot study and a larger statistically significant population of dive profiles be conducted before any deductions and recommendations be made.

David E. Davies
Secretary SPUMS.

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

May 27, 1988

Dr. David E. Davis,
Secterary, 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 decended, 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.

I have also reviewed the available evidence on these tables and written a lengthy report to New Zealand Underwater Association (NZUA)/PADI in New Zealand expressing my own concerns at the lack of scientific validity. Whilst my efforts have been acknowledged and appreciated, NZUA/PADI have chosen to proceed with the marketing of these tables in conjunction with their parent body despite the expressed concerns. Is this also the Australian experience?

If so, what should we be doing about it as a professional body? It would seem to me that a completely new set of tables is being introduced to sport diving on the basis of inadequate scientific validation. Brian Sayer of NZUA/PADI recently informed me of new major trials that are underway, and I understand that Dr Des Gorman has offered also to test these tables in the laboratory facilities at Adelaide. Is this not putting the cart before the horse? Should not tables be fully validated before their release rather than afterwards? We have had numerous examples of this in recent years what with the Huggins Tables, the Bassett Tables and so on. In fact the whole issue begs the question of what is appropriate scientific validation of a table. Weathersby and his colleagues at the US Naval Medical Research Institute (NMRI) have suggested that this can only be done statistically.

Perhaps the pages of the SPUMS Journal are an appropriate vehicle to allow PADI and others to express their views on such an important topic. I personally remain firm in my assessment that, as they stand, these tables lack scientific validity.

On a personal note I adopted the Canadian Defefence and Civil Institute of Environmental Medicine (DCIEM) tables for my own use early in 1987 since the overall evidence, as I understand it, is that these are currently the most conservative repetitive dive tables available. Of course, even with these tables the old maxim of 'one longer and/or one deeper' still applies.

F. Michael Davis
Senior Lecturer in Anaesthesia

REVISITING KEY WEST SCUBA DISEASE

19 Otahuri Crescent,
Greenlane,
Auckland 5,
New Zealand.

30th January, 1989

Dear Sir,

Robert Wong presents a case report of a diver suffering a systemic illness with major effects localised to the lung characterised by breathlessness, a reduced carbon monoxide diffusing capacity and a fine granular pattern chest X-ray (*SPUMS J* 1988; 18: (4) 124-125). The diagnosis of Legionella pneumophilia is made solely on clinical grounds supported by serology.

The serological response is worthy of comment in that a polyclonal response is shown with 4 fold rises in Gp.1, Gp.3, Gp.4, and Gp.6. I think this is far more likely to be a general stimulation of the immune system such as may occur after many infectious and non-infectious illnesses, rather than infection with several serotypes of Legionella, or cross-reactivity between these sub-types. A 'diffuse granular' chest X-ray is an unusual appearance in Legionella infections, but is seen frequently in hypersensitivity lung disease or adult respiratory distress syndrome both of which may occur as a consequence of aspiration. I suspect a transbronchial lung biopsy could not be justified in view of the patients improvement, but would have provided valuable data.

In the early investigation of Legionella pneumophilia the organism was isolated from stored frozen autopsy lung obtained from a diver who died in the late 1950s of a pneumonic illness. I have not been able to locate the reference to this however.

I think the case for Legionella pneumophilia is unproven on the available data.

I would be interested in Carl Edmonds views and also those of an Immunologist.

A.G. Veale,
Secretary/Treasurer,
NZ Chapter SPUMS .

JELLYFISH ENVENOMATION; WHAT DIVING MEDICAL PHYSICIANS SHOULD KNOW

International Consortium forJellyfish Stings,
MSO Box 5695,
Townsville,
Queensland, 4810

January 27, 1989

Dear Sir,

I write to correct what may be an ambiguous statement in my paper (*SPUMS J* 1988; 18: 118-121), under the sub-heading "Analgesia", on page 120. The possibly misleading statement reads "It" (i.e. pain) "is also unquestionably relieved by the specific antivenom for *Chironex*".

It is important for your readers not to misinterpret this statement to imply that the *Chironex* specific antivenom is beneficial for the pain of any jellyfish sting. Our present understanding, based admittedly on only a relatively small amount of circumstantial evidence[1] to date, is that this antivenom offers acute analgesia only for the pain resulting from the sting of *Chironex fleckeri*. It should not be used for the treatment of any other jellyfish sting.

John Williamson

REFERENCE

1 Fenner P.J., Rodgers D., Williamson J. Box Jellyfish Antivenom and "Irukandji" stings. *Med. J. Aust.* 1986; 144: 665.

HYPERBARIC MEDICINE UNIT FOR WESTERN AUSTRALIA

Fremantle Hospital,
Fremantle,
Western Australia 6160.

Dear Sir,

A new clinical hyperbaric unit is being built at last for Western Australia, after almost 10 years seeking funds.

Construction of the chambers will be financed from a Commonwealth grant, and the unit will be funded by the Health Department of Western Australia as the State referral unit for Hyperbaric Medicine.

The chamber is to be located at Fremantle Hospital, which has for the last ten years been the designated centre through which the management of all diving accidents in Western Australia were coordinated. Until now the State has asked the Royal Australian Navy (RAN) to provide recompression facilities for most of the diving problems, and recently some acute medical problems, usually carbon monoxide poisoning.

The contract was won in fierce competition by a Scottish firm, HYOX Ltd., and is to be constructed in Western Australia. The chambers are planned to be moved into the building during March 1989, and first patients are planned for 1st of July 1989. Fremantle Hospital have already commenced advertising for Technical and Nursing staff.

The unit will have two walk-in compartments, one with a 3 ATA capability, and the other of 6 ATA. The two are to be joined by a common entrance lock, and the 6 ATA chamber will, of course, have a transfer-under-pressure flange for use if necessary.

The unit will be available as an information resource for sports and professional divers, and for physicians interested in diving medicine.

We are grateful for the support of many diving medicine friends both here and overseas, in the long years leading up to the decision to fund this exciting facility. The Fremantle chamber will be another link in the ring of Hyperbaric Units which is spreading around Australia, and we plan to work closely together with others in this field.

Harry Oxer

NAUI ACTS ON DIVER SAFETY

80 Wellington Parade,
East Melbourne,
Victoria 3002,
Australia.

Dear Sir,

It is encouraging to see that at least one of the instructor organisations is willing to grasp the nettle of disciplining its members when they fail to meet the minimum standards laid down by the organisation and to publicise the event. As in medicine there is a need in the diving industry for periodical checks on the state of the instructor's (or doctor's) knowledge and performance. As far as I know only the Federation of Australian Underwater Instructors (FAUI) (and the Royal Australasian College of Obstetricians and Gynaecologists) insists on periodic requalification as a condition of membership. It would be in the interests of trainee divers (and of patients) if this periodic requalification was adopted by all the instructor organisations (and medical colleges and regulatory bodies). The statements below are from the press release.

The National Association of Underwater Instructors (NAUI) has announced, in a press release dated 10 October 1988, that it recently suspended two instructors in relation possible breaches of NAUI Diver Training Standards.

The matters, one in Victoria and the other in Queensland, are currently being considered by the NAUI Ethics Committee.

Gregory Blackburn, the President of NAUI Australia, stated "NAUI Instructors throughout the world have the highest reputation as quality educators. This reputation is maintained only through NAUI's willingness to ensure that the flexible but uncompromising NAUI Training Standards are maintained".

Where reasonable doubt exists on serious matters of diver safety, NAUI will continue to take firm action to resolve such matters.

"Determined responsible action on the part of all concerned", said Mr. Blackburn, "will allow the diving industry to be fully self-regulating. This will maximise diver safety and minimise the risk of poorly considered legislation being rushed into place. Emotional calls for restrictive legislation often ignore the real issues in favour of political point-scoring which has harmful rather than constructive long-term effects".

John Knight

STANDARDS ASSOCIATION
COMMITTEE CS/83
RECREATIONAL UNDERWATER DIVING

Standards Association of Australia,
Standards House,
80 Arthur Street,
North Sydney,
NSW 2059
Telephone: (02) 963 4111

7 December 1988

The Secretary,
South Pacific Underwater Medicine Society,

Dear Sir/Madam,

In 1984 Standards Australia received a request from the Australian Underwater Federation for preparation of an Australian Standard for recreational scuba diving. The request was widely supported when Standards Australia surveyed many government departments, divers, diving associations, and diving medical services in 1985.

This project was handled initially by Committee SF/17 - Work in Compressed Air, the committee which has responsibility for standards concerning commercial divng. After the release of DR 88026 - Training and certification of recreational divers, Part 1: Minimum entry level scuba diving, a large amount of public comment was received. Most of the comments were from recreational and sports divers requesting increased input in the preparation of the proposed standard. As this standard's aim is to protect consumers rather than commercial divers it was proposed to set up a separate project in the Conumer Standards section of Standards Australia. This proposal has been reviewed by Standards Australia's Consumer Standards Advisory Board and Safety Standards Board, both of which have endorsed the proposal.

It is envisaged that the proposed standard will deal primarily with the basic course syllabus contents and minimum training activities required for training and accreditation of recreational scuba divers. Other aspects which may be included are medical examinations for candidates, basic first aid and rescue procedures, equipment requirements and underwater communication signals.

A new standards committee is being formed to take over responsibility for the preparation of this standard. A copy of the proposed constitution of committee CS/83 is enclosed (page 34) and you will note that provision is made for your organisation to be represented by the number of persons shown. I would be grateful if you would consider whether you wish to take part in this work, and advise me as soon as possible of the name of your nominee(s) and the address(es) for documents.

The first meeting will be held in Sydney around March 1989 and subsequent meetings at locations according to the wishes of the committee. Obviously for effective participation in the preparation of the standard, it is desirable that committee members be able to attend meetings; however, it is understood that it is not always possible.

Should you require any further information regarding the nature of the proposed standard or the kind of work the committee will be involved in, could you please contact Ms. Carol Foster at this office.

Peter N Walsh
Director-Standards

South Pacific Underwater Medicine Society.

18th January, 1989

Mr. P. Walsh,
Standards Association of Australia,

Dear Sir,

This Society is pleased to be invited to participate on the Committee to discuss the formulation of DR 88206 concerning the training and certification of recreational divers.

SPUMS was constituted to promote the cause of safe diving, to educate divers and doctors in the problems that divers incur and to encourage the dissemination of knowledge about diving medicine in the diving community. It is obvious that the aims of the Standard Association and SPUMS are the same in this field.

Our representative on the Committee will be Dr John Knight of 80 Wellington Parade, East Melbourne, Victoria, 3002. All communication should be addressed to him.

If we can be of any further service to your organisation, please contact me again.

David E.Davies
Secretary SPUMS

PROPOSED CONSTITUTION

RECREATIONAL UNDERWATER DIVING COMMITTEE

Organisation	Number of Representatives
Australian Coaching Council	1
Australian Federation of Consumer Organisations	1
Australian Underwater Federation	1
British Sub-Aqua Club	1
Department of Leisure, Sport and Racing, NSW	1
Department of Sport and Recreation, WA	1
Federation of Australian Underwater Instructors	1
National Association of Underwater Instructors	1
National Safety Council of Australia	1
PADI Australia Inc.	1
South Pacific Underwater Medicine Society	**1**
Diving Industry and Travel Association	1
Queensland Dive Tourism Association	1
Scuba Divers Federation of Australia	1
Consumer Affairs Bureau, Queensland.	1
University of Sydney	1
James Cook University, North Queenslandd.	1
Department of the Arts, Sport, The Environment, Tourism and Territories	1
Victoria Police Search and Rescue Squad	1
Total	19

FOUNDATION FOR THE INTERNATIONAL CONGRESS ON HYPERBARIC MEDICINE

Hyperbaric Unit,
Prince Henry Hospital,
PO Box 233,
Matraville,
New South Wales 2036.

Dear Sir,

As past president of the above organisation and a member of the committee, I wish to encourage everyone from the Australian Hyperbaric Medicine community to enrol as a member. The benefits of membership include the receipt of the quarterly newsletter that deals with international and national meetings of diving and particularly hyperbaric medicine.

The membership fee is DM 18 annually. Funds can be wired directly to Deutsch Bank account number 8129033, Wiesbaden, Federal Republic of Germany (West Germany) in the name of Dr Frederick Cramer, MD, Secretary of the Foundation.

I will be happy to answer any queries. The hospital telephone number is 02-661-0111.

Ian Unsworth,
Director.

CONFEDERATION MONDIALE DES ACTIVITES SUBAQUATIQUES (WORLD UNDERWATER FEDERATION) INTERNATIONAL CONGRESS OF DIVING MEDICINE

Commission Medicale et de Prevention,
(Medical and Prevention Commission)
47, rue du Commerce,
75015 Paris,
France.

Dear Colleague,

I have the pleasure to confirm the organization of our next International Congress of Diving Medicine. It will take place at the "Boucaniers" (village of the Club Mediterranee) from 28th May to 4th June 1989.

We enclose the preliminary information about this Congress, together with a call for papers and a registration form.

Please note that the number of places is limited to 200.

If (as I most sincerely hope) you wish to join us, I invite you to register as soon as possible.

I am happy to be able to inform you that our scientifice conference will be broken each day by diving, excursions and various other events, unique to Martinique.

I look forward to the pleasure of welcoming you in the Tropics and remain, Dear Colleague, with kindest regards.

Marcel E. Bibas,
President.

MEETINGS AND COURSES

SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY ANNUAL SCIENTIFIC MEETING 1989

will be held at Le Lagon Hotel, Port Vila, Vanuatu from May 27th to June 3rd 1989

The Guest Speakers are **Dr Jimmy How**, Senior Medical Officer, Singapore Armed Forces and **Dr Mike Davis**, Senior lecturer in Anaesthesia at the Christchurch Clinical School, Otago University, New Zealand.

For further information contact,
Allways Travel,
168 High Street, Ashburton,
Victoria 3147, Australia.
Telephone 03-25 8818,
Telex AA37428 (Always)

The meeting is scheduled so that members can have adequate time to travel to the

UNDERSEA AND HYPERBARIC MEDICAL SOCIETY ANNUAL SCIENTIFIC MEETING 1989

The Undersea and Hyperbaric Medical Society (UHMS) will hold its 1989 Annual Scientific Meeting at the Hawaiian Regent Hotel, Honolulu, Hawaii from 8-11 June 1989. The meeting will include sessions on research and clinical applications of diving and hyperbaric medicine, as well as sessions for Associate Members and the Baromedical Nurses Association. In addition, there will be two independent but consecutive one day "Fitness for Professional Diving" courses on 6-7 June for the particular benefit of Health and Safety Executive (HSE) approved doctors. Dr. David Elliott of Biomedical Seminars, Surrey, England will be the director of the courses. Capt. John M. Hallenbeck, MC, USN, Chairman, Department of Neurology, Naval Hospital, Bethesda, Maryland will be presenting the Suzanne Kronheim Memorial Lecture. The meeting is expected to be attended by many foreign members, particularly those from Australia and Asia due to the relative proximity to Hawaii. The South Pacific Underwater Medicine Society (SPUMS) and the European Undersea Biomedical Society (EUBS) are UHMS affiliates.

The UHMS was founded as the Undersea Medical Society in 1967. It is a non-profit organisation serving 2,500 members worldwide. Most UHMS members are diving and/or hyperbaric medicine scientists and physicians. Hyperbaric medicine nurses and technicians, as well as sport divers and students, comprise a substantial number of associate members. The Society publishes two journals, workshop reports, bibliographies and books on diving and hyperbaric medicine. Through its workshops and publications, it sets guidelines relevant to diver health and HBO therapy.

For the particular benefit of HSE Approved Diving Doctors who are not resident in the United Kingdom, the annual revision courses, currently organised in the UK by Biomedical Seminars, will also be run in an overseas location. The Undersea and Hyperbaric Medical Society (UHMS) has agreed to run the courses as an extension of its 1989 Annual Scientific Meeting which will be held at the Hawaiian Regent Hotel, Honolulu, Hawaii from 8-11 June 1989.

The program will be presented as two independent but consecutive one-day courses. Together, the courses will provide compliance with the Diving Medical Advisory Committee (DMAC) requirements for revision training of "Approved" diving doctors. The first day, 6 June, will cover the basic principles of fitness criteria and will be entitled "Fit for Sports Diving?". The second day, 7 June, will be "Fit to Dive - Professionally?" and will cover the application of basic principles to the professional diver and will then address specific fitness topics such as fitness to return to diving. Dr. David Elliott of Biomedical Seminars will be the director of these two one-day CME approved courses. These courses are available to anyone interested and will have separate registrations. HSE Approved Diving Doctors are expected to attend both courses.

For details of these courses, please contact either
The Undersea and Hyperbaric Medical Society,
9650 Rockville Pike,
Bethesda, Maryland 20814,
U.S.A.

or:

Biomedical Seminars,
7 Lyncroft Gardens,
Ewell, Epsom, Surrey KT17 1UR,
ENGLAND.

EUROPEAN UNDERSEA BIOMEDICAL SOCIETY

XVTH ANNUAL SCIENTIFIC MEETING EILAT, ISRAEL, SEPTEMBER 17-23, 1989

PROVISIONAL LIST OF TOPICS

1. Breathhold diving
2. Deep sea saturation and mixed gas diving
3. Decompression sickness
4. Diving for the disabled - medical aspects

5. Effects of pressure
6. HBO therapy
7. HPNS
8. Immersion
9. Nitrogen narcosis
10. Oxygen toxicity
11. Preventive diving medicine (education)
12. Seasickness
13. Technical and therapeutic instrumentation in the hyperbaric chamber
14. Unconsciousness in diving

PANEL DISCUSSIONS

HBO Therapy - Specific Indication and the Correct Oxygen Dosage

Different Therapeutic Methods for Severe Type II Decompression Sickness

GENERAL INFORMATION

Meeting Venue

The King Solomon Hotel, Eilat is the headquarters of the XVth Annual Scientific Meeting of the European Undersea Biomedical Society.

Language

The official language of the Meeting is English.

Visas

For participants from most countries, visas for Israel are not necessary, but we suggest you ask your travel agent to check for you. For countries which do not have diplomatic relations with Israel, the Secretariat will arrange for a visa upon receipt of all relevant details.

Second Announcement

The Second Announcement and Call for Papers which will include a more detailed scientific program, as well as a variety of pre and post-Meeting tours, including diving tours, will be mailed out around January 1989.

Climate

The weather in Eilat in September is dry and sunny during the day and cooler in the evening. Temperatures range from 23°C-36°C (74°F-97°F). The water temperature is 27°C (80°F).

Clothing

Informal for all occasions.

Air Travel

EL AL Israel Airlines is the official carrier of the Meeting, and its offices throughout the world will assist you in making your travel arrangements. As the Meeting is at the height of the tourist season, please make your flight reservation as soon as possible.

For Further Information Contact

XVth EUBS Meeting
P.O. Box 983
Jerusalem 91009
ISRAEL.

Tel. 972 2 533717; 527335,
Tlx. 341171 KENS IL;
Fax. 972 3 655674.

THE UNIVERSITY OF SOUTHERN CALIFORNIA CATALINA HYPERBARIC CHAMBER

EMERGENCY DIVING AND ACCIDENT MANAGEMENT COURSE
JULY 23rd to 28th 1989

THE CATALINA HYPERBARIC CHAMBER

The University of Southern California (USC) Catalina Marine Science Center is located on Santa Catalina Island, 27 miles offshore from Los Angeles Harbor. Since 1974, the Catalina Hyperbaric Chamber has provided emergency standby hyperbaric treatment capability for the region's diving accidents. More than 400 patients have been treated for decompression sickness and air embolism. The Catalina Chamber is internationally recognised as a hyperbaric research and diving treatment center.

Course Content

Recognition and assessment of decompression sickness and air embolism.
Decompression tables and procedures.
Patient handling techniques.
Causes of diving accidents.
Approaches to life support.
Helicopter rescue techniques and equipment.
How to coordinate patient evacuation with rescue agencies.
Chamber treatments for decompression sickness and air embolsim.
Hyperbaric chamber operations and chamber locations.

There are no pre-requisites, but enrollments are limited. Tuition, meals, lodging are all included in the program fee of $ US 545.00 per personDeposit required to reserve a place $ US 100.00 per person. Make cheques (in US dollars) payable to **USC Catalina Hyperbaric chamber.**

Option 1 Catalina Chamber Crew

Participants interested in experiencing management of actual diving accident cases can apply to join the Catalina Chamber Crew after successful completion of the EDAM course. This is a volunteer activity and requires further explanation.

Option 2. Chamber Dive to 165 Feet

As an optional feature for participants who have never experienced a "dry" deep air dive, the chamber will be available to take participants to 165 fsw. In order to be eligible for this experience, a **diver medical** signed by a physician is required. A copy of an existing one or the form sent to you in the final information package will do. Please indicate whether or not you intend to participate in this event on the course registration form. $12.00 additional charge for this chamber dive.

For further information write to

Andrew A. Pilmanis or Ron Ryan
Catalina Hyperbaric Chamber,
P.O. Box 398 Avalon, California 90704, USA.
or telephone USA (213) 743-6793

ROYAL ADELAIDE HOSPITAL HYPERBARIC MEDICINE UNIT

Courses in Diving and Hyperbaric Medicine 1989

Basic Course in Diving Medicine

Content Concentrates on the assessment of fitness for candidates for diving. Health and Safety Executive (UK) approved course.

Venues and dates

Royal Adelaide Hospital, Adelaide
11-15 September 1989
NZUA sponsored course, Christchurch
29 Sepetmber -2 October 1989

Cost $A 250.00 or $NZ 275.00

Advanced Course in Diving and Hyperbaric Medicine.

Content Discusses the diving-related and other emergency indications for hyperbaric therapy

Venue and date

Royal Adelaide Hospital, Adelaide
18-22 September 1989

Cost $A 250.00

For further information and enrollment contact
Adelaide courses

Dr D.F.Gorman, Director Hyperbaric Medical Unit,
Royal Adelaide Hospital, North Terrace,
Adelaide, South Australia 5000.
Telephone (08) 224 5116.

NZUA sponsored course

Dr Mike Davis, Division of Anaesthesia,
Christchurch Clinical School of Medicine,
University of Otago, PO Box 4345,
Christchurch, New Zealand.

DON'T PUSH!

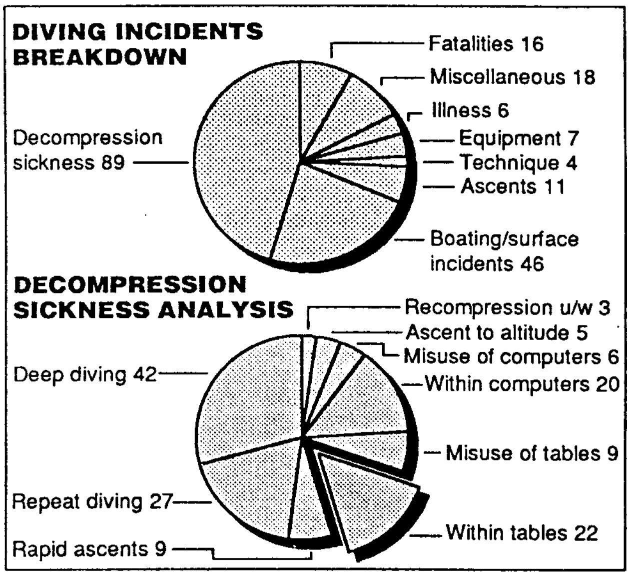
A REPORT ON BRITISH SUB-AQUA CLUB MISHAPS FOR 1988

Chris Allen

The British Sub-Aqua Club Incidents Adviser reports on the year's mishaps: fatalities up, decompression cases up, helicopter call-outs up, lost divers down.

In reviewing last year's (1987) accident statistics (Reprinted in SPUMS Journal 1988; 18: No 1(January to March) 35-38), Dave Shaw highlighted the number of lost diver incidents and the number of decompression sickness cases.

The 1988 figures show a welcome reduction in lost diver cases, but once again the decompression statistics reveal that too many divers are pushing the limits by diving deeper than indicated by their abilities, ignoring common-sense depth recommendations, and displaying ignorance of basic physiology in the process.



Regrettably, last year's reduction in the number of diving deaths has not been maintained, and this year 16 fatalities have been recorded (one a late report from 1987). Ten of these were British Sub-Aqua Club (BS-AC) members; and in spite of the fact that three of the fatalities resulted from natural causes, the figures are disappointing.

In one case two divers failed to surface after a dive to 50 m in tropical waters and were found drowned on the bottom with their mouthpieces out. Both divers had air remaining in their cylinders. From the evidence available it would appear that the accident resulted from unsuccessful attempts at sharing which may have become necessary because the rubber mouthpiece of one diver's demand valve had become detached.

Analysis of the fatal accident reports this year gives a clear message about the difficulties of sharing effectively in an emergency. No fewer than six of this year's deaths involved unsuccessfl sharing or running low on air. Perhaps if the individuals concerned had carried a suitable secondary breathing system some of these cases might have been incidents instead of tragedies.

This theme continues when we look at the ascents, where more than 50 per cent of the reported incidents also involved failure to share air properly in an emergency. Four of these cases resulted in burst lung and/or air embolism.

The message is that if you don't already carry an octopus rig of some sort perhaps you should ask yourself why not? Remember, it is often the buddy rendering assistance who becomes the victim when things go wrong.

Also in the ascents category are a couple of examples which illustrate the classic "incident pit", where a small problem quickly becomes compounded by other small problems until the situation is suddenly and dangerously out of control.

In the first case a pair of divers on a hard boat found that a mix-up on the quayside had resulted in some of their equipment being loaded on to the wrong boat. Not wishing to miss the dive, they went in as the last pair using equipment borrowed from other members of the party who had dived already. During the dive one of the pair had trouble with her borrowed mask which was ill-fitting and flooded constantly. On the ascent she became tangled in the shot rope and had difficulty releasing herself due to the flooded mask. She then made a rapid ascent to the surface which she was unable to control, being unfamiliar with the controls of her borrowed lifejacket. She suffered an embolism, and required repeated recompression treatments.

In another case an ill-fitting neck seal caused a diver's drysuit to flood. This was not noticed until near the end of the dive, when difficulty in ascending was experienced. Air was wasted in trying to inflate the suit and the diver ran out of air and became unconscious underwater. Fortunately, she was rescued by her buddy who brought her to the surface.

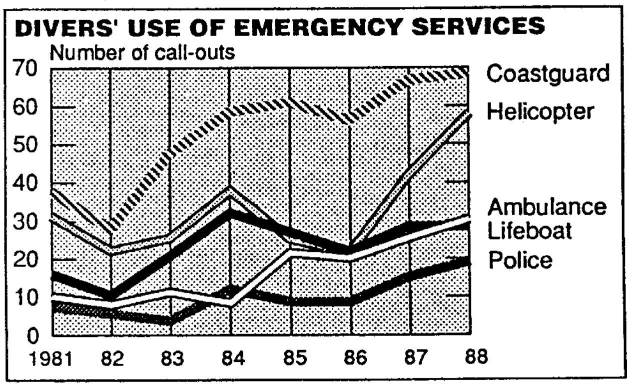
As you will see from the graph showing the breakdown of 1988 diving incidents, decompression sickness and boating/surface incidents lead the way as usual.

Although the number of "lost diver" cases has fallen this year, the involvement of the Coastguard and Royal National Lifeboat Institution (RNLI) has remained constant. There has again been a sharp increase in the involvement of Search and Rescue (SAR) helicopters, with 42 cases in 1987 and 58 cases this year.

People involved in lost-diver incidents, engine breakdowns, etc., often cite their "bad luck". However, if we analyse the reports more carefully one has to ask is it really bad luck which causes the surface market buoy (SMB) to become detached during the dive, as happened on at least three occasions this year? Or is it a failure to use a secure method of attachment and check it before use? Is it really bad luck to use more fuel than anticipated and run out, or is it a failure to plan properly and carry an adequate reserve? Is it bad luck when the engine or a piece of emergency equipment fails to work when needed most, or is it a failure to ensure proper maintenance and to make a thorough check before use?

Once again, a number of small failures can combine to create a potentially serious incident.

Consider the case of the divers whose SMB became detached during the dive. They noticed this quite quickly and surfaced within sight of their boat. But, not being seen by the boat crew, who were closely watching the two buoys in the water, they decided to use a lifejacket whistle to attract attention. The whistle had become detached and could not be located. The divers then tried their personal flares; but



these failed to work and they drifted away from the boat. The boat party eventually realised what had happened and tried to contact the Coastguard for assistance. The radio would not work! Fortunately, after they had fired a red flare to summon assistance, the divers were located by an SAR helicopter and picked up by local lifeboat.

Another diver was not so lucky and was missing at sea for over 12 hours before finally being picked up. He had become separated from his boat and swept out to sea by the current. An extensive search was organised but as darkness was falling search conditions became difficult. When the diver was picked up by a passing fishing boat the next morning he had drifted 7 miles from his original position!

The increasing use of VHF radios in even the smallest of diving inflatables is encouraging, and a significant number of this year's incidents have been quickly reslved by the summoning of assistance in this way. These days there is really no reason why every dive boat shouldn't carry VHF.

Still with boats, it is worth mentioning a couple of charter boat incidents which reinforce the message that charter boats and their skippers should be chosen very carefully.

In the first case a party of six divers were preparing to make a wreck dive from their 16ft open charter boat when it sank! The boat was swamped by the bow-wave of a passing submarine (!) and quickly went under. Two divers and the skipper were trapped in the front cabin, but were pulled out by the other members of the party. Fortunately everyone was rescued safely, but a significant quantity of gear was lost.

In another case a charter boat skipper sped to the assistance of a vessel which had fired a red distress flare. However, as he still had two of his divers down a second incident was almost created by leaving them behind. There were plenty of other vessels in the area which could have rendered assistance. Happily the divers were safely picked up by a second dive boat. The Coastguard were not very impressed!

This year, decompression sickness has had a particularly high profile and has attracted a lot of unfavourable press. The number of recorded cases is up from 69 to 89, though part of that increase may be accounted for by the fact that this year we have had much-improved reporting by chamber operators.

The breakdown of this year's cases is shown in the chart of Decompression Sickness Analysis. Several important lessons arise. First of all, we have recorded three cases of attempted re-entry decompression this year, and on each occasion this only complicated the problem, twice with tragic results.

In the first case, a diver experienced symptoms of decompression sickness after a dive to around 36 m (no accurate record of time or depth apparently). He performed re-entry decompression, and his symptoms worsened. He was subsequently recompressed, but was left paraplegic after treatment.

The second case involved a diver who suspected he had Type 1 decompression sickness. He was advised to dive again by the charter boat skipper and other members of the party, and as a result his symptoms worsened and he too became paraplegic.

The BS-AC advice on re-entry decompression is very clear. Do not even consider it. There is very little chance of success and every possibility that you will make things worse, as in the cases above. The only course of action is to arrange for transfer to the nearest available recompression facility as soon as possible. Those suitably trained on an Oxygen Administration Course and with oxygen available will be able to render useful First Aid.

Of equal concern is the number of bends arising out of prolonged spells of deep diving involving significant decompression stops. This appears to be a particular problem with deep wreck dives where divers are 'working' to recover trophies. One diver in this category who was using a dive coputer made seven dives to 30 m+ in five days including four dives to 40 m+. All were decompression dives, most involving more than 20 minutes of stops. At the end of the week's diving he was recompressed for Type 2 decompression sickness.

This is by no means the only example. A number of divers seem to think nothing of performing 30 minutes or more of decompression stops on each dive. The record this year was 51 minutes!

To my mind this is simply a case of going too close to the edge. Once you start to dive deeper than 30 m and to incur lengthy decompression stops your risk of being "hit" rises dramatically.

On the subject of dive computers, there has been a lot of publicity and criticism of their use in recent months, most of it misinformed.

It is true that the figures show an increase in the number of incidents involving computers (11 in 1987, 30 in 1988). However, there were undoubtedly many more computers in use in 1988, which means a straight comparison is misleading. What is certain from analysing the reports is that a number of these incidents involve misuse of the computer in some way.

Some of the other factors which figure in this year's reports involving computers are repeated ascents to the surface, rapid ascents, late nights, alcohol abuse, "sawtooth" profiles, and flying after diving. Needless to say, the same factors also appear in reports involving the use of tables, where 22 cases (a third of those reported) were apparently "within the tables".

Although only a tiny proportion of dives each year result in death or injury (about 0.01 per cent), the fact remains that many of the incidents which do occur could be prevented.

My advice for 1989 would be to apply the lessons of this year's incident statistics to your own diving practices and in particular "don't push the limits".

Safe Diving!

Reprinted, by kind permission of the Editor, from DIVER December 1988 pages 27-28.

The address of DIVER is 40 Gray's Inn Road, London WCIX 8LR, England.

Chris Allen is the BS-AC Incidents Adviser. The address of the BS-AC is 16 Upper Woburn Place, London WCIH 0QW, England.

DIVING SAFETY MEMORANDA

Department of Energy
Petroleum Engineering Division
Thames House South
Millbank, London SW1P 4QJ

January 1989

DIVING SAFETY MEMORANDUM NO. 2/1989 ON-LINE OXYGEN ANALYSIS OF THE BREATHING MEDIUM WHEN DIVING SHALLOWER THAN 50 METRES

It has long been good deep diving practice to provide on-line oxygen analysis of the diver's gas supply.

With the increased use of commercially supplied air quads, nitrox mixes and in-water oxygen decompression, it is recommended that oxygen analysers, fitted with audio and visual Hi-Lo alarms, are provided for such surface supplied diving operations.

To ensure the accuracy of the analysis the sample point should be taken downstream of the dive control panel and immediately prior to the diver's umbilical.

The normal good practice of analysing the oxygen content of the breathing quads on receipt and when connecting them to the system should still be carried out.

R. GILES
Chief Inspector of Diving

Department of Energy
Petroleum Engineering Division
Thames House South
Millbank, London SW1P 4QJ

January 1989

DIVING SAFETY MEMORANDUM NO. 3/1989 FAILURE OF ACTIVATED CARBON FILTER SYSTEMS

Domnick Hunter has informed us that the disintegration of an activated carbon filter, fitted down stream of a low pressure compressor receiver, resulted in the clogging of a pressurisation line and in the rupture of a silencer inside a deck compression chamber. This could have caused injury to personnel.

The compressor was provided to supply air, not only to the diver and the compression chamber, but also to a tugger winch. Investigations have indicated that the failure resulted from a mechanical stress fatigue fracture which developed from high speed pressure differentials in the plastic filter cartridge, caused by rapidly changing outlet demands.

It is understood that similar accidents have occurred in the offshore industry when compressor systems have been installed in this manner and used to supply large volumes of air at varying rates.

The manufacturer recommends that such filters should be fitted between the compressor and the receiver but the operating instructions also make provision for the filter to be fitted down stream of the receiver. In the case of the latter, the instructions clearly state that the outlet rates at line pressure should be controlled and must not be exceeded.

Operators of LP compressors fitted with Domnick Hunter AC 0035 cartridges should ensure that they are fully conversant with the manufacturer's published specifications and that they strictly comply with them.

It is recommended that where practicable, either 'ship' or 'rig air' should be used to drive the air tuggers.

R. GILES
Chief Inspector of Diving

DEATH IN THE MUD

San Diego Harbour Police scuba divers develop their diving skills in Convair Lagoon, an arm of San Diego Bay. In their practice sessions divers practice rescue by pulling themselves along the muddy lagoon floor in near zero visibility. When they're not practicing or conducting body or weapon searches, they conduct bottom surveys, which also require crawling along the bottom.

Two of San Diego's long time divers, both 41 years old, have developed identical forms of cancer, lymphoma. It now comes to light that the mud in Convair Lagoon is laced with PCBs, a known carcinogen which appears legally in some electrical equipment, but has been otherwise banned by the (U.S.) federal government.

The company charged with putting PCBs into the water - Teledyne Ryan - has denied it is to blame and claims, as do some toxicologists, that it is premature to allege that the PCBs in the water can cause cancer. But there is no doubt that crawling along the bottom increased the divers' exposure to the deadly chemical.

The San Diego Evening Tribune reported that the San Diego Harbour Police Chief has declined to state whether other police divers are worried about the PCBs. The chief says it is a "personal problem that shouldn't be discussed publicly".

The two ill divers, while fighting their disease, are also contemplating a law suit against the polluters.

Reprinted by kind permission of the Editor from UNDERCURRENT March 1987.

The address of UNDERCURRENT is P.O.Box 1658, Sausalito, California 9465, USA.

Note *that in Australia the Department of Arts, Heritage and Environment is responsible for preventing toxic waste disposal in the sea by ships, aircraft or platforms, this including dredge spoil. The 1981 Environment Protection Act (Sea Dumping) makes it an offense to dump into the sea (or load onto a vessel, aircraft or platform for the purpose of dumping), a wide range of specified substances including mercury, cadmium, polychlorinated biphenyls (PCBs), and other organo-halogen compounds, oil hydraulic fluid, etc. It also prohibits the dumping or incineration at sea of radioactive materials. Unfortunately there has been no provision made for the high temperature destruction of such toxic chemical compounds as no locality wishes to harbour a facility able to perform this task. The natural result is that illegal dumping occurs on occasion and reaches the sea at the waste water outfalls. Rock fishermen, who choose such places, appear to be at risk from more than the waves which drown several of their fraternity each year.*

DIVE SKINS AND CORAL DESTRUCTION

A handout with a picture of a diveskin clad model stretched across live coral was left lying on tables and booths at the recent DEMA show. The unsigned handout was probably overlooked by most of the people at the show but carried a very important message:

"Valerie (the model in the photo) is not a conservationist. Dive skins are for thermal insulation, not abrasion protection.

Look what we did to Pennekamp in Florida. A dive location becomes popular only to be wrecked in a few years. We are wrecking out coral reefs.

PADI, NAUI, SSI, NASDS, YMCA all teach buoyancy control to Americans who are conservationists at heart, yet everyday thousands of divers protected by dive skins and wet suits crawl over the reefs, dragging excessive lead, kicking and breaking coral, dragging their gauges, grabbing sponges and gorgonians, and lying on fragile coral to steady their camera.

It takes hundreds of years for coral to grow back and we dive on reefs as if it were sand or bare rocks.

Photographers are the worst. Everyday hundreds of ignorant shutter bugs believe they have a right to wear kneepads over their wetsuits and literally crawl over reefs leaving broken coral to die for their measly pictures. They ought to dive naked bearing the scrapes. We should all demand the right to view undamaged coral.

If we don't care to learn, in five years the reefs will be broken rubble. The only thrill to diving will be getting wet. We are cutting our own throats.

Ideas: Skin Diver Magazine should quit publishing ads with models grabbing coral and sponges. Training manuals should teach conservation. Agencies should require buoyancy skills for certification. Photographers should avoid damaging reefs and limit their shots to those they can perform without crushing coral."

(And *UNDERCURRENT* adds this one: a new diver at a resort should be required to demonstrate buoyancy control skills; if during his dive he fails to keep above the coral, he should be warned that he's got to be careful or he won't be able to dive with a charter operation. If he persists in coral destruction, he should be beached. The industry will have to forego short term income, for long term economic - and reef - survival.

Reprinted by kind permission of the Editor from UNDERCURRENT March 1987.

The address of UNDERCURRENT is P.O.Box 1658, Sausalito, California 9465, USA.

SPUMS JOURNAL BACK NUMBERS

Some copies of past issues are available at $5.00 each including airmail postage.

The relevant issues are

1984 Vol. 14, No. 2. (4 copies)
This contains papers presented at the SPUMS- RAN Meeting in August 1983 and at the ANZICS -SPUMS Meeting in Rockhampton in October 1983.

1985 Vol. 15, No. 4. (7 copies)
This contains papers from the 1985 Annual Scientific Meeting in Bandos and from the New Zealand Chapter of SPUMS Meeting in November 1985, including an account of the formation of the New Zealand Chapter.

1987 Vol. 17, No. 2. (13 copies)
This contains papers from the 1986 Annual Scientific Meeting in Tahiti.

1987 Vol. 17, No. 3. (6 copies)
This contains papers from the 1986 and 1987 Annual Scientific Meetings and papers assessing dive decompression computers.

1987 Vol 17, No 4. (8 copies)
This contains papers from the 1987 Annual Scientific Meeting.

1988 Vol 18, No 1. (25 copies)

1988 Vol 18, No 2. (12 copies)

1988 Vol 18, No 3 (28 copies)

1988 Vol 18, No 4 (18 copies)

Orders, with payment, should be sent to
SPUMS,
80 Wellington Parade,
East Melbourne,
Victoria, 3002,
Australia.

DIVER EMERGENCY SERVICE

008-088200

The DES number 008-088-200 can only be used in Australia.

For access to the same service from **outside Australia** ring **ISD 61-8-223-2855.**