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PROVERBS IV,7. Wisdom is the principal thing; therefore get wisdom: and with all thy getting get understanding.

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EDITORIAL

The best justification for a publication such as this is that it acts as a platform for the display and discussion of facts and opinions, on the assumption that such a course of action will encourage a better understanding of the subject matter. To be effective in such a role will involve an occasional challenge to accepted beliefs, which will be described by the innovators (iconoclasts) as dogma. Medicine certainly has a rich history of entrenched beliefs which had long outlived their usefulness, and it would be unrealistic to think that Diving Medicine escapes the same cycle of events. We now appear to be in the phase of reassessment of the decompression tables. There is an awareness that they are there for a purpose, which is to make a specified type of diving "reasonably free from the risk of significant decompression-related ill effects". For too long a dogmatic opinion held sway that because of the complex mathematics of their construction the results must be right. This ignored a basic and vital rule of science, that if facts and theory disagree, reconsider your theory. This belief in the correctness of the tables is an example of the self-fulfilling prophesy syndrome. As only those who broke the rules would be The Bends, the occurrence of any symptoms was proof of poor diving practices. What had been overlooked was that the designers of the tables had never stated that the tables prevented decompression sickness, only that, after whatever testing that had been done, decompression sickness was so infrequent as to be an acceptable incidence. Naturally the USN divers, who soon learnt that the incidence of decompression sickness considered acceptable by the table's originator was too high for comfort, started adding depth and time increments to the dive that they were doing to calculate the decompression requirements. With these fudge factors, the USN tables give an incidence of around 1 case of decompression sickness for every 3,000 dives. The use of fudge factors resulted in happy compilers of tables, unbent divers, and a misplaced belief in the correctness of the theoretical basis used to construct the tables. Astute readers will recognise this as another plea for the collection of masses of accurate diving data to enable a realistic evaluation of the appropriateness of present ideas on diving. The collection and the storage of such data will be addressed in the next issue.

There are several subjects ripe for re-evaluation, not least those of fitness to dive. Questions that we should consider in this context include the following. Should there be grades of fitness to dive? Should a person with a disability be allowed to dive at his (or her) own risk? Pertinent to this is the question "Does being a doctor give that person the right to play God?" Another is hinted at in a brief notice (whose significance may not occur to those who omit reading the Editorial!) on the question of who is to decide and list "persons considered to be adequately informed to perform a Diving Medical". It would be easy to make the listing a simple yes or no one by requiring the applicant to have passed an RAN course in Underwater Medicine. But such courses do not necessarily produce a thinking diving doctor or only one who at one time knew the expected answers and knew about RAN equipment. But recreational diving is a different matter, a branch of diving not part of the RAN course in past years. On the other hand, one can optimistically assume that the medical eduction produces a thinking person who will be able to apply the basic medical knowledge of underwater medicine, which does apply to everyone who ventures underwater or under pressure, to the civilian scene of the sports diver. There is no doubt that various government departments want a reliable and uniform standard of assessing fitness to dive, if only to reduce the problems of litigation in compensation cases. Other organisations also wish for a uniform standard of medical assessment of fitness to dive. No diving instructor wishes to be sued by the relatives of a deceased student whose medical condition precipitated his or her demise.

The ongoing nature of (diving) medical education is well described in Tim Anderson's paper. The only possible bone of contention is the generous assumption that those who follow the proposed course will, of necessity, thereby acquire understanding as well as experience. We have been fortunate that the RAN School of Underwater Medicine (SUM) has had officers willing and able to break free from strict adherence to the safe haven of the Diving Manual and able to introduce flexibility into management. Without such diving doctors as Carl Edmonds of SUM, the world of diving medicine would have been impoverished. He drew the world's attention to the problems of inner ear barotrauma and saltwater aspiration as well as contributing new ideas to the treatment of decompression sickness. His papers at the recent SPUMS Annual Scientific Meeting highlighted new problems. Some of them will be published in the next issue. He and his successors have illustrated the admonition given by a one time Oxford tutor, Kenneth Bell who, on first meeting his pupils said, "It is our purpose here to make you think rather than to know, but please remember that in order to think it is necessary to know." The validity and relevance of our advice as persons who have knowledge of diving medicine will rest on the degree to which we can live up to this statement.

SPUMS NOTICES

DOCTORS WITH TRAINING IN UNDERWATER MEDICINE

Any doctor, who has completed a course in Underwater Medicine, who wishes to have his or her name added to a list, to be published by SPUMS, of doctors who have completed the Underwater Medicine course conducted by the RAN, is invited to write to the Secretary of SPUMS (Dr Chris Acott whose address is on the opposite page), giving details of the course attended and of underwater medicine experience.

PROPOSED CONSTITUTIONAL AMENDMENT

It has been proposed that the outgoing president (Past President) be a member of the Executive Committee in the future. Having the Past President as a member of the Executive Committee increases continuity and lengthens the Corporate memory.

If any member objects to this change to the constitution they should write to the Secretary of SPUMS (Dr Chris Acott whose address is on the opposite page) registering the objection by 30 September 1985.

If any objections are received a postal ballot will be held.

NEW ZEALAND CHAPTER

At the Executive Committee meeting held at Bandos Island during the Annual Scientific Meeting it was decided to support the formation of a regional branch in New Zealand, to be known as the New Zealand Chapter.

The needs of New Zealand members would be better met with a local committee. It is envisaged that the Journal will be sent by air in bulk to be put in envelopes and posted in New Zealand. Subscriptions may be paid in NZ dollars to the New Zealand Chapter Committee, who will forward the money in one cheque, so saving on bank charges, to the Treasurer of SPUMS. The amount payable in NZ dollars will depend on the exchange rate!

The first meeting of the NZ Chapter will involve lectures and practical sessions at Great Barrier Island in the Hauraki Gulf, Thursday 7 November to Sunday 10 November 1985. Those interested in attending should write to

Dr W Paykel,
120 Vauxhall Road
Devonport, AUCKLAND 9

For further information about the New Zealand Chapter of SPUMS contact

Dr A Sutherland,
4 Dodson Avenue,
Milford, AUCKLAND 10

July 1985 rate	
Members	$ NZ 42
Associates	NZ 28

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 OF SPUMS

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 $30.00 and for Associate Members is $20.00.

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

Anyone interested in joining SPUMS should write to:

Dr Chris Acott,
Secretary of SPUMS,
Rockhampton Base Hospital,
Rockhampton QLD 4700.

REPRINTING OF ARTICLES

Permission to reprint original articles will be granted by the Editor, provided that an acknowledgment to the S*PUMS Journal* is printed with the article. Papers that have been reprinted from another (stated) source require direct application to the original publisher for permission to publish, this being the condition for publication in the *SPUMS Journal*.

NOTES TO CORRESPONDENTS AND AUTHORS

Please type all correspondence, in double spacing and only on one side of the paper, and be certain to give your name and address even though they may not be for publication.

Authors are requested to be considerate of the limited facilities for the redrawing of tables, graphs or illustrations and should provide them in a presentation suitable for photo-reduction direct. Books, journals, notices for symposia etc., will be given consideration for notice in this journal.

LETTERS TO THE EDITOR

Department of Diving and Hyperbaric Medicine
The Prince Henry Hospital
Anzac Parade
LITTLE BAY

25 February 1985

Dear Sir

I write to correct a number of errors and misconceptions arising from comments in the article DAN (Divers Alert Network) Australia by Robert Sands in the October-December 1984 edition of the *Journal*.

The multi-chamber facility in the Hyperbaric Unit at The Prince Henry Hospital, Sydney, is, and will be, available for diver treatment 24 hours a day, as it has for many years. The State Government has denied categorically any future interference with the full functioning of The Prince Henry Hospital, and intends that full service including Hyperbaric will be available for all civilians in the State and from elsewhere. The complex will continue to be fully available and used by divers even after the new complex opens at HMAS Penguin. Any suggestion that adequate facilities or staffing expertise do not exist at The Prince Henry Hospital will be construed as libellous and therefore actionable, and any attempt to dissuade patients from voluntarily using The Prince Henry Hospital facilities by insinuation of lack of expertise or facilities will be similarly regarded. The Hyperbaric Unit in this State Public Hospital has been provided by the State Government for the treatment of civilian diving casualties, and will continue in this role.

Ian P Unsworth
Director of Diving and Hyperbaric Medicine

Albatross Films and Marine Services
PO Box 337
MT ELIZA VIC 3930
Phone (03) 787 6870

13 April 1985

Dear Sir

I have been an associate member of SPUMS since 1976 and as a keen and regular diver I have gained a great deal of information contained in the Journal. Of particular value are the detailed reports from Operation Stickybeak and the annual diver accident reports from the United States. For practicing divers and those who teach it I don't think that there can be too much of this type of material.

Given the recent increase in the number of recompression treatments carried out both in Townsville (in the AIMS chamber) and Morwell (in the NSC chamber) there is an obvious need for an increased level of diver education and advice in the areas of decompression and repetitive diving.

This leads me to comment on item 3 in the General Business section of the Minutes of the Executive Committee meeting reported in the *SPUMS Journal*, Vol. 14, 1984 headed "Diving Tables". I quote, "J Knight suggested that SPUMS should print Bruce Bassett's revision of the USN tables on plastic and distribute it free through dive shops and the National Qualification Scheme as the best compromise between safety and repetitive dives at present available. After lengthy discussion it was decided that SPUMS could not recommend any particular tables." The report continues to say that diver education in this matter should be stressed.

While agreeing with the Executive Committee's decision to stress the importance of diver education, I feel that SPUMS should also be prepared to give an informed lead to the diving community and recommend which tables it thinks should be used and to participate actively in the distribution of such tables.

Decompression and repetitive diving is a fact of life, both amongst sports and professional divers. We are all told of the limitations and dangers inherent in the USN tables and how they are not conservative enough. So here is a chance for SPUMS to contribute in a real way to diver awareness and safety. It's pointless pushing tables that don't allow for repetitive diving. They will not be used by the diving community. But a revised and safer version of the USN tables will. If such a scheme saves even one diver getting bent, it will have been worthwhile.

Yours sincerely
David Parer

The Bassett tables, in an easily used format were presented at the SPUMS Annual Scientific Meeting on Bandos Island in the Maldives Republic. The paper is printed on page 8 of this issue. A commercial version will shortly be on sale in the dive shops.

Mr Parer will be pleased to see that other people are also pushing the Bassett tables as the book review, on page 18, makes clear.

PROJECT STICKYBEAK

The aim of this investigation is to receive, store, and if appropriate publish and make available for discussion, an accurate record of all types and severities of problems encountered by divers.

CONFIDENTIALITY is maintained and no details are published to identify persons involved or sources of information.

Please send reports to:

Dr DG Walker,
PO Box 120,
NARRABEEN NSW 2101.

SPUMS ANNUAL SCIENTIFIC MEETING

APRIL 1985

DIVING SAFETY

Peter McCartney

I would like to concentrate on the few specific aspects of diver safety that I feel are significant in Tasmania and suggest measures that I feel could be utilized to reduce diver morbidity and mortality.

The first point I want to make is that abalone divers, sport divers and high tech divers are distinct groups with different problems.

There are 125 registered diver fishermen (abalone divers) in Tasmania:

120 abalone divers
2 mussel divers
3 sea urchin and cockle divers

This is by far the biggest number registered in any Australian state.

On the commercial and industrial side comprehensive regulations obtain and are strictly and efficiently enforced. Poaching is monitored and dealt with efficiently.

A new diver wishing to enter the industry has to produce financial resources in the range of $250,000. The bulk of this is for the purchase of a licence and a quarter of it is for a boat and equipment.

There have been 4 fatalities in the last 11 years. Two were due to shark attack, the third involved a ruptured lung from a rapid ascent, in a fit, competent diver with a good record. The fourth occurred in fresh, cold water, at high altitude, with nil visibility, ie. the diver was diving in an unfamiliar environment.

There have been 16 cases of decompression sickness in abalone divers in the last 4 1/2 years. Of these, 3 have been spinal bends and 11 limb bends.

In Tasmania abalone divers have an annual medical examination and every third year a major, more comprehensive medical examination. All divers must and do comply with this. Long bone surveys and audiometry are included. The possibility of looking at psychological aspects of divers is being considered by three separate studies and this is certainly an area worth exploring. On two separate occasions the question of diver education has been raised at State and Federal levels, but so far has come to nothing.

People need training and proof of ability to fly a light aircraft or drive a taxi, but inspite of the costly controls and regulations, there is no such provision for the abalone diver.

It is possible for a new person in the industry to receive a brief 20 minute verbal instruction on the equipment he is about to purchase together with the licence. It is usually the case that licence and equipment come as a package deal. If the newcomer considers himself a ‘strong swimmer’ he may have no scuba training or experience. It is entirely his judgement and he is free to purchase the licence and equipment.

This situation is the exception and most abalone divers have had the practical skills taught by established divers and the majority adhere to safe diving procedures.

I suggest that if a newcomer to the industry is not familiar, comfortable and ‘competent’ at his job, he is at a disadvantage from the industrial standpoint. If he is subjected to financial pressure to service his loan on top of this, the scene is set for danger.

As indicated by our records, the incidence of decompression sickness is not decreasing in Tasmania. I feel that here is an area where education and legislation could provide for some basic improvements in safe diving practice. With the availability of a range of training programmes being devised by the National Safety Council of Australia (Victorian Division), I feel it is remiss not to go ahead and implement a course, which could be supervised by such a body.

I would make the point that the majority of Tasmanian abalone divers are responsible, competent people who have good safe diving practices. Indeed I feel that if more consultation could occur the benefit of the skills learned and passed on over the years, could be made available to a wider group of abalone divers, and the new divers coming into the industry could benefit by this information.

I would make the point that the medical profession is not in a position to lay down hard and fast safety limits in relation to the dive times and depths for abalone divers. However guidelines could be recommended. Abalone diving needs the advantages of the ‘art of safe diving’ as well as the ‘science of safe diving’.

On the sport diving scene I would like to mention three diver deaths. There have, incidentally, been no case of decompression sickness over the same period in sport divers. One death was a novice diver loaned hired gear by a diving buddy. This sad scenario shows up over the years in “Project Stickybeak” reports. In the other two cases there was a reported reluctance to dive by the diver who subsequently met his death on the dive. I feel instructors should be made aware of the need to tell their students not to dive if they have a “gut feeling” that conditions are not right for them on the occasion.

I think anyone interested in this field owes a debt of gratitude to Dr Douglas Walker and his excellent work on the “Project Stickybeak”.

RED HERRINGS

Peter Chapman-Smith

Red Herrings do not actually occur in New Zealand's subtropical waters but the handsome red snapper is an attractive alternative. It is hardly surprising that New Zealand has a larger population of divers per capita than any other nation. This reflects a readily available underwater environment, lengthy coastlines, and a fascinating marine world. Most sports diving occurs on the East Cape and the Three Kings Islands in the far North, beckoned particularly by the off-shore island chain. Perhaps SPUMS may have an opportunity to explore this region in years to come.

Inevitably diving related incidents or accidents present to interested medical practitioners, and I would like to present two short cases for discussion. I have chosen my title because it could be that neither problem was related to diving.

Case 1

An experienced New Zealand Underwater Association (NZUA) trained 27 year old male scuba diver presented twice in 6 months with recurrent facial swelling, apparent at shallow depths on ascent. He initially felt "numb" in his right cheek ("like going to the dentist"), the swelling spreading across his upper lip to the midline. This increased over 24 hours and subsided spontaneously over 2 to 4 days.

He dived on most days, predominantly for crayfish. They were frequently hard working dives with reputed non-decompression bottom times of between 5 and 20 minutes. This was to depths of between 100 and 140 feet. (Several other divers confided that he dived below 200 feet on occasions so there is doubt whether his histories are reliable). His ascent rate was allegedly normal, and he always had a snack of potato chips and coke just before diving. He was a non-smoker with no history of previous diving accidents. He was a mild asthmatic on no regular medications but with multiple allergies (to pollen, grass, dust, etc.), and occasional sinusitis, presumably on the basis of allergic rhinitis.

This swelling occurred on 4 occasions, but not on successive dives, and while using different regulators. On one of these occasions he noted reverse ear squeeze (barotrauma of ascent) on ascent, and on another, developed a post-dive bi-temporal headache for approximately 10 minutes.

He presented acutely, as invited, 6 months after his initial presentation. On examination several hours post-dive, he was neurologically normal with an oedematous right upper lip, which was 2 to 3 times its usual size. There were no other relevant signs or symptoms. (On his initial presentation 3 days post-dive he had a similar facial wheal appearance with several small red maculopapules in the same distribution).

X-rays were reported to demonstrate "moderate soft tissue swelling in the inferior aspect of the left antrum". There was apparent dental caries in the right posterior upper molar (which appeared to be non-vital) and also in a right upper premolar. No subcutaneous emphysema was noted.

The viability of a root pulp cannot be determined on radiological appearances alone, but the loss of bone density around the apices was indicative of non-vitality.

He was referred for a dental opinion, but was last seen bound for Hawaii on a yacht.

The differential diagnoses

1. Lymphatic or capillary obstruction causing lymphoedema as in minor decompression sickness.

2. Dental caries with apical gas tracking, but against this is the fact that no subcutaneous emphysema was noted, either clinically or on X-ray.

3. Local allergy to the rubber or metal of the regulator, but against this is that he used a number of different regulators.

4. Any other suggestions.

Case 2

This case is reported with the subject's blessing.

A trained and experienced 54 year old male scuba diver presented with a sudden visual deficit on a charter trip to the Three King Islands 50 miles West of North Cape right off the top of New Zealand. The vessel "Elingamite" attempted to bulldoze the West King Island in a storm during a night in 1902. The island is perhaps 100 yards wide! Some divers have made their fortune and some have since met their maker in subsequent salvage attempts on this moderately accessible wreck. The cold blue water and abundant fish life inevitably command attention, but strong, unpredictable currents and remoteness make it still a relatively untouched and potentially hostile area for divers. This diver had dived in the area previously.

After 5 days of regular diving, mostly in search of that elusive superb underwater photograph, this man had a leisurely first non-decompression dive at 100 feet. After approximately a three hour surface interval he was loading film in his camera aboard the charter boat when he stooped forward head down. He then coughed feeling as though he was perhaps developing a cold. On sitting upright he felt that maybe something was unusual in his vision. Coming out from the dark cabin to the daylight it was apparent that a red curtain was descending in his right superior visual field. This continued to descend equatorially over the next few hours. He was aware of some light above the redness peripherally from the onset of symptoms. After specialist consultation by radio, he aborted his trip. He had sustained an inferior pre-retinal haemorrhage in his right eye.

This man was physically unfit, being mildly obese with uncontrolled maturity onset diabetes melitus, diagnosed 9 years before. He was usually normotensive. His non-insulin dependant diabetes was "controlled" with diet and a small dose of an oral hypoglycaemic agent which had not been changed for some years. A medical practitioner by occupation he had not had any laboratory investigations in the preceding 18 months, and did not attend a GP.

In the 2 days before this incident he had been caught in a powerful surface current involving heavy finning. Wisely he had decided not to dive after contending with the current for several minutes. He could not swim the 20 feet to the anchor chain. The following day he had made a non-decompression dive to 120 feet and had rapidly ascended from 20 feet after running out of air after an abnormally increased air consumption! His buddy had 1500 psi remaining at the end of the dive. It had been a very gentle dive.

Eventually it turned out that he had significant diabetic proliferative retinopathy, severe in one eye, and strangely enough to a mild degree in his remaining left good eye. Fundoscopy and fluoroscein angiography confirmed that he had sustained a vitreous haemorrhage in his right eye, presumably from neo-vascularisation capillary loops. His fasting blood glucose was in excess of 17 mmol/1.

The retina receives its blood supply from two sources. The inner two-thirds is supplied from the central retinal artery, while the outer one-third photo-receptors and pigment epithelium receive their arterial supply from the choriocapillaris, single layer of capillaries attached to the outer layer of Bruch's membrane.

Both juvenile and maturity onset diabetes predispose a diabetic retinopathy which is related to the duration of the disease and its degree of control. In proliferative retinopathy fragile new vessels grow from the retina or the optic nerve head adhering to the posterior surface of the vitreous. Vitreous contraction can pull on these new vessels causing bleeding into the retrohyaloid space or into the vitreous body itself. Associated retinal detachment may occur. Many conditions may cause such bleeding, eg. trauma, systemic diseases (diabetes, hypertension, leukaemia), increased arterial pressure, increased venous pressure, inflamed vessels, arterio-venous malformation, retinal tears, others (tumours etc).

Blood in the vitreous body clots rapidly, forming a red mass with sharp borders. This is related to the collagen fibres and clotting substances present. In the retrovitreal space however blood remains fluid.

It is worth noting that vitreous haemorrhages can occur at rest in bed even with stable diabetic control. This is more dependent on the presence of proliferative retinopathy.

The intraocular pressure is related to the mean arterial pressure, but is generally a stabilising influence on the arterial and venous pressures. Intraocular pressure (IOP) is increased by hypoxaemia, hypercapnia, coughing, sneezing, straining, venous obstruction in the head and neck, and increased CSF pressure. IOP is decreased by hyperoxia, hypocapnia, hyperventilation, and systolic BP less than 85 mmHg.

This case raises the following points.

1. What was the cause of the haemorrhage? Was it merely concurrent uncontrolled systemic disease, or transient hypertension with exertion in previous days, or a cough causing raised venous pressure and IOP, or a bubble phenomena due to decompression sickness, silent bubbles or air embolism.

2. The medical practitioner as a diver. How significant was the denial of the importance of systemic disease, the likely absence of proper medical screening, and the absence of a general practitioner.

3. Fitness to dive. Surely this story raises the problem of medical problems arising in our latter years and perhaps causing unfitness to dive. I would suggest that there is a need for medicals every 5 years over the age of 40, to retain certification.

COMMENTS

These are two fascinating cases from our New Zealand colleague . The first case seems to be consistent with a number of other similar ones who have had recurrent episodes of purely lymphoedema with decompression sickness. I feel that had either a trial of pressure, or the inhalation of 100% oxygen for a few hours been performed, then the diagnosis would have been verified.

Like the first case, the second is a very informative one and serves to remind us of similar situations in the past. The final accident that the diabetic diver experienced is well described and explained. I think Peter skipped over a very good demonstration of one of the problems of the diabetic diver, when he glossed over the incident the day before. Peter and his diabetic buddy performed the same dive but the diabetic panicked and was in an "out of air" situation while Peter had over half his air pressure remaining.

Diabetics often have this trouble. In an attempt to avoid the very likely episode of hypoglycaemia associated with extreme or unexpected exertion, he has no option other than to reduce his insulin or anti-diabetic medication. In doing this, he must increase his blood glucose level, together with the associated acidotic products. Thus he has no option other than to dive in a more or less acidotic state. He is then likely to over-breath his regulator and result in either excessive usage of gas and therefore an out of air situation, or panic because of the resistance from over-breathing the regulator. In this case, apparently both things happened.

Carl Edmonds
Sydney.

TOWARDS SAFER DIVING
BRUCE BASSETT'S REVISED NO-Decompression TABLES

John Knight

Over the past couple of years decompression sickness presenting for treatment has become more common in Australia. The reasons for this increase must include some or all of the following.

1. An unchanged incidence of DCS with a better understanding of the need for treatment among the sufferers. I think that much of the Victorian increase is real, whatever the case is for other areas.

2. Diving exactly the dive set out in the tables. Many divers seem to believe that decompression tables have a zero incidence of DCS if followed properly. This is a delusion fostered by the fact that few sports divers dive in the pattern of the tables which is go straight to the bottom, stay on the bottom at that depth, and return straight to the surface. Those that do such dives, diving on deep wrecks, prove that the tables have an "acceptable" incidence of DCS!

3. Poor dive planning has always been a hazard. With the increase in available treatment chambers some of the less sensible divers may have decided that there is no need to worry about planning dives. If anything goes wrong there is a chamber to treat and cure one. Again this is a fallacy as not every victim of DCS leaves the chamber in "as new" condition.

4. Many divers are unable to use decompression tables properly, especially when calculating repetitive dives.

5. Many depth gauges are inaccurate. If they read deep this does not matter. In fact it is a safety factor as long as the diver does not allow for it! The dangerous gauges are those that read shallow. This is especially true if the diver thinks that the gauge is accurate. Flying can affect Bourden tube depth gauges if they are not kept at sea level by being sealed in a pressure proof container. Fortunately not all depth gauges are affected every flight! The manufacturers of the Bendeez oxygen adaptor have produced a "Jackpot" which is a portable compression chamber for testing depth gauges, and for those with some $400 there is an easy way to know how accurate one's depth gauge is.

6. Finally there is the problem of not diving the planned dive. A friend of mine developed an elbow bend when he surfaced rapidly from 24m (80 feet) when he saw the anchor of his boat go past. He caught his boat and came back to pick up his wife.

One man, who had neither watch nor depth gauge, drifted an unknown distance below his companions on a dive planned to go to 60m (200 feet). The three divers decompressed as for a longer dive to 63m (210 feet) however the wanderer developed DCS (an elbow bend) soon after surfacing. His companions thought that the correct treatment was to repeat his stops, so he got back into the water. Shortly after reboarding the boat he developed neurological symptoms. It took 6 hours to get him to a chamber by which time he was quadriplegic. A week later he was taken from the chamber with a residual paraplegia which has now improved so that he is walking again.

What can be done to reduce the incidence of DCS? One has to alter the behaviour of divers so that they dive more safely. A very obvious statement but difficult to achieve.

The only time most divers are taught anything is during their training course. This is when they are introduced to decompression tables and, judging by divers I have met over the years, introduced is unfortunately the correct word, as many divers do not know how to use the tables correctly.

The simplest layout for any decompression table that I have seen is the RNPL/BSAC table (Figure 1). This table has the depths in increments of 2m. Problems arise with repetitive dives as, although there is an allowance for outgassing nitrogen with time, the second dive's decompression requirements are based on the deepest (sic) depth reached in the two dives. It is easy to forget this when calculating the no-stops time for the second dive.

In 1981 Dr Bruce Bassett delivered a paper entitled "The safety of the United States Navy decompression tables and recommendations for sports divers" at the SPUMS Annual Scientific Meeting at Madang.2 He pointed out that in chamber dives the USN no-decompression table, when dived to the limit, gave a 6% incidence of DCS. In practice the USN rate for DCS is less than 0.1%. What is the explanation for this large difference? It is because the USN divers never dive the USN tables. For decompression dives they always add at least one depth and one time increment and decompress for the time applicable to the fictitious depth and time. For no-decompression dives within 5 minutes of the limit for that depth they again add one depth and one time! As most USN diving is surface supplied the decisions are taken by the supervisor, who is unaffected by nitrogen narcosis, and not by the diver.

In the December 1984 issue of Undersea Biomedical Research, Dembert et al give the USN DCS figures for 1981. Thirty-five divers developed DCS out of 92,484 dives which is 0.037%.[3] Almost all USN scuba diving on air is shallow.

Obviously if the USN air tables are used as the USN actually uses them they are as good as any other table in preventing DCS.

Would promoting the use of Dr Bruce Bassett's Revised "No-Decompression" Limits Decompression table reduce the incidence of decompression sickness (DCS)? I believe that it would, especially using the layout that John Lippmann and I have worked out (Figure 4)

Dr Bruce Bassett is a physiologist who served 20 years in the US Air Force. His last assignment was to construct a Set of tables for flying at 10,000 feet immediately after finishing a dive. This was, I understand so that combat

RNPL/BSAC Air Diving Decompression Table

Max Depth metres	No Stop mins	Bottom Time					
9	NO LIMIT						
10	232	431	–	–	--	–	
12	137	140	159	179	201	229	270
14	96	98	106	116	125	134	144
16	72	73	81	88	94	99	105
18	57	59	66	71	76	80	84
20	46	49	55	60	63	67	70
stops at	5m	5	10	15	20	25	30

Max Depth metres	No Stop mins	Bottom Time				
22	38	42	47	51	56	58
24	32	37	41	45	48	51
26	27	32	37	40	43	45
28	23	29	33	36	39	41
30	20	25	30	33	36	37
32	18	23	27	30	32	34
34	16	21	25	28	30	31
36	14	20	23	26	27	29
38	12	18	21	24	26	27
40	11	17	20	22	24	25
42	10	16	19	21	22	24
44	9	15	18	20	21	
46	8	14	17	18	20	
48	8	13	16	17		
50	7	12	15	17		
stops at	10m	5	5	5	5	5
	5m	5	10	15	20	25

ASCENT RATE 15 metres per min
DESCENT RATE Max. 30 metres per min
No more than 8 hrs. in 24 hrs. spent under pressure (submerged).

DOUBLE DIVES (A, B)	
Decompress for the deepest depth	
1st dive duration	A mins
2nd dive duration	B mins
B < 9 metres – No stop	
Interval	**Bottom Time**
Both dives less than 40 metres	
Up to 2 hr.	A + B
2-4 hr	A/2 + B
4-6 hr.	A/4 + B
6 + hrs.	B
Either dive more than 40 metres	
Up to 2 hr.	A + B
2-4 hr.	A/2 + B
4-8 hr.	A/4 + B
8-16 hr.	A/8 + B
16 + hrs.	B

DETAILS OF PREVIOUS DIVE
Time Depth Duration

swimmers could be picked up by helicopter and then flown away in normal aircraft.

He calculated, using the mathematics of the USN air diving tables, a set of equivalent no-decompression dives so that the supersaturation levels and ratios allowed by the USN no-decompression table were achieved in the diver at 10,000 ft. If the USN tables were safe these shorter dives followed by decompression to altitude, with the same supersaturation ratios at altitude as the USN tables had on surfacing, should have been safe. They were not as they had a DCS incidence of 6%, which was unacceptable.[2]

Dr M Spencer in Seattle had already tested the USN No-decompression tables in a chamber and found that he had about a 6% incidence of DCS.

These two sets of dry chamber data and the knowledge that the USN divers always added depth and time before calculating decompression led Dr Bassett to recalculate his dive schedule using lesser M values, that is he reduced the allowable supersaturation in the various half time tissues. The two sets of supersaturation ratios for each half time tissue appear in Table 1.

TABLE 1

LIMITING VALUES OF USN AND BASSETT TABLES

HALF TIME	US NAVY RATIO	BASSETT RATIO
5	3.15	2.88
10	2.67	2.52
20	2.18	2.03
40	1.76	1.63
80	1.58	1.41
120	1.51	1.33

When Dr Bassett tested his revised decompression procedures in the chamber there were no bends.

NO-DECOMPRESSION LIMITS AND REPETITIVE GROUP DESIGNATION TABLE FOR NO-DECOMPRESSION AIR DIVES

Depth (feet)	No-decompression limits (min)	Group Designation A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
10		60	120	210	300											
15		35	70	110	160	225	350									
20		25	50	75	100	135	180	240	325							
25		20	35	55	75	100	125	160	195	245	315					
30		15	30	45	60	75	95	120	145	170	205	250	310			
35	310	5	15	25	40	50	60	80	100	120	140	160	190	220	270	310
40	200	5	15	25	30	40	50	70	80	100	110	130	150	170	200	
50	100		10	15	25	30	40	50	60	70	80	90	100			
60	60		10	15	20	25	30	40	50	55	60					
70	50		5	10	15	20	30	35	40	45	50					
80	40		5	10	15	20	25	30	35	40						
90	30		5	10	12	15	20	25	30							
100*	25		5	7	10	15	20	22	25							
110	20			5	10	13	15	20								
120	15			5	10	12	15									
130	10			5	8	10										
140	10			5	7	10										
150	5			5												
160	5				5											
170	5				5											
180	5				5											
190	5				5											

RESIDUAL NITROGEN TIMETABLE FOR REPETITIVE AIR DIVES

*Dives following surface intervals of more than 12 hours are not repetitive dives. Use actual bottom times in the Standard Air Decompression Tables to compute decompression for such dives.

Repetitive group at the beginning of the surface interval

	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
A																0:10 12:00*
B															0:10 2:10	2:11 12:00*
C														0:10 1:39	1:40 2:49	2:50 12:00*
D													0:10 1:09	1:10 2:38	2:39 5:48	5:49 12:00*
E												0:10 0:54	0:55 1:57	1:58 3:22	3:23 6:32	6:33 12:00*
F											0:10 0:45	0:46 1:29	1:30 2:28	2:29 3:57	3:58 7:05	7:06 12:00*
G										0:10 0:40	0:41 1:15	1:16 1:59	2:00 2:58	2:59 4:25	4:26 7:35	7:36 12:00*
H									0:10 0:36	0:37 1:06	1:07 1:41	1:42 2:23	2:24 3:20	3:21 4:49	4:50 7:59	8:00 12:00*
I								0:10 0:33	0:34 0:59	1:00 1:29	1:30 2:02	2:03 2:44	2:45 3:43	3:44 5:12	5:13 8:21	8:22 12:00*
J							0:10 0:31	0:32 0:54	0:55 1:19	1:20 1:47	1:48 2:20	2:21 3:04	3:05 4:02	4:03 5:40	5:41 8:40	8:41 12:00*
K						0:10 0:28	0:29 0:49	0:50 1:11	1:12 1:35	1:36 2:03	2:04 2:38	2:39 3:21	3:22 4:19	4:20 5:48	5:49 8:58	8:59 12:00*
L					0:10 0:26	0:27 0:45	0:46 1:04	1:05 1:25	1:26 1:49	1:50 2:19	2:20 2:53	2:54 3:36	3:37 4:35	4:36 6:02	6:03 9:12	9:13 12:00*
M				0:10 0:25	0:26 0:42	0:43 0:59	1:00 1:18	1:19 1:39	1:40 2:05	2:06 2:34	2:35 3:08	3:09 3:52	3:53 4:49	4:50 6:18	6:19 9:28	9:29 12:00*
N			0:10 0:24	0:25 0:39	0:40 0:54	0:55 1:11	1:12 1:30	1:31 1:53	1:54 2:18	2:19 2:47	2:48 3:22	3:23 4:04	4:05 5:03	5:04 6:32	6:33 9:43	9:44 12:00*
O		0:10 0:23	0:24 0:36	0:37 0:51	0:52 1:07	1:08 1:24	1:25 1:43	1:44 2:04	2:05 2:29	2:30 2:59	3:00 3:33	3:34 4:17	4:18 5:16	5:17 6:44	6:45 9:54	9:55 12:00*
	0:10 0:22	0:23 0:34	0:35 0:48	0:49 1:02	1:03 1:18	1:19 1:36	1:37 1:55	1:56 2:17	2:18 2:42	2:43 3:10	3:11 3:45	3:46 4:29	4:30 5:27	5:28 6:56	6:57 10:05	10:06 12:00*
NEW → GROUP DESIGNATION	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
REPETITIVE DIVE DEPTH																
40	257	241	213	187	161	138	116	101	87	73	61	49	37	25	17	7
50	169	160	142	124	111	99	87	76	66	56	47	38	29	21	13	6
60	122	117	107	97	88	79	70	61	52	44	36	30	24	17	11	5
70	100	96	87	80	72	64	57	50	43	37	31	26	20	15	9	4
80	84	80	73	68	61	54	48	43	38	32	28	23	18	13	8	4
90	73	70	64	58	53	47	43	38	33	29	24	20	16	11	7	3
100	64	62	57	52	48	43	38	34	30	26	22	18	14	10	7	3
110	57	55	51	47	42	38	34	31	27	24	20	16	13	10	6	3
120	52	50	46	43	39	35	32	28	25	21	18	15	12	9	6	3
130	46	44	40	38	35	31	28	25	22	19	16	13	11	8	6	3
140	42	40	38	35	32	29	26	23	20	18	15	12	10	7	5	2
150	40	38	35	32	30	27	24	22	19	17	14	12	9	7	5	2
160	37	36	33	31	28	26	23	20	18	16	13	11	9	6	4	2
170	35	34	31	29	26	24	22	19	17	15	13	10	8	6	4	2
180	32	31	29	27	25	22	20	18	16	14	12	10	8	6	4	2
190	31	30	28	26	24	21	19	17	15	13	11	10	8	6	4	2

RESIDUAL NITROGEN TIMES (MINUTES)

The Bruce Bassett "Revised No-decompression limits for the Sports Diver", to give the table its full name, are based on these reduced supersaturation ratios. The result is a no-stops table which differs from both the USN, RN, and RNPL/BSAC tables.

The main difference is that the Bassett Table, being designed for sports divers, does not go below 42m (or 140 ft) as he has evidence that deep dives are more dangerous. The USN no-decompression table (Figure 2) allows dives to 57m (190 ft) while the RNPL/BSAC table (Figure 1) allows dives to 50m (165 ft). Dr Bassett holds that sports divers dive for fun and that fun does not include getting bent! I agree with him.

The UK Health and Safety Executive limits air diving in the North Sea oilfields to 50m (165 ft) partly because of a high accident rate at these depths in the early years, and partly because of diver inefficiency meant that jobs were badly done. If it is unsafe for professional divers to go below 50m on air it must be equally unsafe for sports divers. As the professionals are usually using surface supplied equipment, which means an unlimited air supply, the balance is tilted even further against the sports diver who always uses scuba and may run out of air.

Another difference is that Dr Bruce Bassett puts a time limit on dives to 9m (30 ft) which none of the other tables do. The limit is hardly going to inconvenience a scuba diver as it is 220 minutes. It should be an exceptionally peaceful diver who could make a single cylinder last 3 hours 40 minutes!

By using lower allowable super-saturation ratios the bottom times have to be shorter. This is especially noticeable at shallower depths. At 10m (35 ft) the USN limit is 310 minutes, the RNPL/BSAC limit is 232 minutes and Bruce Bassett's is 180 minutes. At 12m (40 ft) the USN allows 200 minutes, the RNPL/ BSAC table 137 minutes and Bassett's limit is 120 minutes. At 15m (50 ft) the USN limit is 100 minutes while Bassett's is 70 minutes. The RNPL/BSAC table is in multiples of 2m, so the next deeper depth is 16m when 76 minutes are allowed. At 18m (60 ft) the USN limit is 60 minutes, the RNPL/BSAC one is 57 minutes and Bassett's is 50 minutes.

For 21m (70 ft) the USN allows 50 minutes, the RNPL/ BSAC allows 38 minutes (at 22m), while Bassett allows 40. At 24m (80 ft) the USN limit is 40 minutes, the RNPL/ BSAC one is 32 minutes and Bassett's is 30 minutes. At 27m (90 ft) the USN allows a 30 minute dive, the RNPL/ BSAC dive is 23 minutes (at 28m), while the Bassett limit is 25 minutes. At 30m (100 ft) the USN limit is 25 minutes, the RNPL/BSAC and the Bassett tables allow 20 minutes. At 33m (110 ft) the USN allows 20 minutes, the RNPL/ BSAC allows 16 minutes (at 34m), while Bassett allows 15 minutes. At 36m (120 ft) the USN limit is 15 minutes, the RNPL/BSAC has 14 minutes and the Bassett tables allow 12 minutes. At 39m (130 ft) both the USN and Bassett tables allow a 10 minute dive while the RNPL/BSAC limit is 11 minutes (at 40m). At 42m (140 ft) the USN and RNPL/BSAC table allow 10 minutes while Bassett has 5 minutes.

TABLE 2

"NO-DECOMPRESSION" LIMITS

DEPTH		TIME IN MINUTES		
FEET	METRES	USN	BS-AC	BASSETT
30	9			220
35	10.5	310	232	180
40	12	200	137	120
50	15	100	72	70
60	18	60	57	50
70	21	50	38	40
80	24	40	32	30
90	27	30	23	25
100	30	25	20	20
110	33	20	16	15
120	36	15	14	12
130	39	10	11	10
140	42	10	10	5

The depths in the BS-AC table are in increments of 2m. For odd numbered depths in metres the standard procedure, of using the next greater depth, has been followed for the BS-AC table.

To summarize, the Bassett tables call for shorter bottom times than the USN No-decompression tables allow. As the USN table, taken to its limits has a 6-8% DCS rate, in the chamber, a reduction in bottom time seems reasonable as chamber dives are known to have a lower rate of DCS than in water dives. The reduction is 5 minutes at depths of 27m (90 feet) and below. From 18 to 24m (60 to 80 ft) the reduction is 10 minutes. Above 18m (60 ft) the reductions from USN limits are considerable but leave plenty of diving time, 70 minutes at 15m (50 ft), 120 minutes at 12m (40 ft), 180 minutes at 10m (35 ft) and 220 minutes at 9m (30 ft).

Dr Bassett's revised no-decompression limits are made safer still by adding a 3 to 5 minute safety stop at 3 to 5m (10 to 16 ft) for all dives below 9m (30 ft). He uses both belt (shorter bottom times) and braces (suspenders in his words), because developing DCS is not fun and sports divers dive for fun.

The introduction of a safer set of no-decompression limits is excellent, but would sports divers use them? Unfortunately very few sports divers are willing to accept only one dive a day. They want at least two, and most are unwilling to limit themselves to a second dive at 9m (30 feet) or less, or three or more. Personally I limit myself to 2 dives a day. The RNPL/BSAC tables (Figure 1) have failed to catch on in Victoria inspite of being taught in many of the diving schools. I think that one of the reasons is the fact that the second dive has to be less than 9m or decompression has to be calculated for the deeper of the two depths, and there is no provision for a third dive. The USN tables (Figure 2) do allow for second and third dives. By using repetitive groups and the surface interval table one can calculate the "residual nitrogen" which is expressed as minutes already "dived" on the next dive. Simple

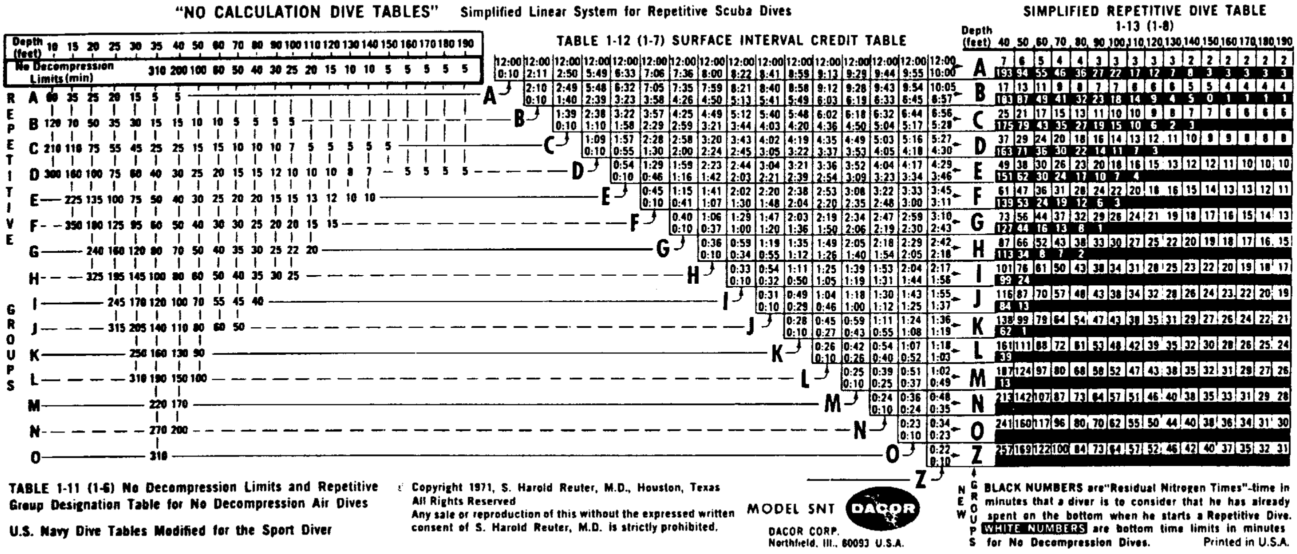

TABLE 3

<u>REPETITIVE DIVE TABLE</u>
(No Decompression Dives)

For each repetitive group the upper line is USN Residual Nitrogen Time, the *lower line is the time available for "no decompression" diving using Dr Bruce Bassett's revised "no decompression limits"*.

Depths (m)	9	12	15	18	21	24	27	30	33	36	39	42
(feet)	30	40	50	60	70	80	90	100	110	120	130	140
A		7	6	5	4	4	3	3	3	3	3	2
	213	*113*	*64*	*45*	*36*	*26*	*22*	*17*	*12*	*9*	*7*	*3*
B		17	13	11	9	8	7	7	6	6	6	5
	203	*103*	*57*	*39*	*31*	*22*	*18*	*13*	*9*	*6*	*4*	-
C		2.5	21	17	15	13	11	10	10	9	8	7
	195	*95*	*49*	*33*	*25*	*17*	*14*	*10*	*5*	*3*	*2*	-
D		37	29	24	20	18	16	14	13	12	11	10
	183	*83*	*41*	*26*	*20*	*12*	*9*	*6*	*2*	-	-	-
E		49	38	30	26	23	20	18	16	15	13	12
	171	*71*	*32*	*20*	*14*	*7*	*5*	*2*	-	-	-	-
F		61	47	36	31	28	24	22	20	18	16	15
	159	*59*	*23*	*14*	*9*	*2*	*1*	-	-	-	-	-
G		73	56	44	37	32	29	26	24	21	19	18
	147	*47*	*14*	*6*	*3*	-	-	-	-	-	-	-
H		87	66	52	43	38	33	30	27	25	22	20
	133	*33*	*4*	-	-	-	-	-	-	-	-	-
I		101	76	61	50	43	38	34	31	28	25	23
	119	*19*	-	-	-	-	-	-	-	-	-	-
J		116	87	70	57	48	43	38	34	32	28	26
	104	*4*	-	-	-	-	-	-	-	-	-	-
K		138	99	79	64	54	47	43	38	35	31	29
	82	-	-	-	-	-	-	-	-	-	-	-

subtraction from the no-decompression limit of the second dive depth gives the time available for a second no-decompression dive. And the process can be repeated time and time again. Very convenient and used by most Australian sports divers. Unfortunately the USN seldom uses its repetitive dive table, so there are no statistics of how safe they are in USN hands diving the USN way (adding at least one depth and one time). However there are drawbacks to this system. DCS is seen more often after repetitive dives than after single dives. Also there is always the possibility of an error when subtracting the residual nitrogen time from the "no-decompression" time. Errors of ten minutes are very easy to make.

The subtraction error is avoided in such layouts of the USN tables as the "Nu-way" and the "No calculation dive tables" (Figure 3) where both the residual nitrogen time and the time available for the second dive are given. The only problem then is to choose the right numbers. Is it the black on white numbers that give the residual nitrogen time or is it the white on black numbers? The answer is printed on the card but in very small print.

Another possible error is forgetting to add the residual nitrogen time to the bottom time of the second dive. In this case the wrong repetitive group will be taken at the end of the second dive.

How can Dr Bassett's table be used for repetitive dives? It is quite simple. The Bassett tables use the same mathematical formulae as the USN tables with different M values (super-saturation ratios). So the USN residual nitrogen calculations apply with all their imperfections. The residual nitrogen table is based on the 120 minute tissue. In Madang Dr Bassett said that he wanted to revise the repetitive dive tables. However as far as I know he has not done so yet. As the Bassett tables produce a lower surfacing super-saturation the residual nitrogen after any given time will be less than that calculated by the USN tables so introducing an extra safety factor.

We can use the USN repetitive dive table to calculate the repetitive group when the Bassett tables are used, but instead of bottom time, which is the time from leaving the surface to starting the ascent, the total time underwater is used to enter the table. After the surface interval the residual nitrogen table is entered. The next dive can be calculated by subtracting the residual nitrogen time from the Basset limit. Table 3 shows the USN residual nitrogen times and the times available for Bassett no-decompression dives.

In order to encourage divers to use the Bassett Revised No-Decompression limits, John Lippman and I have laid out these tables in an easy to follow format (Figure 4). One enters the table by reading the instructions (Table 4). As these tables are derived from USN mathematics the ascent rate must be no faster than 60 feet (18m) a minute. I have chosen 10m (33 feet) a minute as we know that sports divers trying to come up at 60 feet a minute usually come up much faster, some even as fast as 120 feet a minute.

The top table in Figure 4 is for calculating repetitive groups at the end of a dive. Times inside the Bassett limits are in ordinary type. The times in italics are provided to find the repetitive group using the total time underwater. If the diver follows Dr Bassett's recommendations to do a safety stop of 3 to 5 minutes on all dives below 30 feet (9m) his total time underwater will often be more than five minutes longer than the Bassett no-decompression limit. So I have included times in italics that are at least 10 minutes longer than Dr Bassett's limits. Not all of the italic times are

TABLE 4

DR BRUCE BASSETT'S REVISED BOTTOM TIMES "NO DECOMPRESSION" DIVE TABLE
READ THIS BEFORE USING THE TABLES

Basic facts about the use of these USN derived decompression tables

1. Bottom time starts on leaving the surface and stops on starting the ascent.
2. Use the deepest depth of the dive as the depth of the dive for calculation.
3. If the deepest depth of the dive is between two depths in the table use the greater depth for calculations.
4. If the time is between two times in the table use the longer time for calculations.
5. After a dive calculate the repetitive group.
6. After the surface interval calculate the new repetitive group.
7. Using the planned depth of the next dive enter the repetitive dive table to find the no-decompression dive time available for that repetitive group and depth.

ASCENT RATE 10M A MINUTE

ON ALL DIVES DEEPER THAN 9M (30ft) DO A 3-5 MINUTE SAFETY STOP AT 3-5M.

USE THE TOTAL TIME UNDERWATER (BOTTOM TIME + ASCENT TIME + SAFETY STOP TIME) TO FIND THE REPETITIVE GROUP at the end of the dive.

FIGURE 4

DR BRUCE BASSETT'S REVISED BOTTOM TIMES "NO DECOMPRESSION" DIVE TABLE

ON ALL DIVES DEEPER THAN 9M (30ft) DO A 3-5 MINUTE SAFETY STOP AT 3-5 M.

USE THE TOTAL TIME UNDERWATER (BOTTOM TIME + ASCENT TIME + SAFETY STOP TIME) TO FIND THE REPETITIVE GROUP at the end of the dive.

The times in *italics* in the table are OUTSIDE the Bassett limits but are included for ease of calculating the repetitive group using the TOTAL TIME UNDERWATER

Depth M	Depth feet	Bassett Limits	Time Underwater											
9	30	220	15	30	45	60	75	95	120	145	170	205	*250*	*310*
10	35	180	5	15	25	40	50	60	80	100	120	140	160	*190*
12	40	120	5	15	25	30	40	50	70	80	100	110	*130*	*150*
15	50	70		10	15	25	30	40	50	60	70	*80*	*90*	*100*
18	60	50		10	15	20	25	30	40	50	*55*	*60*		
21	70	40		5	10	15	20	30	35	40	*45*	*50*		
24	80	30		5	10	15	20	25	30	*35*	*40*			
27	90	25		5	10	12	15	20	25	*30*		*40*		
30	100	20		5	7	10	15	20	*22*	*25*	*30*			
33	110	15			5	10	13	15	*20*	*25*				
36	120	12			5	10	12	*15*		*20*	*25*			
39	130	10			5	8	10	*15*		*20*				
42	140	5			5	*7*	*10*		*15*					
Repetitive group at the end of dive			A	B	C	D	E	F	G	H	I	J	K	L

ABBREVIATED U.S.N. SURFACE INTERVAL TABLE

Enter the table from the top using the appropriate repetitive group. Move across to the left until the appropriate interval is found then move down the column and out of the table into the REPETITIVE DIVE TABLE

0:10												
12:00												← A
2:11	0:10											
12:00	2:10											← B
2:50	1:40	0:10										
12:00	2:49	1:39										← C
5:49	2:39	1:10	0:10									
12:00	5:48	2:38	1:09									← D
6:33	3:23	1:58	0:55	0:10								
12:00	6:32	3:22	1:57	0:54								← E
7:06	3:58	2:29	1:30	0:46	0:10							
12:00	7:05	3:57	2:28	1:29	0:45							← F
7:36	4:26	2:59	2:00	1:16	0:41	0:10						
12:00	7:35	4:25	2:58	1:59	1:15	0:40						← G
8:00	4:50	3:21	2:24	1:42	1:07	0:37	0:10					
12:00	7:59	4:49	3:20	2:23	1:41	1:06	0:36					← H
8:22	5:13	3:44	2:45	2:03	1:30	1:00	0:34	0:10				
12:00	8:21	5:12	3:43	2:44	2:02	1:29	0:59	0:33				← I
8:41	5:41	4:03	3:05	2:21	1:48	1:20	0:55	0:32	0:10			
12:00	8:40	5:40	4:02	3:04	2:20	1:47	1:19	0:54	0:31			← J
8:59	5:49	4:20	3:22	2:39	2:04	1:36	1:12	0:50	0:29	0:10		
12:00	8:58	5:48	4:19	3:21	2:38	2:03	1:35	1:11	0:49	0:28		← K
9:13	6:03	4:36	3:37	2:54	2:20	1:50	1:26	1:05	0:46	0:27	0:10	
12:00	9:12	6:02	4:35	3:36	2:53	2:19	1:49	1:25	1:04	0:45	0:26	← L
A	B	C	D	E	F	G	H	I	J	K	L	

MAXIMUM TIME AVAILABLE FOR A REPETITIVE DIVE

Depth M	Depth feet											
9	30	213	203	195	183	171	159	147	133	119	104	82
12	40	113	103	95	83	71	59	47	33	19	4	
15	50	64	57	49	41	32	23	14	4	-	-	-
18	60	45	39	33	26	20	14	6	-	-	-	-
21	70	36	31	25	20	14	9	3	-	-	-	-
24	80	26	22	17	12	7	2	-	-	-	-	-
27	90	22	18	14	9	5	1	-	-	-	-	-
30	100	17	13	10	6	2	-	-	-	-	-	-
33	110	12	9	5	2	-	-	-	-	-	-	-
36	120	9	6	3	-	-	-	-	-	-	-	-
39	130	7	4	2	-	-	-	-	-	-	-	-
42	140	3	-	-	-	-	-	-	-	-	-	-

For each repetitive group the number shown is the MAXIMUM time available for a repetitive "no/decompression" dive using Dr Bruce Bassett's revised "no decompression" limits.

within the USN no-decompression limits, so the table is not the USN no-decompression table. It is a table to find the repetitive group applicable using the total time underwater as the entry point.

Having found the repetitive group the diver enters the surface interval table by running his (or her) finger down to the appropriate vertical line and then over to the left to find the surface interval. The new repetitive group is found at the bottom of that column.

The bottom table shows the maximum time available for a no-decompression dive for the various repetitive groups and depths. By showing only the time available the problems of subtraction and wrong answers are avoided.

Should one want to do a third dive, memory and arithmetic are required. The second dive has been to the Bassett limits if the total time available has been used so that total time underwater will be the Bassett limit time (set out beside the depths in the top table) plus ascent and safety stop times NOT the ACTU**AL** total time underwater of the second dive.

To calculate the repetitive group after a repetitive dive one must

1. Subtract the actual bottom time (ABT) from the maximum time available **(MTA)** in Table 3 to get an answer in minutes **MTA - ABT** = X minutes.

2. Subtract this time from the Bassett limits (BL) in Table 1. BL - X minutes is the equivalent bottom time of the repetitive dive.

3. To this add the ascent time (AT) and the safety stop time (SST). BL - X minutes + AT + SST is the equivalent total time underwater of the repetitive dive. Use this time to enter Table 1 to find the repetitive group at the end of the repetitive dive.

This procedure can be repeated after every repetitive dive. Remember a repetitive dive is defined by these tables as one within 12 hours of finishing the previous dive.

There is a need for a decompression table that can be dived as it is written. Dr Bruce Bassett's can. So problem 2, diving exactly the dive in the tables could be solved by promoting the Bassett tables.

The safety factors of the Bassett tables are shorter bottom times and lower surfacing supersaturation ratios, which reduce the nitrogen load; the ascent rate of 10m a minute reduces the chances of bubble formation while a safety stop at 3 to 5m has been shown to markedly reduce bubble formation on deep dives; using the total time underwater to calculate the repetitive group ensures that the diver has a lower tissue nitrogen tension than the tables assume; when calculating a repetitive dive the residual nitrogen time is assumed to be the same as that in the USN residual nitrogen table, but the diver's nitrogen load will be less.

The Bassett tables meet the sports diver's requirements for repetitive dives. They are easier to use than remembering to add a depth and time to every dive using the USN tables. I think that the Bassett tables are the answer to the sensible sports diver's prayer.

TABLE 5

BASSETT'S SAFETY FACTORS

SHORTER "NO-DECOMPRESSION" TIMES

The surfacing super-saturation ratios are less than those of the USN tables.

A SAFETY STOP AT 3 TO 5M FOR 3 TO 5 MINUTES ON ALL DIVES BELOW 9M REDUCES BUBBLE FORMATION

TOTAL TIME UNDERWATER IS USED FOR CALCULATING REPETITIVE GROUPS.

REPETITIVE DIVE STARTS WITH LESS RESIDUAL NITROGEN THAN THE TABLE ASSUMES.

Allways Travel and I presented all those who attended the SPUMS 1985 AGM with two copies (one large and one small) laminated in plastic to make them waterproof and a water soluble marker pen to write on the plastic to help work out repetitive dives. They were used by some for their diving in the Maldives. The smaller one was a size to fit in any BC pocket. Figure 2 was only the first edition. The second edition will soon be available in dive shops. It will be printed on flexible plastic, which can be written on with a 2B pencil. On the back will be the instructions for calculating the repetitive group after the second and later dives with a space for the calculations, and a modified USN air decompression table for those who accidentally exceed their no-stop limit.

ACKNOWLEDGMENTS

I wish to thank Dr Bruce Bassett for permission to reproduce his Revised "No-Decompression" table, and John Lippmann for the idea of the layout. Neither have any responsibility for the finished product which is entirely mine.

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TWO CASES OF NEAR FATAL BOX JELLYFISH STINGS SUSTAINED IN LITTORAL WATERS OF THE SULTANATE OF OMAN

Nick Cooper

The Sultanate of Oman lies almost entirely within the geographical latitudes 17° North to 26° North. The Northern Batinah coast of Oman, where these two cases occurred, abuts the Gulf of Oman, and surface sea water temperatures of 40° and above have been recorded during the months of August and September at bathing beaches along this coastline.

The majority of the populace of the Sultanate of Oman live on the Batinah coast and its immediate environs. So the beaches on this coast sustain heavy use by bathers particularly during the hot weather months of June to October each year.

Several anecdotal accounts of jellyfish stings with severe systemic complications have been related to me by both Omanis and expatriates. The Omani fishermen who work this area of the sea refer to the very unpleasant effects suffered by persons coming into contact with particular types of jellyfish which are caught in their fishing nets. ‘Dijna’a’ and ‘Halwa el bahr’ are two of the several Omani names which are applied to the local species.

The Gulf of Oman and adjoining Arabian Sea form part of the Indo-Pacific Ocean system, and are in direct contact with the tropical and subtropical waters of the system. No barrier of temperate seawater separates these parts, and free migration of larval forms of poisonous tropical jellyfish to Omani waters can therefore occur, with maturation to adulthood taking place under suitable climatic conditions.

This paper describes the clinical courses of two victims of jellyfish envenomation, and seeks to show the probable culprit as a species of Cubomedusan Box Jellyfish.

Case One

A thirty-five year old European expatriate employee of the Ministry of Defence of the Sultanate of Oman was stung by a jellyfish whilst bathing at Seeb beach in August 1981. He later described the offending specimen as resembling a plastic bag in appearance.

The patient sought immediate medical attention at the Force Base Hospital Casualty Department nearby because of the excruciating pain which he was experiencing. He arrived at hospital within minutes of being stung.

On examination in the Casualty department he was noted to be fully conscious and orientated. Red urticarial wheals were noted on the patient’s right infra-axillary, mammary and scapular regions where he had been stung.

The patient’s blood pressure was recorded as 120/75 mm Hg and pulse 86/min on arrival, and IM Chlorpheniramine 10 mg and IM Pethidine 50 mg were given.

Shortly afterwards the patient complained of difficulty in breathing, and examination of the chest revealed generalised rhonchi. IV Aminophylline 250 mg and IV Decadron 2 mg were given but did not relieve his symptoms. The patient continued to sweat and experience difficulty in breathing. He also exhibited pallor and coldness of extremities. Anaphylactic shock was diagnosed.

His symptoms continued to worsen in spite of an intravenous infusion of Mannitol 20% and oxygen given by mask. His blood pressure rose to 230/120 mm Hg and cardiac monitoring was commenced. IV Adrenalin was given in 1 mg boluses with little effect on the bronchospasm, a total of 3 mg being given within the space of 15 minutes.

Some 2 1/2 hours after he reached the hospital he had had a total of

IV Adrenalin 5.5 mg	IM Chlorpheniramine 10 mg
IV Dexamethasone 10 mg	IV Mannitol 20% 400 ml
IM Pethidine 150 mg	IV Crystalloid fluids 4 litres.

His blood pressure was 170/80 mm Hg and his pulse rate variable.

Seven hours after admission, the patient’s pulse was noted to vary from 40/min to 80/min, and cardiac monitoring showed episodic nodal rhythm with occasional 2:1 atrioventricular block. Atropine 0.3 mg IV gave a rapid tachycardia for 30 seconds which then settled after admission, when a bradycardia of 40/min was noted, together with a blood pressure of 140/ 100 mm Hg. By the following day, the patient’s blood pressure was 150/90 mm Hg and his cardiac rhythm was regular. On the fourth day after admission, the was fit for discharge, but has sustained permanent scarring in the regions of his chest and back where he had been stung.

Case Two

The twelve year old son of a European expatriate employee of the Diwan of Royal Court Affairs of the Sultanate of Oman dived off a surfboard into the sea at the Sultan’s Armed Forces Aqua Club at Ras al Hamra in early September 1984. He recalls seeing a mass of reddish-brown strands which he thought were seaweed just before diving, and immediately came into contact with them.

He screamed with pain on surfacing and was quickly rescued from the water. Red urticarial wheals were noted to cover extensive areas of the abdomen, trunk and arms and his respirations were wheezy. Cold cream was rubbed into the affected areas by a well meaning rescuer and IM Chlorpheniramine 10 mg administered by a nurse who was fortuitously present.

The patient was transferred to a nearby civilian hospital and required cardiac massage and expired air resuscitation during the journey. Anaphylactic shock was diagnosed on arrival at hospital and treated with hydrocortisone and antihistamines. He began passing urine of ‘Pepsi Cola’ appearance which was positive on testing for blood. His blood pressure remained elevated at 140/90 mm Hg for 24 hours during which period there was no evidence of central overload or cardiac failure.

After the passage of dark urine he became oliguric and was referred to the Nephrology Service. Necrosis was noted on the affected areas of the patient's skin.

He was treated with IV fluids, frusemide and hydrocortisone but the oliguric renal failure persisted. Peritoneal dialysis was commenced and was required for three weeks. Oliguric renal failure secondary to myoglobinuria was diagnosed. On the fifth day after being stung he developed severe pulmonary oedema secondary to hyperkalemic cardiac failure. Emergency haemodialysis with forced ultra-filtration via a femoral vein catheter gave a dramatic response with clearing of the pulmonary oedema and improvement in the patient's cardiac status.

His laboratory investigations at the time of referral to the Nephrology Service were:

Hb 16.8 g/dl
WCC 21,000/c mm with PMN 81%
Normal platelet count
Prothrombin time normal
Albumin 49 g/1
Phosphate 2.93 mmol/1
CPK 1328 u/1
Urea 30 mmol/1
Creatinine 490 mcmol/1
Na 132
K 4.7 mmol/1
Calcium 2.31 mmol/1
Urates 584 mmol/1
LDH 1749 u/1

Whether the muscle breakdown with consequent myoglobinuria was a toxic effect of the jellyfish sting, or else was caused by severe muscle spasms secondary to the pain of the stings is not clear. The patient continued to recover well and two months after being stung his renal function was virtually normal. Extensive scarring at the sites of the stings remains however.

Discussion

The near fatal immediate clinical effects of jellyfish stings in these two cases together with the permanent cosmetic disfigurement sustained as a result of necrosis of the envenomated skin raises the question as to whether or not Commonwealth Serum Laboratories Sea Wasp antitoxin would be helpful in the management of future cases. The oscillations in blood pressure of the first case and oliguric renal failure in the second case indicate that toxins from a Cubomedusan species of jellyfish were acting in both cases.

A Cubomedusan jellyfish specimen taken from littoral waters near the site of the second case has been tentatively identified as *Carybdea alata* by the Department of Zoology at the University of Queensland. The reports of the victims on the appearance of their jellyfish contacts support this type of coelenterate as being the most likely culprit, and it may be that the Omani variety is more poisonous than its Australian counterpart. No reports of Chironex species in Omani waters exist but investigation of this possibility continues.

The views of the expert speakers at the SPUMS Annual Scientific meeting are particularly sought on the question of the usefulness or otherwise of Commonwealth Serum Laboratories Sea Wasp antitoxin in the management of such cases in Oman.

ACKNOWLEDGMENTS

I thank the Office of the Chief of Defence Staff, Sultanate of Oman for permission to present this paper, also I thank Dr J Hanley MRCP, Consultant Physician to the Sultan of Oman's Armed Forces and Dr Feidhlim Woods MRCP, Consultant Nephrologist at the A1 Nahda Hospital, Ruwi for permission to present these cases under their care. I am very grateful to British Sub Aqua Club Muscat Branch No 621 and particularly to the wife of the Branch President, Mrs Peggy Woodiwiss for catching the specimens of Box Jellyfish.

Dr Cooper is a Major in the Sultan of Oman's Armed Forces and is the Casualty Surgeon, Force Base Hospital, Muaskar A1 Murtafa'a.

A TENTATIVE GUIDE TO MANAGEMENT OF MARINE STINGS

SK Sutherland

Pain relief (often required for fish stings).

Bathe in warm, not scalding, water. Use outboard engine cooling water if necessary.

Local anaesthetics. A regional nerve block may even be necessary (eg. bupivacaine).

Opiates

Emetine (rarely available)

Antivenom for severe stonefish stings

Local tissue damage.

Take positive action and remove foreign bodies or dead tissue. Ensure good drainage. X-ray if indicated.

Wash well with fresh water as sea water may encourage bacterial growth.

The wound is potentially infected so remember marine bacteria represent a wide range of organisms, many of which are not fully characterized. Many are resistant to common antibiotics. Expert opinion is that trimethoprim sulphamethazole (Respin, Bactrim, Septrim) is the best first choice.

Tetanus prophylaxis if indicated. Death from tetanus has occurred especially after stingray injuries.

NB. It may be necessary to rest the injured region for days for satisfactory healing to occur.

General effects:

Shock, note pain relief above.

Effects of venom, give antivenom if indicated.

Maintain vital functions (ABC is Airway, Breathing and Circulation).

With the exception of Blue-ringed octopus bites, conus stings and sea snake bites, the pressure/immobilization technique should not be used to attempt to hold the toxins at the site of the bite or sting. To do so may increase pain and local tissue damage.

JELLYFISH STINGS

Prompt application of domestic vinegar to the affected areas appears to be the simplest and most rational first aid. Methylated spirits should not be used.

BOOK REVIEWS

THE DIVING EMERGENCY HANDBOOK

John Lippmann and Stan Bugg
1985 Melbourne. JL Publications.

The subtitle "A guide to the identification and first aid for scuba (air) diving injuries" is a clear description of the book's purpose. No medical knowledge is needed to be able to use the book. The Section A of the book is a list of signs and symptoms with their possible causes. Section B is a list of diving ailments (the causes of Section A) their causes, signs and symptoms and first aid. Occasionally there is a fourth heading "Doctor" where simple accurate advice to a non-diving medical practitioner is given. All the descriptions are accurate and the first aid appropriate and simply set out. If the book stopped here it would be an excellent buy.

But there is more. Section C gives information on such things as the pressure immobilization technique for snake bite, what to do about omitted decompression, emergency recompression using oxygen in the water, decompression tables, diving at altitude, flying after diving, oxygen therapy, a diver's first aid kit, EAR and CPR, flow charts for coping with an unconscious patient, and for first aid for a diving accident, and a page for emergency telephone numbers of the police, ambulance service, recompression chambers, diving doctors, hospitals and a place for the name of the organisation to which a diving accident report should be sent.

The authors, who are both experienced diving instructors, have included Dr Bruce Bassett's no-decompression tables and recommended their use. SPUMS members who attended the ASM at Bandos Island in the Maldives were introduced to these tables and were given waterproof copies to use. They are based on the mathematics of the USN tables but with lower supersaturation ratios. They are a set of no-decompression bottom time limits. For all dives below 9m (3Oft) a safety stop of 3 to 5 minutes is done at a depth of 3 to 5m. This total time underwater is used to enter the USN no-decompression repetitive group tables at the end of the dive. The USN surface interval table is used to calculate the new repetitive group after the surface interval.

The residual nitrogen time for the new repetitive group is subtracted from the Bassett bottom time to give the bottom time available for the second dive.

The safety factors in favour of the Bassett tables over the USN tables are:

1. The shorter bottom times.

2. The safety stop, which allows any bubbles that have formed a chance to be got rid of.

3. By using the total time underwater to find the repetitive dive group, one assumes a higher tissue nitrogen tension than actually exists.

4. The repetitive dive is started with a smaller nitrogen load than the USN repetitive dive table assumes.

I whole heartedly concur with their advice to use the Bassett tables as safer than other available tables.

I strongly recommend all divers, including doctors who dive, to buy this excellent book. It is waterproof, so can be taken on all diving expeditions. A 2B pencil writes clearly on the waterproof pages. For permanence use a spirit based marker for the emergency telephone numbers etc.

John Knight
Melbourne

OCTOPUS DANGER

There was an encounter recently in the waters off Cyprus between a scuba diver and an octopus. There were two divers making a search of a gulley possibly 15 metres deep, keen to find and film an octopus. One was seen making a break from its resting place to obtain cover and relative safety in the nearby rocks. It expelled ink and jetted towards a sanctuary but one of the divers managed to grasp the end of one tentacle and to pull the octopus towards him, but lost his grip and was therefore surprised to find that the octopus was too ill-read to know that it was supposed to flee from him when given the chance. It draped itself around the diver's body, changed its colour to a fiery red, and squirted more ink. It is reported that the octopus had one tentacle to below his fins and another well above his head, a distance of over 6 feet. At this stage the gallant diver decided that the octopus was in a position to make a real impression on him and it was time to end the encounter, so used his full strength to reach the shallows. By the time they reached 4 metres both the players were becoming exhausted and the octopus let the diver go free. Newspaper reports called the octopus the attacker.

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RAN MEDICAL OFFICERS' TRAINING IN UNDERWATER MEDICINE

Tim Anderson

THE PRESENT SITUATION

Underwater Medicine, like many other branches of medicine, places us in the realm of the ever-changing and ever-developing. The increasing complexity of the associated therapeutic kit mirrors the corresponding advances in the world of International Diving, as man strives to go deeper for longer and not just once, but repeatedly, and to live there for days and weeks at a time, ensconced in a hyperbaric goldfish bowl from which individual forays into the murky subaquatic unknown are made.

Against this however, is contrasted the comparative lack of sophistication of Royal Australian Navy Diving in comparison to that of other navies and the commercial diving industry at large. I do not imply that Navy diving is bad, it is quite excellent and has an excellent safety record, but in terms of sophistication, as to what it can do and what it has done, it is literally a babe in arms. It is however, a fairly rough babe, and is rapidly growing up.

Underwater Medicine in the RAN was originally introduced to provide medical support for Navy Diving. ABR 1991 lists the following as existing underwater medicine activities:

1. Care for diving personnel including therapeutic treatment for Service and civilian divers and submarine escapees.

2. Diving related research.

3. Training/education in underwater medicine.

4. Submarine suitability testing.

5. Investigation of suspect diving equipment.

The commitment to civilian diving has recently received greater emphasis by the formal tasking of the Navy to provide emergency care and advice. The situation has virtually always been like this but was formalised some four years ago by the then Minister of Defence, was re-affirmed in the middle of last year by the Minister Assisting the Minister of Defence, and at the end of last year was ratified by the Chief of Naval Staff in a letter to the Naval Support Commander. In fact, most of the therapy conducted at the School of Underwater Medicine (SUM) is on civilians. Most of these are sports divers, with a sprinkling of commercial abalone divers, and very rarely have we the requirement to treat Service divers. Our running score is around 80 cases per year, which although less in total than that seen by the United States Navy, still represents the greatest number of diving cases in the world dealt with by one small unit of this size and capacity. In Hawaii they deal with a comparable number of diving cases, but these are shared amongst some fifteen doctors and we have only three.

Naval Doctors trained at SUM have been intimately involved in the treatment of diving casualties throughout the whole of the Australian continent and beyond. Along the lengths of the East and West coasts, from Mt Gambier in the South to the Katherine Gorge, deep in the heart of the Northern Territory, and from the waters beyond the Great Barrier Reef to the Islands of New Guinea.

In a consultative capacity the School of Underwater Medicine has been called upon to advise:

- All State Health Departments, many other State bodies, eg. Police, Paramedics, Emergency Services.
- Hospitals, Civilian Doctors, other Armed Services.
- The National Safety Council of Australia.
- The Australian Underwater Federation.
- The Australian Institute of Marine Science.
- Commercial Divers.
- Individual sports divers, Diving Clubs and Instructor bodies.

THE FUTURE

Our patient numbers are increasing and diving casualties are presenting with worse disease, as diving continues to become even more popular and is pursued to even greater adventure.

We have already been tasked to support the imminent Deep Diving Phase of the RAN, to verify and amend existing decompression schedules and to develop new ones to meet this requirement, and this has already been started.

We will be involved with the Australian Submarine Escape Training Facility (SETF) at HMAS STIRLING. We are already required to support existing submarine escape, and with the new generation submarines for the Australian Fleet with a dive capability of several days, we will almost certainly be involved in their environmental monitoring and control.

In order to satisfy these requirements, we need experts and specialists. I would urge with the greatest powers of my persuasion that Underwater Medicine is not a minor sub-specialisation which one can casually drift in and out of. It is without doubt a major entity in its own right requiring much training, a very significant depth of understanding and literally years of dedication.

THE UNDERWATER PHYSICIAN

The Underwater Physician must have qualities and training to assist him in his activities.

Diving

As a diver, the doctor has a far better understanding of the problems facing another diver. He will well understand the piercing, throbbing of sinus pain over the forehead, the problems associated with clearing the ears, the almost incomprehensible weight of his diving set as he climbs out of the water onto a heaving boat, the uncomfortable constrictions of a diving suit, and the murk, the cold and the lonely isolation of the man beneath the sea. He will understand the difficulties of buoyancy, both on the way up and on the way down, of disorientation, communication, and of the strange curiosities of vision caused by light refraction.

Physiology

The whole of diving medicine is based on a sound knowledge of physiology and more than that, physiopathology. The knowledge of what happens to the body after varying conditions determined by the hyperbaric environment, when they are likely to happen, how they are likely to present, and what the prognosis is likely to be. In respiratory physiology particularly, his training and understanding will be verging on that of the biophysicist and the anaesthetist.

Physics

He must have total familiarity with the concept of gases, bubbles and liquids, their actions and interactions together, as described by the laws of Boyle, Charles, Dalton, Henry, Hagan, Poisieulle, la Place, to name but a few, and how all this effects the diver.

Electrodiagnostics

He will need a working knowledge of cardiac monitoring, cortical evoked responses, the electroencephalogram, and electronystagmogram. Obviously his expertise will not be to the same degree as the relevant specialist, but it is nevertheless of paramount importance that he should have a good working knowledge of these facilities, not only for diagnoses but also as a measurement of the efficacy of his treatment.

Therapeutics

He will need to understand how decompression tables are constructed and be able to evaluate critically whether decompression schedules should be used as they are published or whether in a given situation he should modify them on the basis of his clinical findings and experience. He must know why the various types of intravenous therapy are used, the pros and cons of surface oxygen, and when to treat and when to wait.

Research

In the concept of research, he will be fulfilling part of his initial tasking as defined in ABR 1991. Of even greater importance is the fact that here he will acquire the capability of asking the right questions of the right people at the right time, in order to pursue a point of contention. As a researcher he will have a great deal of background information and also will acquire the capability of scientific evaluation of the efficacy of new techniques.

New techniques

With the new deep diving chamber, scheduled to be functional later this year, a whole new concept in diving medicine has opened up to us. No longer are we restricted to the use of air, oxygen or various prescribed mixtures from cylinders, but we now have the capability of creating any given atmosphere with whatever partial pressures we choose, using any combination of nitrogen, helium and oxygen. Our depth capability has increased from 50 metres to more than four times that. With the new chamber the modern concept of saturation therapy will soon be common practice as opposed to the state in our existing recompression facilities where, in spite of ingenious adaptation, based on the best of scientific reasoning, a young man died in May 1984 when we simply ran out of chamber as his therapeutic requirements far exceeded those which were available.

Political

The Underwater Physician must also act in a political sense. This is particularly relevant as OIC of the School of Underwater Medicine, and as CMO or SMO of HMAS STIRLING, where continual exposure to the searching questions of Senior Officers, the media, and civilian pressure groups, have to be handled with diplomacy. Ideas have to be transformed to the written word and couched in a form which is both correct Service writing and which carries the greatest diplomatic persuasion.

Experience

Experience can never be learned from a book, only by being there, seeing what is happening and participating to the full. There is no substitute for this and without it the academic can never aspire to be a clinician. The concept of experience exists in everything we do and its importance can never be over-emphasised.

Career

If we wish to have good people in the medical branch of the RAN, we must persuade them to stay and the same applies to underwater medicine. I believe that it is vital that a career should be planned for those interested in spending a large part of their working life in this subject. This career must be meaningful, based on a programmed career plan with progressive training and jobs. Obviously as much training as possible should be in Australia, although even with the new Submarine Escape Training Facility, some training will almost certainly have to take place overseas. The career should encompass academic and research involvement as I have already mentioned, and could profitably extend over a period of 14 or 15 years. We should work in close co-operation, and be involved, with national and international underwater medicine organisations such as the Undersea Medical Society in the United States, the European Underwater Biomedical Society and here in Australia the South Pacific Underwater Medicine Society.

Specialisation

Almost hand in glove with a programmed career is the concept of specialisation. Recognised specialisation with appropriate academic qualification will be beneficial to the Navy, the individual, and the diving community at large. Such qualification should almost certainly come from the Australian College of Occupational Medicine which already accepts that it has a role to play in the regulation of underwater medicine and in this capacity has already recognised a member of SUM with the award of a Fellowship.

Credibility

This is the one concept that we all seek to achieve. We all hope that one day we will aspire to the professional respect which we feel is owed to us by those around us and by our colleagues. Without credibility, nobody will believe you, or trust your judgement. Each is vital to the practice of any form of medicine and the only way to achieve it is to do the right sort of training in the correct sequence in order to gain the appropriate experience so as to make wise decisions, and to be seen to be so doing.

UNDERWATER MEDICINE TRAINING AT PRESENT

Ships Diving Officer's Course

Basic Underwater Medicine

Advanced Underwater Medicine

Apprenticeship

One-off aspects of training:

(1) Admiralty Marine Technical Establishment (Physiology Laboratory) [AMTE(PL)]

(2) Institute of Naval Medicine

(3) Submarine Escape Training Tank (SETT), HMS DOLPHIN.

(4) RN Submarine Squadron

(5) MV SEAFORTH CLANSMAN (RN deep diving vessel)

(6) Clearance Diver (CD) training in Australia

(7) Oxyhelium diving in Canada

(8) Research PhD

(9) Attachment to the USN
   (a) Naval Medical Research Institute (NAMRI)
   (b) Naval Experimental Diving Unit (NEDU)
   (c) San Diego

All of these training activities are very valuable and each gives knowledge which is part of the large jig-saw. The one-off training activities, although each is of excellent quality, depend to a greater extent on the drive and enthusiasm of the individual doctor. It is fair to say that the more you put into it, the more you will get out of it. So far, it is only a handful of people who have been exposed to some of the one off training and only one person who has completed all of it. However, this existing training must be updated in terms of the programmed career, specialisation, and academic qualification, in order to fully prepare the Underwater Physician for the daunting tasks ahead.

At present there are four billets in Underwater Medicine. These are the OIC SUM, the 2nd MO SUM, the Junior MO SUM and the Command Medical Officer/Senior Medical Officer (CMO/SMO) HMAS STIRLING.

SUGGESTIONS FOR THE FUTURE OF UNDERWATER MEDICINE IN THE RAN

Since the Submarine Escape Training Facility is proposed for Western Australia I suggest this virtually obliges the creation of two further Underwater Medicine posts, of SETF MO and Junior MO HMAS STIRLING, which is ironic since if it were to be built adjacent to the existing facilities at HMAS PENGUIN it might have been possible to make do with fewer doctors. This increased number of Underwater Medicine positions could make possible a combination of training and career, which I will outline below. This is my version and is not necessarily shared by the RAN.

We start with the Junior MO at SUM, who would spend a year there. He would already have done an Introductory Underwater Medicine Course which would last for 1-2 weeks, possibly as part of his Direct Entry Officers' Course or shortly thereafter. He would be a volunteer, and should be interviewed and selected when he came to HMAS PENGUIN to do his Ships Diving Officers' Course. During his year at the School of Underwater Medicine he would undergo the existing Basic and Advanced Underwater Medicine Courses and also the latest concepts in the more technically advanced phases such as saturation underwater medicine, electro-diagnostics, the use of the new deep recompression chamber, gas analysis, and on an opportunity basis would carry out experience dives on all RAN diving systems. He would then go to HMAS PLATYPUS for a short submarine acquaint course, for about 2 weeks. This is purely to show him what a submarine is, the basics of how it works, how the submariners feel about their own particular problems and their own way of handling them, such as cramped living conditions, toxic atmospheres and submarine escape. The balance of the year would be spent at SUM with on-the-job training and general experience in underwater medicine.

His next post would be to HMAS STIRLING in Western Australia as the Junior Medical Officer for 6-12 months where for about 1 month he should undergo a SETF Course. In this his knowledge of the problems of the submariner would be broadened, with a greater emphasis on the problems of submarine escape. He would undergo submarine escape training and participate fully in submarine escape activities.

Following this, when he will have 18 months to 2 years experience in Underwater Medicine, he would be sent overseas for 6 months consolidation training either in Europe or North America. At present, probably the place with greatest experience of underwater medicine in Europe is Aberdeen University in Scotland with whom we have more than a nodding acquaintance. Experience of the industrial type of diving, and diving medicine, which is practiced in Aberdeen, and which is very much of an international nature, would be quite invaluable to any aspiring underwater physician. I suggest a week is sufficient for a visit to the Institute of Naval Medicine and the Physiological Laboratory, since sadly the RN seems to have lost most of its experts in Underwater Medicine. The greatest use, however, which can be made of the Royal Navy, would be for some form of 'Sea Surge' exchange on their ship the SEAFORTH CLANSMAN, which is a deep diving support vessel with its own saturation complex. A minimum period of 5 weeks would be required since without doubt this is the direction which the Royal Australian Navy must surely go in the fullness of time. In North America, equivalent training could be acquired with the USN at NAMRI, Bethesda, or NEDU, Panama City, or preferably a combination of both.

On his return from overseas he would come back to the submarine escape training facility in HMAS STIRLING as the SETF Medical Officer. At this point he should receive the Diploma of Underwater Medicine. This should probably be awarded by peer group election and also on the results of a running case thesis which he would have kept during the previous two years. So far the Diploma of Underwater Medicine does not really exist in Australia, however, it would be appropriate if the College of Occupational Medicine were to champion this cause.

The two years as SETF MO would be essentially of a clinical, advisory, supporting nature, during which time the MO would be able to select his particular interest for the following year, where he should have the opportunity to do a year's research for an MSc. This research should be relevant to Underwater Medicine and as such would again fulfil existing commitments of the School of Underwater Medicine. It would probably not matter materially, however, whether the research was done in either the East of Australia or the West. Subjects which are particularly relevant in the field of Underwater Medicine are biophysics, physiology, and applied anaesthetics. For example, nobody has yet tried to find out how a high frequency jet ventilator or high frequency oscillator works inside a hyperbaric chamber. It is noteworthy that a member of SUM has recently designed and built a revolutionary $C0_2$ scrubber for use in RCCs. Industry has not yet equalled this feat to anywhere near the same efficiency.

The Medical Officer should now return to the School of Underwater Medicine as the second Medical Officer. This should probably be of the order of three years, but during this time would include the RAN Staff College Course and also the Australian College of Occupational Medicine Course of 10 weeks. The combination of these two courses would therefore take about a year, leaving two of the three years for carrying out the tasks of SUM second MO. This is a particularly important post and very much a cog-wheel position since the vast majority of education, training, research and projects in underwater medicine falls on the shoulders of the 2nd MO. It is appropriate that soon after completing the College of Occupation Medicine Course, he should be considered favourably for the award of the Fellowship of that College.

The natural progression is to become the OIC of SUM, or the CMO/SMO of HMAS STIRLING. On posting to either of these positions, which I consider to be equivalents and therefore interchangeable, the MO will have completed some 9 years of underwater medicine. If he continues to do 3 years at SUM as the OIC followed by 3 years at HMAS STIRLING or vice-versa, it will mean that he will have completed 14 years in the Navy as an Underwater Medicine doctor. I consider this is not to be sneezed at and long before he had completed that 14 years and been dragged off to Canberra to drive a desk and push a pen, this doctor would be of immense benefit to the RAN and to the diving community at large. It would certainly be possible to take him off and have him do sea time or a Deputy Medical Officer in Charge job, or some other form of administrative job, virtually at any time through this progressive career training. I do not think it would help his underwater medicine, but it could help the Navy out of a posting jam and obviously in terms of the Naval Medical Branch as a whole, such postings must be considered.

CONCLUSION

What I have tried to do has been to show you what the position is at present, to indicate current training in underwater medicine and to demonstrate that for the existing tasks confronting us, let alone those of the future, this is far from adequate. I believe the way ahead which I have shown is the correct way based on the logical principles of the appropriate training for the job with a predictable career pattern, which is obviously what we all want to have. A great deal depends on the individual resourcefulness of the Medical Officer concerned, and his willingness to work hard at the job. However, all the way through my plan there are academic carrots which are worthy rewards for continued pursuit in this subject. Further to this I feel that with the increasing complexity and responsibility in Underwater Medicine, it will sooner or later become apparent that the posts of OIC SUM and CMO of HMAS STIRLING should be occupied by Medical Officers of the rank of Commander. A lot of lessons at this Conference have been taken from the British experience in the Falklands War of 1982. We do not need a Falklands War to show us the problems or teach us the lessons. We have our Falklands here in Australia, all around us in the waters that lap the shores of this great and ancient continent, it has been with us for years and the problem is steadily getting worse. I believe the Navy must accept the problem of underwater medicine in its entirety in Australia since there is no other organisation, either State or private enterprise which has the horsepower or the potential for the backing and influence that we could have. The Navy is like a great rock, a rock of stability, a Federal rock. Our responsibility is surely to the diving community at large and so from this Federal rock, we must extend a helping hand and show the way by accepting the challenge of our rightful place as the National Authority on Diving Medicine but with an international voice.

Dr Tim Anderson is the Officer-in-Charge of the RAN School of Underwater Medicine. He has some years experience as an off-shore medical officer in the North Sea oil fields, based on Aberdeen.

This paper is an edited version of a paper presented at a RAN Health Services Conference on 2 February 1985. The ideas expressed in this paper are Dr Anderson's and not necessarily the official views of the RAN.

The conditions for the award of the SPUMS Diploma of Diving and Hyperbaric Medicine are

1. *Passing both the Basic and Advanced Courses in Underwater Medicine run by the School of Underwater Medicine.*

2. *Passing the Hyperbaric Medicine Course run by the Hyperbaric Department of the Prince Henry Hospital.*

3. *Six month's full time, or the equivalent as part time, experience in Underwater or Hyperbaric Medicine.*

4. *Submitting a thesis. The examiners are the President of SPUMS, the OIC SUM and the Director of the Hyperbaric Unit at the Prince Henry Hospital.*

DECOMPRESSION TABLES UNDERLYING ASSUMPTIONS

A report on a workshop held at the UMS Annual Meeting in San Antonio in May 1984.

STATISTICAL SIGNIFICANCE AND DECOMPRESSION TABLES

Lou Homer of NMRI tackled one of the stickiest and most unsolved problems of decompression science: how to assess when a table is acceptable. This has always been done on a more or less ad hoc basis; even though many sets of tables have been amply tested there have been few done against predetermined criteria based on sound statistical analysis. Homer pointed out that we have assumed that a fixed probability of decompression sickness (DCS) exists (but this is among the aware, there are still those who apparently take a black-or-white view and behave as if it were not a matter of probability at all), and that it is the same for all individuals and conditions for a given decompression schedule. Based on these assumptions we can use the binomial distribution to make a prediction, such that if there are two cases of DCS in 40 dives, we are 95% confident that the underlying incidence is between 0.6% and 17%. Note that the final step is not an assumption, but a specific result following accepted statistical procedures.

Homer believes there is a better way. For one thing, statistically we worry as much about those cases in the range less than 0.6% as those with greater than 17% probability, even though only the high probability is a problem. We also are not sure we have defined a safe table. The more we push to assure safety, the greater the chance we will reject a good table. He suggests using sequential analysis techniques that allow a test series to be terminated as soon as it fails. Using the basis of two cases of DCS in 40 dives as "acceptable", he showed a strategy that results in an average of 32 dives needed to validate a good table. He also discussed basing the test on details of the model, so that different schedules could be pooled to help validate the model itself within given limits. This depends of course on having a sufficiently universal model, and that its parameters can be put to the test.

PROVOCATIVE DISCUSSION

This paper generated more discussion than any other. There was clear sentiment that Doppler bubble monitoring could be used in the same way as DCS, for the end point. Dick Vann (Duke University) suggested that the Doppler score could be put into the model. Dave Yount suggested testing individual parameters and then combining them in a global model, using nucleation instead of a "matrix". Gene Wissler (University of Texas) asked if the equation (Homer's probability calculation based on a decompression model) was physiological, to which Homer answered that it was more a matter of common sense than physiology, and that they looked at common sense things like deeper stops. One comment was that the models were indeed physiological in that they look at the integral of the gas remaining. Billy Bell asked if the assumption of constant incidence was realistic. Homer answered that we have to hope that our subjects are representative.

To a question about comparison of UK and US approaches, Paul Weathersby said there are really no specific approaches from the two schools, and that assumptions cannot necessarily be transferred between models. It was mentioned that the Defence and Civil Institute of Environmental Medicine (DCIEM) had progressed from a somewhat intractable hardware based model to a more general one, that 5000 test dives have shown some limitations, but that they are still trying to find a general model (bubble detection has played a big role in this development progress). DCIEM is the only place that considers different levels of confidence in all their table assessments. Dick Vann commented on the evolution of the British tables, noting that early Haldane tables had deeper stops than the ones Haldane ended up with.

NEDU'S VIEW OF FUNDAMENTAL ISSUES

Ed Thalmann approached the underlying assumption by pointing out that US Naval Experimental Diving Unit's (NEDU) role is to develop practical decompression procedures for use by the US Navy, without too much concern about the theory behind the tables as long as they work. He short circuited Van Liew's flow chart by having the results of table testing go to information which moves to assumptions and then back to more tables; only when it works do we "learn some science".

NEDU has been involved since 1978 in non-saturation decompression development, and during that period has done some 2300 man dives. This effort has been mainly to test the US Navy's closed circuit breathing apparatus, which provides a constant 0.7 ATM oxygen partial pressure. They started with the traditional Haldane approach which had been used by the US Navy for some time. This model can be made to fit any experience since it has many degrees of freedom, but Thalmann feels it does not take oxygen into account, that it looks only at inert gas tension. This model worked first with some manipulation, but for Thalmann would not predict both safe repetitive dives and reasonable no-decompression limits.

LINEAR OUTGASSING

Next NEDU introduced a new concept of linear outgassing during ascent, rather than the traditional exponential. This was based on the assumption that a gas phase formed whenever there was a certain degree of supersaturation, and the slope was proportional to the difference in inert gas tension between arterial and venous blood. This model predicted repetitive dives satisfactorily, but when used for air tables made the decompressions two or three times too long. Brute force adjustments to the slope fixed this, and the new model was next used for 0.7 ATM heliox tables. Once again, the model broke down, but good tables could be generated once some of the half-times were empirically modified.

The model was the next tested against 25% oxygen scuba tables, already proven and in use. Yet another adjustment was needed. This time the assumption was that when inspired oxygen was high it made the corresponding venous blood oxygen tension higher as well this was achieved in the model by making tissue compartments with longer half times have a lower oxygen extraction rate. Whether this adjustment will result in a more generally useful model has yet to be determined.

Discussion at first centred on whether high oxygen would lead to high venous blood oxygen levels, with a great deal depending on the levels considered. Asked whether the tables were down to a few elbow niggles at this point, Thalmann answered that they have set of tables now, longer than the ones they started with. He mentioned that helium was different from nitrogen, that with helium they might see 30 clean dives and one case of amnesia: helium has always been considered less predictable than nitrogen.

DUKE'S EYE VIEW

In the last paper of the session, Dick Vann reviewed his bubble-growth assumptions, and showed how the effect of exercise can be taken into account. The "assumption" that undissolved gas is the responsible offending agent in decompression sickness can hardly be challenged, but he pointed out that while this clearly true for the spinal, cerebral, and pulmonary situations, the way gas acts in pain-only bends is not yet clear. He noted also that "biochemical" effects of the gas-blood interface are no doubt important ones.

Both diffusion and perfusion are at times assumed to be the limiting factors. Vann described the different circumstances where each of these is predominant. Diffusion, for example, is more important in undissolved than in dissolved gas exchange.

The assumption on which Vann basis his computation of decompression tables is that the risk of DCS increases with larger volumes of undissolved gas. His approach is to find the smallest bubble volume that will result in DCS, then to relate this to the smallest pressure reduction to cause DCS symptoms. Bubbles are assumed to form on each stage of and to be dissolved during the stop. This process is assumed to work if the bubble size is kept below the critical volume.

THE ROLE OF EXERCISE

During the trials at Duke testing the 0.7 ATM oxygen partial pressures mentioned in Thalmann's talk, different exercise regimes were tried. Work on the bottom unequivocably increases the risk of DCS. However, the role of exercise during and after decompression is less clear. WWII aviation studies showed that fliers who exercised while exposed to high altitude suffered more symptoms and got them more quickly. Early Navy work showed that exercise following decompression was detrimental, and the resulting directly also did away with the previous Navy practice of exercising during decompression, even though the experiment did not involve exercise during decompression.

Work at Duke showed that divers exercising during stops could have their stop times reduced by as much as 30%; conversely, heavy exercise on the bottom can increase decompression time threefold. The assumption here is that bubble formation was slight enough that the exercise could accelerate gas elimination. If bubble size is large enough, exercise is no help, the bubbles are limited by diffusion and do not dissolve. Results of some 20-30 trials in each schedule tested were encouraging but there were not enough of them to provide statistical validity. Vann feels light exercise during decompression is beneficial.

Several comments were offered relative to exercise in decompression. Ian Buckingham noted that bell tenders, who rest during the dive and decompression but often work hard right after surfacing, tend to get DCS more than the working divers. Vann offered the thought that work also raised the diver's temperature, another factor known to be beneficial during decompression. He suggested that exercise and temperature may account for some of the big "individual" differences often seen. Ed Thalmann says that his divers now take a hot shower after surfacing, which was formerly a no-no.

The Vann approach of letting a bubble exist but not grow too much drew some comments on biochemical effects of the bubbles. Van readily admits bubbles lead to trouble but did not see many biochemical changes in his subjects. All Brubakk of the Norwegian Underwater Technology Center (NUTEC) noted that even though the profiles free of DCS would be considered "safe", there is still some effect (Vann agrees), and that "bubbles" are observable in animals for as long as a month. Dave Youngblood reminded us about the long-standing problem in patients placed on a heart-lung bypass machine; there are often serious after-effects due, it is assumed, to bubble damage to the blood.

Hugh Van Liew closed the symposium with the comment that those involved in practical table development appear to be strongly influenced by feedback derived from table tests, and apparently have not yet found ways to make such use of the other kinds of theoretical or experimental information that exist.

(Many thanks to the UMS and Dr Bill Hamilton for permission to reproduce their excellent overview. Editor TRIAGE).

(Reprinted by kind permission of the Editor from TRIAGE, the newsletter of the National Association of Diver Medical Technicians, No. 9, January 1985.)

BLAME NATURE DEPARTMENT

The British Government was reportedly not satisfied with the safety standards at Sellafield (formerly called Windscale), a Nuclear fuel reprocessing plant. Apparently there is a 2.5 km pipe which takes solvents, used to clean radiated tanks and pipes, out to sea. Workers claimed that up to 20 times the legal amount of radioactive waste was pumped recently into the Irish Sea by mistake. The company (British Nuclear Fuels) blamed "adverse climatic conditions" for returning the radioactive slick onto a local beach. A geiger counter would seem an essential extra piece of equipment when diving off this area of Cumbria.

SERENDIPITY STRIKES AGAIN

Decompression Studies at University of Wisconsin

Rev EH Lanphier MD and CE Lehner PhD
University of Wisconsin, Madison, Wisconsin

Pasteur once said "... chance favours only the mind prepared." Whatever else, the minds that were trying to put together a high-pressure research program at the University of Wisconsin in the late 1970s were prepared enough to grab a fine hyperbaric chamber for $1.00. That is actually what we paid another university for a large, three-compartment, 1000-foot working depth research chamber and all its adjuncts.

By early 1979, the chamber had been installed in the University of Wisconsin Biotron, a world-renowned facility for environmental research. The Sea Grant College Program helped with installation costs and has supported our research ever since. The initial decompression studies were aimed at characterizing the responses of sheep and pygmy goats. We hoped to use them as subjects for basic research that we were reluctant to undertake in human subjects.

We began by looking at 24 hour exposures with direct ascent to "surface". Results in the pygmy goats matched those reported elsewhere for goats of normal size, and we found that sheep were somewhat more resistant to decompression sickness (DCS). Both appeared remarkably similar to humans. In this phase, we saw very little except "limb bends". The incidence of "CNS hits" was extremely low.

When we looked at 4 hour exposures, there was little change in the range of pressures required to produce "least-detectable signs" of DCS, and there was no real change in DCS types.

The next stage in our plan was to look at 30 minute exposures with direct ascent. To our surprise, this was a whole new ball game. As expected, we had to go deeper to produce any form of DCS, but now signs of spinal cord involvement were frequent and often devastating. Early on, we lost one of our favourite goats to respiratory paralysis despite very prompt recompression. Another old friend, Jane, became quadriplegic. She responded to treatment but then relapsed during the slow ascent. She showed no response to further recompression and was unable even to lift her head to drink. What happened to Jane after that is worth telling.

Our veterinary neurologist found some faintly encouraging signs and recommended that we keep Jane alive to see what would develop in a week. The need for intensive care was met with the help of a large box in Dr Lanphier's study, a great quantity of old newspapers, and not a little effort. In a week, Jane showed some favourable changes, and definite progress continued.

Recovery from Quadriplegia

In the tenth week after her accident, Jane crawled out of her box and tried to join the Lanphiers at dinner. Their joy was tempered by deposits left on her way, so Jane was shifted to quarters outside. There, daily, she was set on her feet and encouraged to take steps. Within another few weeks, she was able to stand for a time, walk a little, and, finally, to get up without help. Except for one transient setback, Jane's condition has been stable for over two years. She is clearly impaired but able to walk reasonably well and even to run a little.

Our astonishment at Jane's recovery sent us to the older literature, where we found a number of accounts of equally remarkable convalescence in divers. Thus, Jane taught us that spinal cord injury from DCS can have a far better prognosis than do more common forms of damage. The implications for management and rehabilitation of cord-injured divers are clearly important.

32% Spinal DCS (Goats) and 64% (Sheep)

That was the good news, but the bad news overshadowed it completely. By far the most important lesson of our 30 minute exposures was in the overall incidence of spinal DCS. In many repeated dives, this reached 32% in 6 goats and 64% in 3 sheep. By then, we were much more willing to believe recent accounts that contradicted older sets of data. We asked ourselves whether the prevalence of short, relatively deep dives with scuba could perhaps account for such a change in statistics. Conversations with the Divers Alert Network (DAN) and friends who were seeing actual cases strongly supported this idea.

We assume that even well-trained divers occasionally take liberties with the tables, and many of them probably do so on the assumption that, even if they do "get bent", the chance of a serious (Type II) hit is remote. But instead of 1-in-10 or even 1-in-4, the risk of spinal cord injury is probably even greater than 50-50 for most scuba divers who take chances (and for some who follow all the rules). We are talking here about dives that are barely sufficient to produce any sign of DCS, and about the proportion of resulting cases that include injury to the nervous system. Obviously, gross violation of the decompression tables can produce almost any form or forms of damage.

With possibilities like lifelong paraplegia in the balance, misinformation can be very dangerous. Even more scary is the fact that many divers still do not realize that a weak leg or numb foot or "pins and needles" somewhere, or an odd kind of belly ache, can signal a very urgent need for recompression. For such a diver, the risk of injury is large, the chance of timely treatment is rather small.

At the 1984 UMS meeting, Dr Lanphier talked with some of the leaders about the need for authoritative information on this subject, specifically aimed at divers. He returned to Madison discouraged by the lack of interest. A Sea Grant writer called just then to ask him to reconsider his "embargo" on a press release that had been prepared on this subject. This time, Lanphier said "Go ahead".

Serendipity and Chokes

In the course of nearly 1000 simulated dives in our animals, serendipitous development of dysbaric osteonecrosis (aseptic bone necrosis) gave us the impression that we could produce that condition almost at will. Little is really known about this unfortunate complication of DCS because there has never been a very satisfactory animal model of the condition. We devised a "recipe" for producing necrosis deliberately; the protocol included what we called "altitude provocation", a process that had been extremely useful in our earlier studies.

In the first trial, we exposed 6 sheep to a moderate depth for 24 hours and then, after observation at surface, took them to 8,000 ft of altitude (570 torr). We planned to "park" them there for another 25 hour period.

"... DIVERS WHO MAKE VERY LONG DIVES OR DO MUCH REPETITIVE DIVING MAY BE AT GREAT RISK OF CHOKES IF THEY FLY TOO SOON AFTERWARDS.

The idea was that if any showed undue signs of DCS in the meantime, we could simply take them back to the surface. There, experience indicated, they would almost certainly be relieved without further recompression.

Fate had other plans. To our astonishment, just 45 mins at altitude produced prostration in 3 sheep, and dear old Blanche was dead before we could get them back to ground. The problem was obviously "the chokes", but the two sheep still living did not respond at all rapidly to recompression. Both of them ultimately recovered at treatment depth, but one died abruptly during subsequent ascent. Here was an appalling problem. We were mainly grateful that the subjects were sheep and not divers.

Despite our unprepared minds, serendipity had given us a sure-fire method of producing chokes. We subsequently utilized this method many times in a new project in which we learned much about this condition. We have no proof that our experience applies closely to real-life situations. However, we believe that divers who make very long dives or do much repetitive diving may be at great risk of chokes if they fly too soon afterwards. Eight thousand feet is all it took with our sheep, and that is an accepted cabin altitude. We were also impressed that what we saw in many sheep could easily be mistaken for a heart attack if it occurred in a diver.

Bone Necrosis

Our recipe for producing bone necrosis obviously had to be modified; it has now been tested and the results are entirely encouraging. We hope that this, together with our discovery that bone marrow pressure is often elevated in "limb bends", may lead to significant progress in understanding both these conditions.

Does chance favour <u>only</u> the prepared mind, as Pasteur said? Some of our best "discoveries" suggest that it may be enough just to be "doing something actively" and being willing to appreciate whatever turns out.

(NOTE: Appropriate references etc., will be supplied by writing directly to Dr Lanphier.)

Reprinted, by kind permission of the Editor, from PRESSURE, the newsletter of the Undersea Medical Society.

<u>DCIEM UPDATE</u>
<u>"New Canadian Dive tables coming"</u>

In early 1983, The Defence and Civil institute of Environmental Medicine (DCIEM), a Canadian Department of National Defence Research Establishment located in Downsview, Ontario developed a new decompression model for air diving. This new model, the DCIEM 1983 Decompression Model, is the result of many years of decompression research at DCIEM.

"Standard Air", "In-Water O_2" (at 9 msw) and Surface Decompression on Oxygen (Sur D O_2) decompression tables, as well as very simple "Repetitive Diving" procedures for all the above tables and "Altitude" corrections based on the new model have been developed and are currently being evaluated at DCIEM using Doppler ultrasonic bubble detection techniques.

Although no realistic decompression procedures can totally eliminate the occurrence of Decompression Sickness, it is felt that a more conservative approach to decompression procedures than those published in the United States Navy and Royal Navy diving manuals is necessary (1.2).

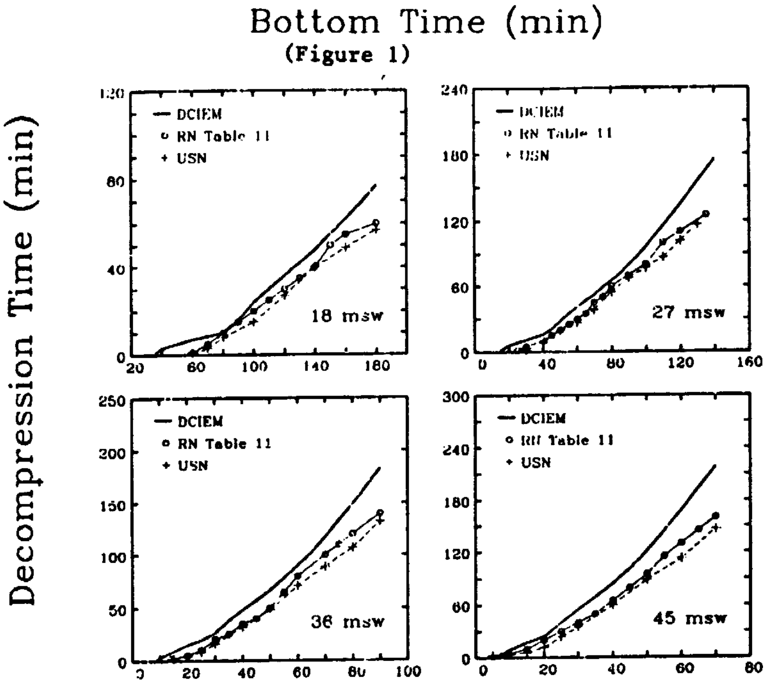
Figure 1 provides a simple comparison of the DCIEM, USN and RN "Standard Air" decompression tables. The DCIEM table is consistently more conservative than the USN table and RN Table ll. As the DCIEM "Oxygen" decompression tables are derived from the same basic model, these tables are equally conservative.

Experienced divers have long believed that the USN "Standard Air" table often does not provide quite sufficient decompression and therefore apply the "one longer bottom time" rule for hard working dives quite regularly. For more severe exposures, the actual decompression is often further increased by the "one longer plus one deeper" modification.

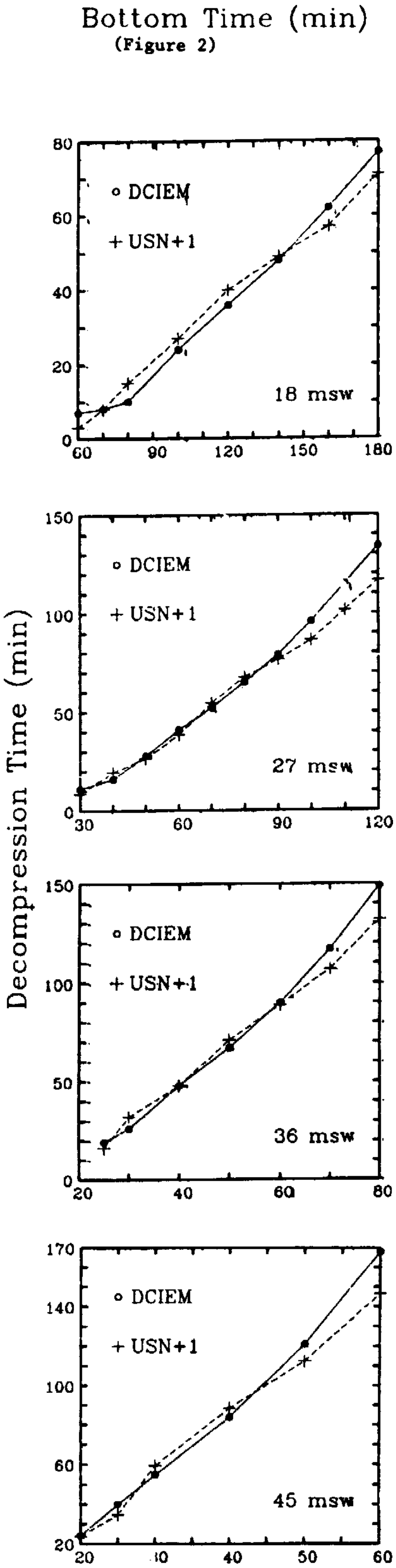
Figure 2 shows that when the "one longer" rule is applied to the USN table (USN + 1), the DCIEM and USN methods result in similar decompression times - except at extended bottom times. If, however, the "one longer plus one deeper" philosophy is applied in this region, the results are again very similar.

The current evaluations of the DCIEM 1983 model using Doppler ultrasonic bubble detection procedures have shown that the basic conservatism of this model is indeed justified and necessary. Experimental working dives to 72 msw for 40 minutes bottom time have shown this model as safe in the "exceptional exposure" range as in the "normal" air diving range. This is attributed to the fact that the relative conservatism of the DCIEM model increases as bottom times are extended.

For short, shallow dives, the DCIEM model is perhaps too conservative. However, this extra margin of safety - in the region where most of the diving by "novice" divers and

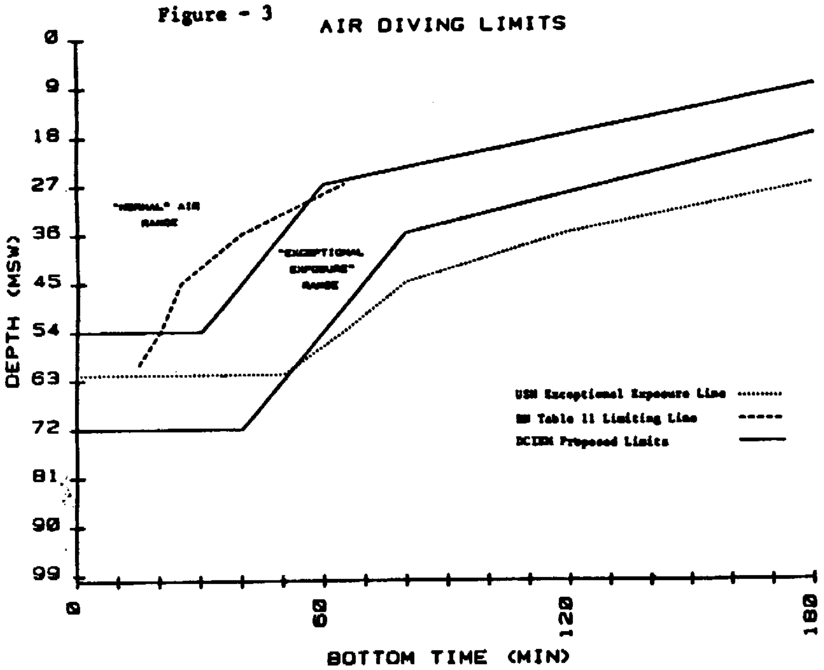


(Figure 1)



(Figure 2)

Figure - 3 AIR DIVING LIMITS



"occasional" divers is done - is not considered overly restrictive for recreational diving.

The definition of "limits" is considered an essential part of the decompression table development process. The air diving limits shown in Figure 3 are proposed by DCIEM. These limits are not dictated by the DCIEM 1983 decompression model. Rather, they are based on a consensus opinion of what are considered realistic maximum exposures for compressed air diving in typical Canadian waters. They also define the scope of the table validation process and provide guidance for planning diving operations.

In the very near future, the decompression tables and procedures for compressed air diving based on the DCIEM 1983 decompression model will be published and available for use by all divers.

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NORTH SEA DIVING ACTIVITY DURING 1984

Commander SA (Jackie) Warner OBE, DSC
Chief Inspector of Diving, UK

It is once again my privilege to bring you the last year's situation report from the North Sea. We are well into the second decade of diving operations involved with the North Sea offshore industry. The progress that has been made in every aspect of offshore diving during that period has been fantastic. The standard of safe diving practice is only one part that has improved but there is no doubt that the work will always be potentially hazardous. The professionalism of the offshore diver is certainly of a much higher standard than hitherto but there is still a long way to go compared with the standards in such areas as international air travel. Progress has and will continue to be difficult as divers are not produced out of a common mould and the standardisation of the behaviour and techniques, which is sometimes regarded as professionalism, is difficult. The historical description of the diver's cavalier, buccaneer or even cowboy approach to life will take a long time to outlive. This is why I am glad to see that the training standards for divers and support personnel are getting away from the "wooden top" approach. It is not true that you have to be mentally subnormal to go under water. It has been said so many times "that diving is only a means of transportation" albeit it involves the application of the result of years of research into physiology, chemical engineering, electrical engineering, hydraulic engineering etc., but at the end of the day the diver has to be capable of carrying out useful work at depth.

Offshore activity is increasing on the UK continental shelf and at the end of 1984 there were 126 installations and 55 diving spreads working. Exploration work is continuing at a high level and is limited largely by the availability of mobile drilling rigs. Changes in gas prices and tax concessions are also encouraging activity. The trend in pipeline work is slightly different as there are few major operations but a larger number of smaller projects. Superimposed on this activity is an increasing need for surface and sub-surface inspection, maintenance and repair of existing installations and pipelines as they age in a hostile environment. All this adds up to a considerable amount of diving activity and makes the North Sea the major offshore operational centre in the world. In the Norwegian sector there has been a lot of deep diving activity involved in the laying of pipelines across the Norwegian trench. Last year diving was being conducted on a regular basis to 260 metres and training and selection has already commenced in preparation for this year's diving programmes to 350 and 380 metres aimed at providing a repair capability for new pipelines.

Training and Certification

The high level of diver activity in the North Sea is proving attractive to divers from all over the world but once again I have to stress the absolute need for UK training or UK recognised training qualifications before a diver can be employed. In past years I have explained the reason for the setting up of the training standards which appear to be justified by the improvement in the casualty figures. You may also remember that the need for training certification was introduced in 1981 but with a possibility of obtaining certification by experience. This was designed to look after the experienced divers who did not take advantage of the grandfather clause for a variety of reasons and who had not necessarily been to a recognised training school. At the same time this method of certification provided a loophole by which to avoid expensive recognised training and this is now considered no longer justifiable. Action is being taken to delete from UK legislation the possibility of obtaining certification just by experience or by some training and some experience. We believe that everybody who was justified in claiming under the scheme like the old and bolds who were diving prior to 1981 have now done so.

Accidents and Incidents

In 1984 there was one fatal accident, 15 dangerous occurrences, 17 serious injuries (and this includes Type 2 decompression sickness) and 7 minor injuries. Included in the total accident/incident list are 2 explosions which occurred whilst the divers were cutting/burning underwater, 3 trapping incidents, one of which almost severed a man's hand, 11 Type 2 bends, but as we are encouraging supervisors to treat all cases of decompression sickness as serious, one cannot place too much reliance on the Type 2 figures. There were 2 explosive decompressions of medical locks which I think supports our requirement for the fitting of interlocks. There was a minor fire resulting from a pillow leaning against an unprotected lightbulb, one incident in which it was suspected that the diver may have had more than the acceptable radiation exposure, 3 problems with dynamically positioned vessels which was entirely due to design failure and 2 bell recovery problems.

With the amount of diving activity in the UK sector during 1984 and the escalation of diver time subjected to pressure I believe that the diving industry has every reason to be pleased with the present safety record but, as always, we must all avoid complacency. This may sound like a lot of platitudes and OK phrases but it is a fact that the fatal accident rate in the North Sea is now fifty times better than hitherto.

In the UK we have now established a computer programme for recording and assessing diving accidents. It will take some time before this programme is of real value as we are dealing really with quite small numbers but for your interest, I can show you the figures and brief statements on all the fatal diving accidents of known diving fatalities involved in oil and gas operations in Northern Europe since 1971.

1984 Research Projects

We are continuing to invest money in research into diving problems. However, I must admit that I considered it a very sad day when the industry initiative aimed at improving diving safety was disbanded.

Breathing Gas Purity

We are continuing to assess the toxicity of contaminants likely to be introduced into the chamber atmosphere from the work site, for example, epoxy resin, crude oil, silicone rubber solvents, etc. We have undertaken a study to predict the identity and quantity of likely contaminants in the chamber/habitat atmosphere and to establish maximum acceptable levels.

The offshore analysis of gases breathed by divers is particularly difficult if we are looking for trace contaminants. Ideally we require an on-line technique which can be operated, and results interpreted, by non-specialist personnel. We are undertaking a survey to identify the technique most likely to meet these ideals within a reasonably short development time.

Hyperbaric Evacuation

A great deal of money has been invested by the industry in various pieces of hardware for evacuating teams of divers under pressure from a threatened offshore installation. A number of these devices have been the cause of some concern in the terms of:

(a) ultimate recovery;

(b) thermal stress for the occupants.

We have recently undertaken some trials addressing both of these concerns. Our conclusions include:

(a) The marine recovery of a buoyant chamber mounted within a substantial steel framework is considered much more feasible than that of a chamber mounted inside a GRP "lifeboat".

(b) As with the lost bell situation the occupants' thermal balance is essential for their survival. However, with a hyperbaric rescue vessel thermal stress can be due to cold when we have a few occupants pressurised to significant depths, or it can be due to excessive heat when we have a large number of occupants at relatively shallow depth. In either case, the thermal stress can be life threatening within a matter of hours.

So far we have only studied the heat stress situation where the ambient air and sea temperatures dominate the rate of cooling possible with the limited self contained power sources normally associated with hyperbaric rescue vessels (HRVs). It would seem that provision for the net extraction of heat of around 110 watts per diver from the chamber is essential for thermal equilibrium to be maintained. This requires reasonably sophisticated techniques when the ambient temperatures are above 10°C for the sea and 15°C for the air.

Air Decompression Schedules

We have been receiving anecdotal evidence that currently used air decompression schedules may be causing an unacceptably high incident rate under certain conditions. We are undertaking a survey identifying dive parameters and associated incident rates to identify (a) if there truly is a problem, and (b) if so, what particular combination of diving parameters and decompression schedules is causing the problem. As I told you last year my own sift of the raw data suggested an across-the-board decompression sickness percentage of less than 1%.

Long Term Effects of Diving

One common method for assessing early signs of potentially hazardous toxic fumes or ionising radiation is to examine the type and frequency of modifications to chromosomes in blood cells. Early indication showed that 4% of the diving population studied showed unreported level of chromosome damage in only 2% or less of their white blood cells. This compared with less than 1% of the non-diver control group. The chromosomal damage has been related to general medical history, type of work, degree of exposure to X-rays, smoking, alcohol consumption, chemical exposure, diving experience including types of diving, hours of exposure, partial pressure of breathing gas constituents, working depth range, deepest dives, diving related illnesses and accidents. NO, and I must repeat NO correlation between any of the above and the occurrence of severely damaged cells has been found. The conclusion to date is that diving per se is not the cause of these damaged cells. It could be that some sporadic activity is the most likely causative factor with divers showing a higher propensity.

Also we are undertaking a study to identify the possible role of oxygen in the initiation of bone necrosis. A hypothesis linking an elevated partial pressure of oxygen with a reduced blood flow, and thus reduced gas transport out of bone tissue during decompression, is being tested.

Finally, I am pleased to report that the UK hosted the first meeting between the various international diving contractor organizations in Aberdeen last year. Representatives from the AODC (Europe), the ADC (America) and the CADC (Canada) informally agreed to exchange information. Also present were the Diving Inspectors from the Governments concerned. There was a strong willingness to co-operate and to standardise certain procedures. The whole theme of the meeting was based on "communication" and it is hoped that this is another step in the direction of international standardisation.

This paper was presented at the Association of Diving Contractors' International Symposium, 1985. This was Commander Warner's tenth paper, as the UK Department of Energy's Chief Inspector of Diving, to this forum.

Commander Warner retired in May 1985. His successor as Chief Inspector of Diving for the UK Department of Energy is Mr Roy Giles.

THE WORLD UNDERWATER FEDERATION PASSES ITS FIRST QUARTER CENTURY

A Press Release

In Paris on 14 January 1984 the World Underwater Federation celebrated the 25th anniversary of its foundation.

THE 'BYFORD DOLPHIN' DIVING ACCIDENT

Stein Tonjum, head of the Diving Division at NUTEC, was a member of the expert committee appointed by the Ministry of Local Government and Labour to investigate the diving accident aboard the semi-submersible 'Byford Dolphin'. In this article, Tonjum summarizes the findings and recommendations of the committee, which reported earlier this year.

Almost one year ago, in November 1983, a serious accident occurred in the diving system of the semi-submersible 'Byford Dolphin' on the North-East Frigg Field in the Norwegian sector of the North Sea. Four divers and a member of the surface personnel lost their lives as a result of the accident and a sixth man was seriously injured.

How could such an accident occur in a modern vessel, with trained crew and given the wealth of regulations and procedures which should cover every eventuality? To answer this and similar questions, the Ministry of Local Government and Labour immediately appointed a six-man expert committee which was given the mandate of investigating the circumstances which surrounded the accident, and if possible, of ascertaining its causes. The committee was also asked to consider whether the appropriate regulations had been followed and whether these regulations and procedures should be improved.

Sequence of Events

The accident happened as two divers were being transferred at a pressure of nine atmospheres from the diving bell to the hyperbaric chamber complex. A further two divers were resting in the chamber complex, and all doors, both between the bell and the complex, and between the chambers of the complex, were open.

The bell was secured to the chamber complex connecting trunk by means of a hinged clamp, which was placed over the mating flanges of both units, and manually tightened by a bolt and nut at the open ends of the clamp arms. At some point during the transfer procedure the clamp was loosened, and the pressure differential between the chamber complex and the outside atmosphere blew the bell away from the chamber. The pressure inside the chamber immediately fell to one atmosphere, killing all four divers inside. Two divers who were acting as surface crew were seriously injured by the bell as it blew off the chamber flange; one of them died as a result of the accident.

No Mechanical Defects

The clamp which should have held the bell flange tight to the flange of the connecting trunk was examined after the accident. No material defects were found, apart from a slight deformation, believed to be due to the explosion itself. The accident was thus not caused by a mechanical fault. In fact, the nut on the bolt which held the two ends of the clamp together was completely unscrewed when the clamp was examined, suggesting that the clamp had been loosened manually, presumably by one of the surface crew.

Human Error

This appears to be confirmed by the surface crew diver who survived the accident, who noticed his companion unscrewing the nut as he returned from performing another errand. The expert committee concluded that the accident was due to human error, and that the surface crew diver who was killed in the accident, unscrewed the clamp locking nut before the door to the chamber complex had been closed and the tunnel depressurized. Whether he did so by order of the diving supervisor or on his own initiative is not clear.

Warnings and Regulations

The diving procedures and safety manual used in connection with the 'Byford Dolphin' diving spread makes it clear that diver transfer entails procedures requiring special care and attention to correct procedure.

The 1982 revision of Det norske Veritas' regulations regarding the technical arrangements of diving spreads included a requirement that it should be impossible to open the mechanism connecting chamber and bell while the connecting trunk is pressurized. Such modification, however, had not been implemented on 'Byford Dolphin' at the time of the accident. At the time of the accident, the change in Veritas' regulations had not been given retroactive effect, and the diving company had no specific plans to introduce the modification.

Improvements for the Future

The expert committee recommended that the chamber system should be modified to prevent separation during pressurization. A further suggestion on the technical side was that doors between chambers should be kept closed, or at least that a system should be installed to ensure that they would close automatically in the case of a pressure drop.

Clearly defined operating procedures should be worked out and adhered to, and conversations between divers and chamber operators should be recorded during transfer operations.

The responsibility for various aspects of safety should be more clearly defined, and diving safety committees should be given a more formal status in order to increase the level of preventative safety activity.

The committee made several other recommendations of more general character, and in conclusion, pointed out that while diving is usually regarded as a dangerous occupation, this particular tragedy occurred after the divers had been brought to the surface and were entering a rest period, during which time they ought to have been able to feel that they were in safe hands.

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OXYGEN FIRE IN A HOME MADE ADAPTOR

Des Walters

The following is recounted in the interests of diver safety and in the hope that others will be able to avoid errors associated with the careless use of oxygen apparatus.

A training exercise was being conducted by the New South Wales Volunteer Rescue Association involving 20 divers in a series of exercises over two days. Activities included simulated body recovery and responses to simulated diver emergencies. In keeping with current safety procedures a "D" size oxygen cylinder was available for use and was utilised in the training programme without incident on the first day when a commercially available Bendeez adaptor and a diving regulator were used to administer oxygen.

The cylinder's use on the second day produced a more dramatic effect. The Bendeez adaptor was not available so a home-made adaptor comprising a K valve with a standard CIG oxygen bullnose coupling attached was employed with the same regulator that had been used the previous day. When the cylinder and valve taps were turned on sparks erupted from the water sensing holes in the first stage. They started like a sparkler on bonfire night and got progressively stronger like a Mount Vesuvius fire cracker as the oxygen carved out the parent metal. I kicked the cylinder away and a small explosion occurred. The fire abated and the cylinder valve was turned off.

Within seconds the noise and fire had stopped and all I had to show for it was an accelerated heart beat, a case of "sunburn" on arms and face, and a T-shirt full of holes from the sparks.

The regulator was destroyed. The fire had been so hot that the brass surface of the valve was burned away where the regulator mated with it. The 1st stage filter and the "O" ring were consumed, as the fire had jetted into the regulator. The Delrim piston was melted, as was most of the teflon HP seat. The flame created a 5 mm diameter hole in the body of the 1st stage. The stainless steel stem of the piston was either ejected from this hole or consumed. The neoprene and fabric in the pressure gauge hose was burnt, and the hose was filled with soot. The hose leading to the 2nd stage was intact, but filled with soot. The downstream valves had been forced open and the 2nd stage mouthpiece was stained with soot. I have no doubt that if the regulator had been in a diver's mouth the result might have been fatal.

I was understandably alarmed by this potentially lethal accident and was keen to ascertain the cause. I made preliminary enquiries of Jim Agar (of Airdive), Dow Corning (who had supplied the lubricant in the regulator), CIG, CSIRO and Bob Sands (of Bendeez). The latter was contacted because of the research he had done in developing the Bendeez adaptor and his many industrial and technical contacts.

DISCUSSION

In considering why this fire occurred when using a home-made adaptor but not while using the commercially produced Bendeez adaptor the following points are important.

The regulator had just been serviced by the manufacturer, the octopus and tactile gauges were brand new, and the unit had not been used prior to the weekend. The fact that it was used the previous day indicates that it was unlikely to be the cause. It is doubtful whether any regulator, even one dedicated to oxygen, would have withstood this firey onslaught.

The lubricant used in the regulator was a Dow Corning Compound 7 or 14, which is widely used for regulator service. Dow Corning is adamant that this compound is unsuitable for use with high pressure oxygen or high pressure air! Cheaper lubricants are considered to be even more dangerous (eg. vaseline, petroleum jelly).

The adaptor valve was the difference between trouble free use on the first day and the potentially disastrous situation on the second day, and possibly the key to the problem.

The requirements for combustion are known to all who have done basic science. They are oxygen, heat and fuel. Oxygen was available in abundance. Heat could have been produced in two ways within the system used, either by a rapid pressure increase or by turbulent gas flow.

Oxygen delivery using the home-made adaptor required the turning on of <u>two</u> taps, one on the oxygen cylinder and one in the K valve. I turned on the oxygen cylinder first, <u>then</u> the K valve. This would produce a sudden pressure increase within the K valve and it is possible that sufficient heat was generated to cause a fire, which jetted into the regulator when the K valve was opened. That the source of the fire seems to have been the K valve seat supports this theory.

Heat can be produced by turbulent gas flow. Here the home made adaptor may be at fault when compared with the Bendeez adaptor which has been designed to reduce turbulent flow to a minimum. But heat produced by turbulent flow does not explain why the home-made adaptor had been used many times without any problems up to the incident described here.

The final requirement for combustion is fuel, and here the picture is not so clear. <u>Something</u> had to be fuel for the fire and my suspicion is that it was the silicone lubricant. All authorities contacted were quick to point out the unsuitability of the commonly used lubricants for high pressure oxygen, and that a regulator prepared for <u>air</u> is not suitable for oxygen. But this does not explain the many thousands of times the Bendeez adaptor has been used without any problems whatsoever! In fact on the recent "Pandora" expedition the Bendeez adaptor was used 647 times without incident.

So the explanation of the occurrence seems to be a combination of factors not present when using the Bendeez but occurring when the homemade adaptor was used.

First testing has now been completed by Bendeez engineers and by the CIG laboratory. While it is difficult after the fact to find the cause, both agree the fire started in the adaptor and CIG believe the cause to be a contaminant. The view is supported by the fact that the fire abated when the fuel was consumed. When the oxygen cylinder was checked after the fire it still had over 1000 psi in it. However, the contamination theory does not explain how the adaptor had been used without incident previously. Was it a contaminant or was it the silicone? We may never know, however clear guidelines for the use of high pressure oxygen emerge.

GUIDELINES FOR THE SAFE USE OF OXYGEN

1. Never use oxygen near heat or flame, which includes people smoking.

2. Only use lubricants recommended as suitable for use with oxygen. This may not be as easy as it is to write, as Dow Corning say that they do not have a lubricant suitable for oxygen or high pressure air.

3. Turn oxygen cylinders on slowly. This reduces the heat caused by sudden compression of the gas inside whatever is attached to the oxygen cylinder.

4. Home-made adaptors should <u>not</u> be used.

5. Regulators used with oxygen should be scrupulously clean, and should be sealed until required for use as any contaminant, oil or grease, can be a source of fire. Remember that even using a prepared or new regulator on an ordinary scuba cylinder could contaminate the regulator with oil residue from a dirty compressor. Experts recommend that oxygen regulators be unlubricated and fitted with special "O" rings (as neoprene burns at a relatively low temperature). Consider using a regulator that has been designed specifically for oxygen use, eg. the Airdive Dedicated Oxygen Regulator or a CIG Oxygen Mini-Reg with flow meter, mask and reservoir bag to deliver 100% oxygen.

6. All divers should be trained to use oxygen and oxygen equipment as this is possibly the single most important life saving measure for all diving accidents. Remember, oxygen only becomes dangerous when mishandled. Perhaps this training should become mandatory as part of all basic diver training?

I will conclude by thanking all those who have assisted this investigation, in particular Bob Sands whose Bendeez was NOT responsible for the incident.

COMMENT

I congratulate Des Walters on his excellent paper.

This frightening demonstration of the fury of combustion in a pure oxygen atmosphere should not blind readers to the real value of post-dive oxygen (100%) in the management (and prevention, as on the Pandora expedition) of diving casualties.

Like the author, I have often used a made up adaptor similar to the one mentioned above. However I have ALWAYS had the adaptor tap fully open before turning on the oxygen cylinder.

This procedure means that instead of a ml or less of gas being rapidly compressed, as happened in the above incident, a much larger volume is compressed slightly more slowly so generating less heat, and as it is being compressed some gas is escaping into the low pressure side of the regulator so removing heat.

I think that Des Walter's guideline 5 could jeopardise the ready availability of oxygen for diving casualties. Murphy's Law suggests that when the equipment was needed either the oxygen or the dedicated regulator would not be available! Using a CIG Oxygen Mini-Reg with flow meter, mask and reservoir bag cannot be guaranteed to deliver 100% oxygen unless positioned by an anaesthetist or someone with a similar training in getting an airtight seal with a mask. Very few divers have had this training, and beards make the seal almost impossible to obtain.

For these reasons I prefer to continue to take a D size oxygen cylinder with a Bendeez adaptor already screwed into the outlet with me when going diving, and attaching any available regulator if the need arises. I believe the risk of a fire is low enough to be acceptable.

John Knight
Melbourne

Ed. This paper appears to have been submitted to more than one journal. It is printed here because of its interest and importance.

<u>AIRLIFT SERIOUSLY INJURES DIVER'S ARM</u>

JC Fine

Pirates, sharks and legendary curses are the least of a treasure diver's perils. The real danger of serious injury comes from the use of machinery and equipment on board ship and in the water.

While many stories about successful amateur and professional underwater treasure hunting ventures abound in popular dive magazines, there are far more unsuccessful ventures where one of the unfortunate divers is the victim of an accident.

It stands to reason that working with and around machinery that is designed to employ force on the surface or underwater requires special training and precautions. All too frequently, sport divers set about fabricating or buying treasure digging equipment without ever having professional training in its use.

Underwater demolition and blasting devices, hydraulic tools, welding and cutting equipment, airlifts, lift bags, water jets are all tools used in underwater treasure hunting work. All are potentially dangerous to a diver.

Recently a freak accident seriously injured a professional salvage diver. The piece of equipment he was using is often considered relatively harmless by most treasure divers and safety precautions with its use may be overlooked.

Geno Robeson was working at 80 feet in the Gulf of Mexico using a professional helmet with surface supplied air. He was digging ore out of the bottom of a sunken ship with an airlift. It consisted of a four inch diameter tube made of PVC-like material along the outside of which ran a high pressure air hose connected to a powerful compressor on the surface. The high pressure air shooting into the tube near working end creates a vacuum in the airlift which sucks material off the bottom and carries it to the surface where it is sifted and screened.

Geno Robeson was wearing neoprene gloves and a thin wetsuit. Somehow his hand got directly in front of the airlift tube while he was fanning ore toward its mouth. The powerful airlift sucked his hand and arm into the tube. Because the diver was wearing the neoprene glove and wetsuit, his arm made a perfect seal in the pipe. The diver's arm was caught in the lift. Robeson described the pain: "It liked to pull all the blood out of my body. I never felt pain like that in my life", he said.

Although the airlift was shut down and Robeson could communicate with the men on the surface through the helmet communication system, the suction continued even after shut down and Robeson could not remove his arm from the airlift. The diver surfaced where the tube had to be cut off his arm. In spite of the pain, Robeson had to enter the support ship's decompression chamber before he could be evacuated to the hospital. His hand and arm were swollen several times normal size. When finally evacuated, surgery had to be performed to release the blood trapped in the diver's swollen arm by the suction.

This accident involved a highly trained and experienced professional diver. Using underwater salvage equipment was part of his job. None of this made the freakish accident any more avoidable perhaps, but it emphasizes the need for awareness for sport divers tempted to fabricate and use salvage equipment underwater.

Signs at construction sites which proclaim: THIS IS A HARD HAT AREA, could just as well apply to most underwater salvage and treasure hunts. They are "Hard Hat Jobs", better left to professional Hard Hat divers. Remember too that professional divers are "working" and that their job related injuries are covered by Worker's Compensation Insurance. Sport divers may be taking the same risks only to find that any resultant injury is a sport injury, not covered by their insurance. It pays to check before plunging into a potentially dangerous situation unprepared and uninsured.

This article originally appeared in CMAS Bulletin News, No. 139, January 1984, to whom we are indebted for permission to reprint. The text is printed as it appeared in the original.

WATER BLASTER **INJURIES**

Tim Everest
Singapore

The water blaster operating at ten thousand pounds per square inch, or more, as become a standard piece of diving equipment. Before any inspection, bolt removal, anode replacement or non destructive testing can be carried out the subsea structure usually has to be cleaned. The most efficient way to do this is to water blast, followed, in some cases by either wet or dry sand blasting (where regulations permit).

There are no hard and fast rules governing the operation of water blasters under water. The Department of Energy (DOE) (UK) regulations make only one firm recommendation, that the end of the barrel/nozzle must be at least one metre away from the trigger. I have been unable to establish whether there are any regulations regarding the trigger mechanism, most manufacturers supply blast guns with a "dead man" style trigger which causes the gun to dump or unload the pressure as the trigger is released. However, I have seen guns in the field with the triggers taped down with duct tape, and others supplied two pieces of pipe and a nozzle at each end, to be "made hot" from the surface.

As a result, in a period of three months (450 engine hours) three divers were injured while using the blaster, documented with three sets of crossed fins painted on the side of the unit!

Injuries caused by high pressure water are often serious even though the superficial damage may not look severe initially. In the business of hiring out water blasters, my two units have collected the end of an index finger, a severely infected foot with the loss of feeling in two toes and one lacerated forearm! This latter injury was caused by the retro tube being incorrectly fitted and falling off. The diver failed to check the gun prior to entering the water and did not check it prior to engaging the trigger.

On coming out of the water he had a wound similar in appearance to a burn, with the skin torn off and a lump the size of a hen's egg beneath the skin containing sea water. The diver required a long decompression and by the time he came out of the pot the lump had almost gone, although he complained of numbness in three fingers and a patch on the back of his hand. The supervisor was in a quandary, trying to decide whether the damage was due to the water blasters, BS or a bend. It was eventually decided that a watch would be kept on the diver and he was sent off shift. I talked with the diver last night (48 hours after the accident) and took a look at the wound. The egg shaped swelling has gone, the half inch wide by two inch long wound has a scab, almost black, along its length. The scab is surrounded by an area of red inflammation extending about three inches up and down his arms. I suggested that he see a doctor but this was rejected out of hand, he is a "day rater" and at the moment work is hard to find. Feeling has returned to his hand and except for a feeling similar to a torn muscle he claims to be fit to dive.

Some employers, supervisors and DMT's may not be aware of the potential for severe tissue damage resulting from a water blaster accident. Over the past few years I have seen some horrific damage inflicted by water and grit blasters. In Brunei, a diver somehow placed the gun under his arm and pulled the trigger, injecting dirty sea water and copper slag into his shoulder socket! The reader can imagine the trauma caused by this type of accident.

This article may still fail to get the message across strongly enough. Would it not be possible for someone on your staff who is better qualified than I to devise a set procedures and lay down some standards for the use of water and grit blasters underwater.

TRIAGE Editor's Note:
Despite the constant warnings by equipment manufacturers and individual diving contractors guidelines, such injuries are clearly on the increase. Readers are referred to TRIAGE 4 (October 1983). Page 13 outlines both the treatment of HP water jet injuries and details of the Association of High Pressure water jetting contractors publication "Code of Practice".

Reprinted by kind permission of the Editor from TRIAGE, the newsletter of the National Association of Diver Medical Technicians, No. 9, January, 1985.

DISABILITY + KELP = DISABLED

The victim was diving with his coach when he became caught up in kelp in about 10 feet deep water. He had largely lost the use of his right leg because of polio and apparently tended to use his arms as his main form of propulsion. When his arms became immobilised by the kelp he was freed by his coach but about 3 feet from the surface his right leg became entangled and again his coach began to cut him free.

At this point the victim panicked and let his regulator fall from his mouth. The coach attempted to inflate the buoyancy compensator but found that the low pressure hose had become detached so dropped the victim's weight belt instead. He then dragged the victim to the surface before himself becoming entangled and having to call out for assistance. The second rescuer, another student, also dropped his weight belt and assisted the coach keep the victim afloat. He stopped breathing and mouth to mouth resuscitation was immediately instituted in the water. He was unconscious for about 1 minute but rapidly regained consciousness and resumed breathing after being brought ashore.

COMMENT

Thick kelp can be hazardous even for experienced divers. For a partially disabled, inexperienced diver the situation can be particularly hazardous. It is to the credit of the instructor and the students that the incident was concluded without ill effects. Panic is always lurking around the corner and unless prompt, definitive, correct action is taken by the rescuer the victim can rapidly succumb.

EDITOR

Readers may wish to consider the advisability of taking pupils, particularly those with significant disabilities, into such a dangerous situation. The unattached vest inflation hose suggests imperfect checking of the pupil's equipment by the instructor. The margin between a "well managed response" and a "most unfortunate incident" is terribly slight.

This report was kindly made available by the New Zealand Underwater Association.

EVEN DIVERS WITH DISABILITIES CAN DIE

This fatality involved an overseas diving incident, the victim being a man with two and a half years of diving experience. His disability was an incomplete T5 paraplegia which at the beginning of his diving career (May 1982) required the assistance of two persons to walk him up a short ramp. By February 1985 he was able to walk in full diving gear on flat ground, using a cane to assist him and without diving gear over logs on the beach. He had by the time of his last dive become an expert diver with 150 logged dives, which included an advanced course, and he was taking an assistant instructor course.

The events of the fatal dive evolved quietly. The dive site was one the victim and his buddy knew well, though this day the visibility was only fair to poor and there were strong currents. The pair dived together 3 to 5 times a week and had done so for over a year. As a family picnic was planned the less experienced diver had loaned his diving gear to another regular buddy as they had no intention of diving. Some time during the day it was decided to collect crabs for dinner. The more experienced diver, the victim, was suited up in his usual gear (regulator with octopus, depth and pressure gauges) with the exception of using a 50 cu ft tank rather than his usual 80 cu ft tank. He was weighted for slight negative buoyancy and had attached his "goodie" bag to the right side of the buoyancy compensator (BC). The other diver used borrowed gear, a 50 cu ft tank (he usually used twin 50's) with a regulator without a gauge. He had no buoyancy compensator because none was available for him to borrow.

They were regular buddies and the second diver, a smoker, was the one who usually ran short of air first. The dive plan was for a 30 ft depth but it was established by investigating officers at the inquest that they must have been at approximately 70 ft. They had collected a number of crabs when the first diver signalled to his buddy that he was low on air. Buddy breathing procedures were instituted and the regulator was successfully passed twice, then the donor found he was breathing water plus air (his set did not have an octopus). He remembers arriving at the surface without his weight belt. A valiant effort was made at rescue but the first diver did not surface and his body could not be found by later searchers.

At the inquest it was stated that the donor regulator had a crack in the mouthpiece. Death was recorded as "accidental drowning" and the Coroner made a recommendation that all divers use proper standard gear, including J valves, but made no comment about the need for regular checking of equipment for defects, or about the error of attaching the "goodie" bag to the BC rather than to the weight belt, or to the dangers of over-confidence. A series of small errors led to a tragedy.

COMMENT

This diver had overcome great odds to become a scuba diver and had become very experienced, and possibly came to believe that everything was possible to him. Both he and his buddy failed to recognise the import of the smaller tanks they were wearing and the victim, who had a contents gauge, ignored the warning of a low air situation. Had he followed training and commenced his ascent then there would have been no incident and he would be still alive. Naturally when he ran out of air the buddy was also low on air and the double demand on the dwindling supply quickly exhausted what remained. That the buddy only received the water and air mixture at this time suggests that the reported leak was not a significant factor in the fatal outcome. It was not stated whether they started to ascend immediately or had attempted to establish a breathing rhythm first. Nor was any reason given for the failure to inflate the BC (type not stated). It is debatable whether the Coroner was correct in believing a J valve to be a safety factor for divers. A contents gauge which if used intelligently is a better guarantee of having adequate air at the end of a dive.

It was not his disability which killed him but rather his failure to realise that he was only human and that the sea does not play favourites.

DIVING SAFETY MEMORANDA

Department of Energy
Diving Inspectorate
Thames House South
Millbank London SW1P 4QJ.

DIVING SAFETY MEMORANDUM NO. 2/1985 SHOCK HAZARD FROM IMPREST CURRENT ANODES

10 January, 1985

1. A reassessment of underwater electrical safety criteria suggests that imprest current anodes do not constitute a hazard to divers providing that the voltage at the anode does not exceed a nominal 24 volt DC.

2. This implies that if the power is derived from a rectified AC source, adequate protection must be provided to trip supply if:-

(a) the higher primary voltage breaks through to the secondary circuit; and

(b) the ripple on the rectified DC exceeds 5%, eg. due to phase failure.

3. Provided that these precautions are taken imprest current anodes need not be switched off when divers are working in their vicinity. However, operators may consider reducing the voltage to 6 volts.

4. This note effectively cancels the two previous Safety Memoranda Nos. 12/1976 and 9/1977.

DIVING SAFETY MEMORANDUM NO. 3/1985 MONITORING OF CO_2 LEVELS IN DIVING BREATHING GASES

April 1985

During the past 12 months reports have been received of incidents in the UK sector of the North Sea where divers, using the diver return line breathing system have been fed breathing gas contaminated with carbon dioxide to a level which, if immediate action had not been taken, could have been hazardous. These incidents can be attributable to the existing method whereby samples of breathing gas contained in the divers' return line breathing system loop are periodically collected and analysed for levels of CO_2. This procedure fails to provide the dive controller with immediate warning of any contamination.

The attention of all diving contractors is drawn to the need to ensure that all breathing gas supplies to the diving bell and divers, when utilising the divers' return line breathing system, should be continuously monitored for carbon dioxide content and should be fitted with a visual/audio high level CO_2 alarm system.

DIVING SAFETY MEMORANDUM NO. 4/1985 GUIDANCE ON MAXIMUM PLANNED DURATION OF BELL RUNS

April 1985

It is becoming apparent that the recommended maximum bell run time of 8 hours is being ignored. (Diving Safety Memorandum No. 9/1982.)

Extension of bell runs beyond 8 hours is considered to be unsafe diving practice and, except in emergencies, is unacceptable. Bell runs should be planned not to exceed 8 hours including the necessary time for pre-dive bell checks and travel to and from the worksite.

Individual divers should not do more than a total of 4 hours lock-out in any bell run and it is recommended that they have at least a 12 hour rest period in each 24 hours.

Commander SA Warner
Chief Inspector of Diving

THE HANDICAPPED SCUBA ASSOCIATION

The Handicapped Scuba Association, a non-profit organization that specializes in teaching scuba diving to people with physical disabilities, recently produced its own 20 minute documentary, "FREEDOM IN DEPTH".

...

The film, hosted by famed oceanographer Jean-Michel Cousteau and starring 19 handicapped divers, dramatically depicts what the HSA has been accomplishing for the past 10 years, bringing the self-image enhancing benefits of sport diving into the lives of paraplegics, quadriplegics, even the blind. Says Jim Gatacre, NSA Program Director, "Because water permits three-dimensional movement in a gravity-free environment, diving is an ideal sport for people with impaired mobility on land".

Beginning in 1975 as a student group on the University of California Irvine campus, the HSA is recognized today as the world's leading authority on handicapped diving. Over a year ago Gatacre realized that communicating over such great distances and to such divergent cultures as Japan, New Zealand, Denmark and others, demanded a unifying medium to carry the message beyond differences of nationality and custom. "FREEDOM IN DEPTH" became that unifying medium.

Funded almost entirely by the Diving Equipment Manufacturers Association (DEMA) and Professional Association of Diving Instructors (PADI) the film is an upbeat, action-packed adventure destined in inspire novice divers, challenge experienced ones and entertain us all, divers and non-divers alike. If you are able-bodied "FREEDOM IN DEPTH" will make you re-assess what you presumed were the limits of physical capability. If you, or someone you care about, is handicapped it will urge you (or them) to look within and listen to the private voice that says, "You can do it if you really want to!" This HSA film provides proof positive that handicapped people can scuba dive safely and skillfully. It takes viewers on an exciting and unprecedented discovery of human spirit, one that progresses from initial pool training, to mastery of beach entries through the surf, to the peak experience of exploring a century-old merchant ship, submerged beneath 100 feet of ocean water.

To order "FREEDOM IN DEPTH", which is available as either a video cassette (VHS or BETA) or a 16 mm film, or to request further information about the purposes and projects of the HSA, please write to:

Handicapped Scuba Association
1104 El Prado
San Clemente CALIFORNIA 92672
USA
Telephone (714) 498-6128

DISCLAIMER FOR LIBEL

The following disclaimer is said to have been published in *Brief*, the West Australian Law Society's magazine, in reaction to Australian libel laws. Its sentiments are not unknown to any editor who receives an angry communication from some affronted reader. Just substitute the word "SPUMS" for "Law Society" and take the words to heart:-

> *"The views expressed in this column are not those of the Law Society. In fact, the society expressly disagrees with each and every allegation and denies publishing or republishing it or them. The views expressed are not those of the author. In any case he-she-it has no money and is not insured for anything. No breach of the Sex Discrimination Act, the Trade Practices Act, the Criminal Code or the Indecent Publications Act is intended or admitted."*

Should any reader actually approve of anything published in the SPUMS Journal they are permitted to ignore the above disclaimer and send a sworn affidavit to that effect to the editor.

RESEARCH DEVELOPMENTS FROM THE FIELD

Dick Clarke

Dr Sem-Jacobson, a pioneer of early jet aviation and space research in both the United States and Europe, has, in recent years, turned his attention to commercial diving operations. With an introduction to deep diving, the Sea-Lab projects and early saturation dives in the Gulf of Mexico, Dr Sem-Jacobson became increasingly disturbed at the high accident/incident rate associated with the offshore diver, particularly with the frequent absence of a clear cause.

Monitoring in the Field

Subsequent to his survey of more than 40 fatalities and 200 cases of a loss of consciousness while under water, in the North Sea alone, a program of biomedical monitoring of the working diver was developed, that would include 'field' trips of up to ten days at a time (recognized by many DMT's, no doubt, as extremely unique and most welcome).

Accompanied by two female Norwegian assistants (who certainly must be credited with helping to get everyone's attention, and made probe and electrode placement less discomforting and almost exciting), Dr Sem-Jacobson set out to learn more in the following areas:

1. Physiological fluctuation of the diver's alertness and efficiency at various depths and during saturation dives of various durations.

2. Physical and mental load/overload during air and mixed gas operations.

3. Diving accidents and standardization of procedures to combat the most common accident cause, human error.

4. Improvement in the diagnosis and treatment of decompression sickness via Brain Evoked Response examination.

To permit such monitoring during working dives, coax-cables were taped to umbilicals supplying the surface diver, diving bell and both bellmen. Additionally, a multi-pin penetrator was fitted to each storage/decompression chamber. All monitoring and testing was designed to take place on a not-to-interfere basis, to ensure client approval and to maintain operational efficiency.

Alertness testing during saturation dives produced surprising results (alertness had long been considered a downward gradient with time, and a basis for limiting saturation exposures). Following a marked instability during the first two to four days, with response time to auditory stimuli varying between 120-275 milliseconds (from surface controls averaging 140 ms), a general improvement was seen. So much so, that by seven to nine days all subjects had plateaued out at close to control levels.

These levels were maintained for the duration of the longest exposure monitored (20 days).

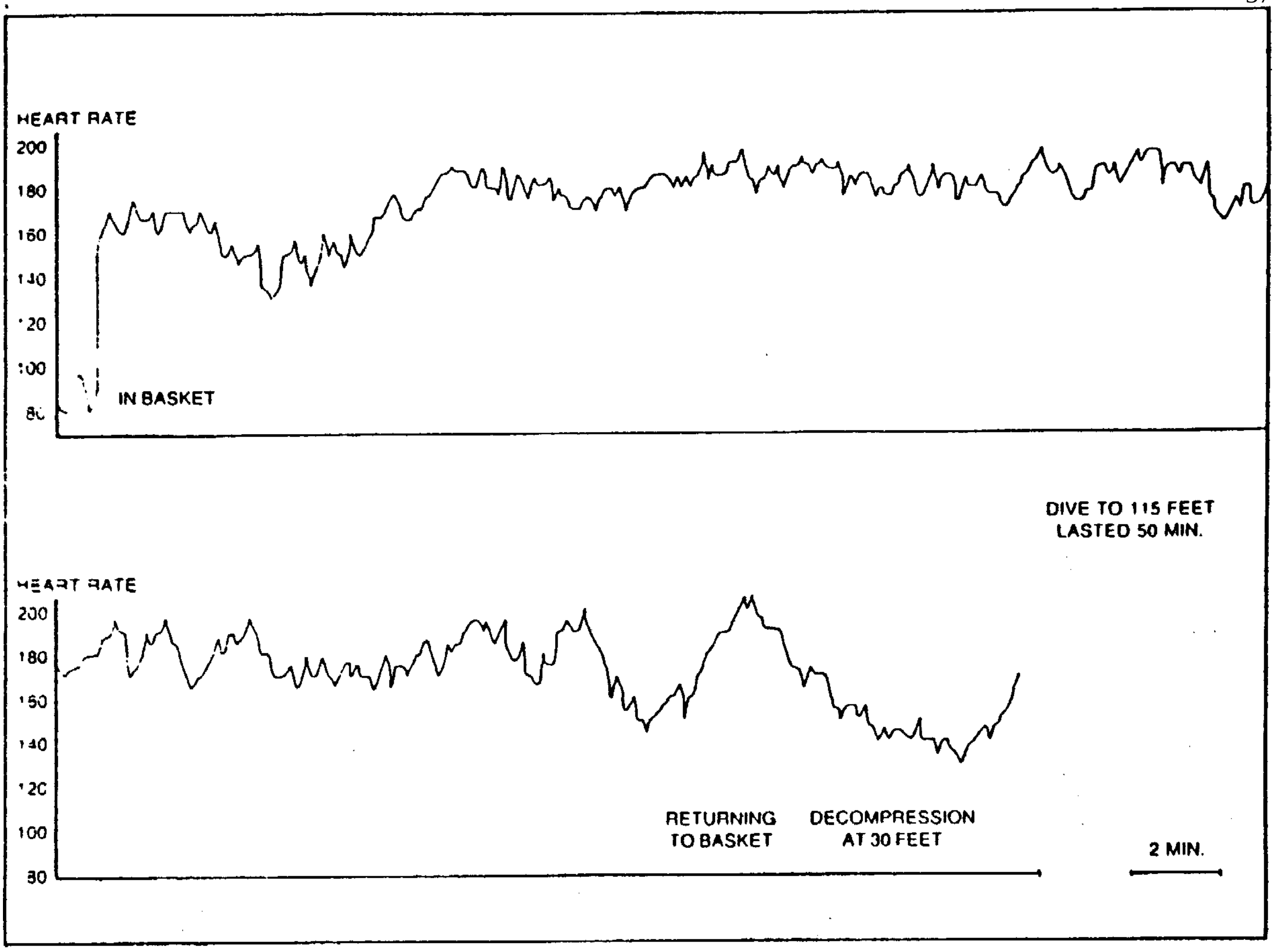
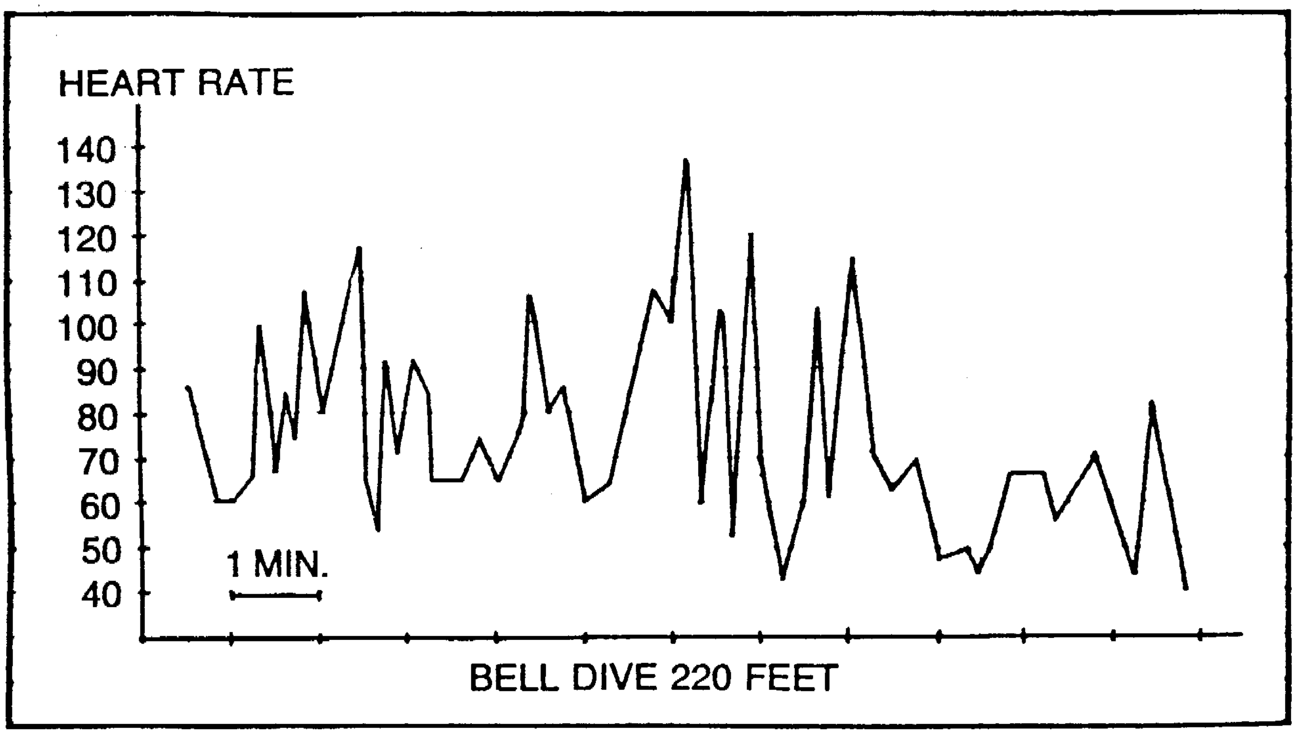


FIG. 1: ROUTINE WORKING AIR DIVE



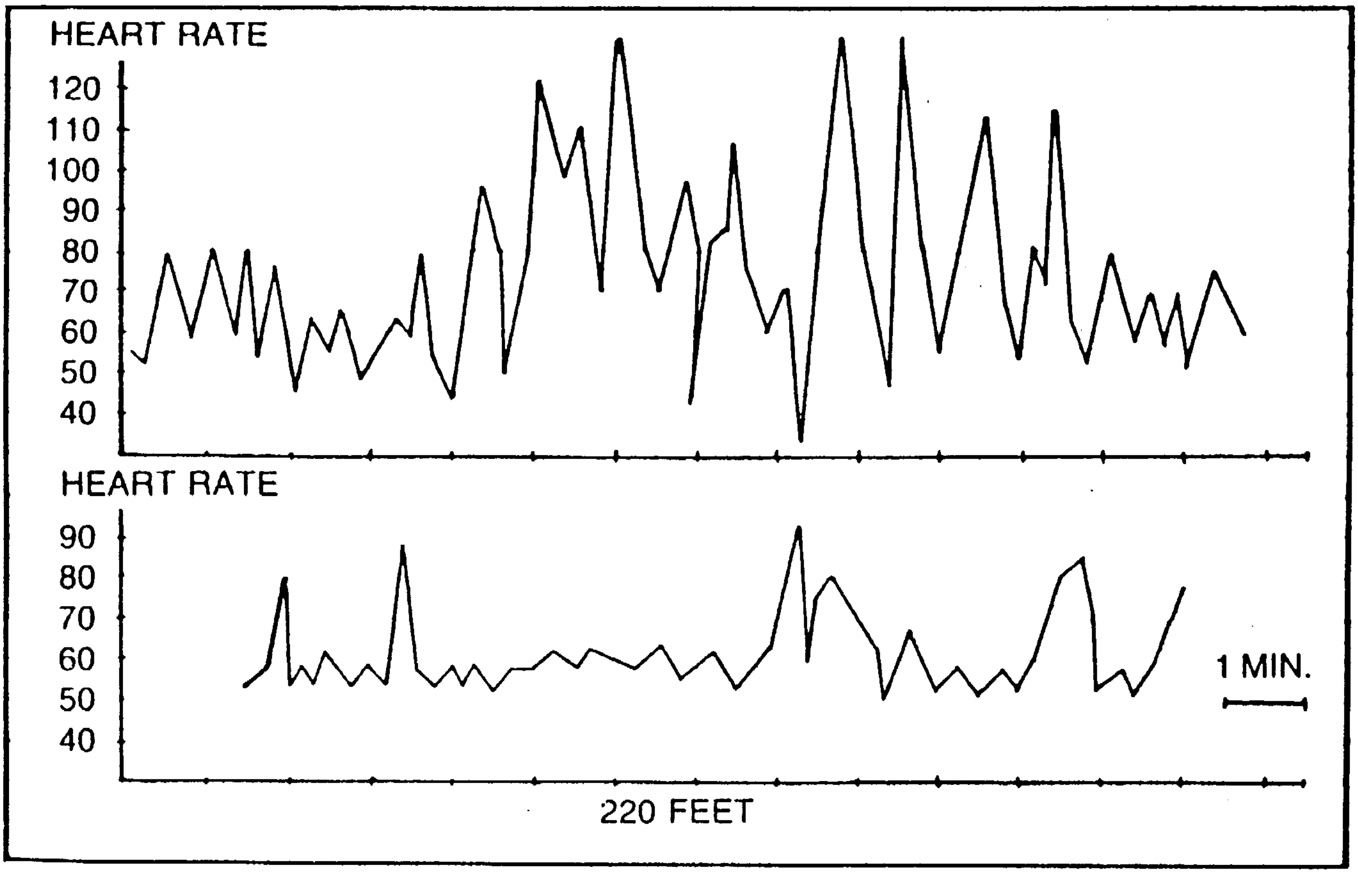


FIG. 3: SATURATION EXCURSION DIVE: BELLMAN

Underwater, it was again the air diver (already a greater risk of CNS decompression sickness than his gas diving counterpart) that indicated significant physical overload and stress. EKG monitors detected heart rates of between 175 and 200 for periods of 60 to 90 minutes in half the subjects, while working between 30 and 130 feet (Figure 1). Dr Sem-Jacobson considered this finding of particular importance and a possible contributing factor in episodes of loss of unconsciousness.

"Armchair" Diving

Excursion dives from storage, even with prolonged bottom times (greater than eight hours), as anticipated, failed to indicate similar degrees of stress (Figure 2). Heart rates rarely exceeded 120, an exception being the bellman's during routine recovery of the diver (Figure 3), thereby adding support to the popular contention that saturation is essentially "arm chair" diving for the semi-retired!

Decompression sickness may produce a number of signs and symptoms not always readily detected at the work site. Associated oedema and oedema resulting from hypoxia and other mishaps can contrive to interfere with gas exchange, even after initial therapeutic compression.

In order to better examine the brain and brain stem, and to provide objective information, Dr Sem-Jacobson, in conjunction with researchers at Scripps Institute in California, developed a small portable Brain Evoked Response unit. This recent development in neurophysiology has permitted direct examination of the brain stem and central brain area under operational conditions.

Cerebral "Fingerprint"

To be of greater value, a baseline BER recording under normal conditions is necessary. This can be attached to the diver's log book and will provide a permanent record (essentially, the diver's cerebral "fingerprint").

The value of such an examination was realized somewhat sooner than expected. Three divers decompressing from a saturation exposure were inadvertently switched to a pure helium atmosphere. Unconsciousness was resolved by rapid compression, using heliox, and intervention by a DMT appeared to stabilize all three men. Dr Sem-Jacobson happened to be in the general vicinity, and arrived at the diving support vessel, by helicopter, in a matter of hours. His equipment was hooked up via the multi-pin penetrator (a case for such a permanent fitting on all chambers). Comparing the post-hypoxic BER's to baseline records, two of the divers appeared normal. In the third, who had been unconscious longest, marked pathological indicators were in evidence and a distinct probability of cerebral oedema existed. Follow-up BER's provided a basis for determining the length of time the diver was maintained at treatment depth. Within twelve hours his BER examination was considered normal (exactly matching his baseline), and decompression was commenced, which proved uneventful. Ascent prior to resolution could have seriously compromised off-gassing at the involved site.

Research on Working Divers

Dr Sem-Jacobson has demonstrated that meaningful research data can be collected during working dives. Hopefully, his efforts will lead to further such projects, as some of the traditional barriers are eased, ie. divers are becoming more willing subjects, realizing the value of procedures not based entirely upon data collected from goats, rats and dogs. Diving contractors are also less resistant, realizing that if they cannot keep their own "house" in order someone else (government agencies) soon will.

Dr Sem-Jacobson has written a number of reports based upon his North Sea investigations, four of which are particularly interesting and informative.

1. Efficiency and Safety in the North Sea (#160).
2. Operational Diving in the North Sea (#165).
3. Monitoring Divers and Diving in the North Sea (#161).
4. Diving Problems and Diving Accidents in the North Sea (#159).

Should you be interested in obtaining any of these publications you might try contacting Dr Sem-Jacobson at the following address:

CW Sem-Jacobson
The EEG Research Institute
Box 9, Gaustad
Oslo 3, Norway

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WAS DR DOOLITTLE RIGHT?

The one-time favourite of children, Dr Doolittle, claimed to talk to the animals in their own languages, and many non-mythical scientists have tried to speak dolphinese (though still uncertain of how to do so). Now Moynihan and Rodaniche, American biologists at the Smithsonian Institute's research station in Panama, have postulated that squid use their amazing ability to change their body marking and shape as a non-verbal means of communication with each other. They distinguished a large number of possible words in the form of colour patterns and/or body contortions and believe that these encode concepts we call nouns, verbs adjectives and adverbs. They therefore have started to test this hypothesis using a computer programmed for linguistic analysis. Should their theory seem to be supported by such an analysis there will be a widening of research to include other cephalopods. It is already known that the appearance of blue rings on Hapalochlaena maculosa means "leave me alone before you provoke me too far".

PORPHYRIA VARIGATA, "FUNNY TURNS", AND DIVING

Robert M Wong

The patient was a 27 year old woman who as a child suffered "funny turns". She had no recollection of these. From 1970 onwards she had episodes of major convulsions, later thought to be induced by sun or heat. A diagnosis of epilepsy was made in 1971 and she was treated with Valium and Dilantin. After an unfortunate incident of a dog bite she developed a "funny" skin reaction and was seen by a dermatologist, who referred her to a haematologist. It transpired that the girl had an aunt who had died after an anaesthetic in South Africa and apparently thiopentone was used. The girl is of Dutch extraction and her paternal grandmother was a Boer. Eventually, in 1977, a diagnosis of Porphyria varigata was made and advice given to avoid the sun.

Her convulsive episodes were all preceded by "auras" consisting of dizzy turns and a sick feeling in her stomach. Each episode lasted about 3 minutes and she was never incontinent.

In 1977 a neurologist changed her medication to Tegretol. By 1980 she felt well and healthy and had not had an epileptic attack since 1975 so decided to wean herself off medication under the supervision of the neurologist. However, her EEG remained abnormal.

Despite her abnormal EEG and history of convulsions she was passed as "medically fit to dive" by a doctor in January 1983 and undertook a Scuba diving course. She was again passed as "fit to dive" 18 months later, just prior to her Advanced Diving Training, by the same doctor. She dived successfully without incidents.

In February 1985 she was diving in the tropics to depths between 24 and 34 metres and completed 9 such dives. On the 10th dive she snorkelled to 10 feet on 3 occasions prior to the scuba dive to 36 metres for 22 minutes. Visibility was described as poor, the water was warm, and she thought she had overstayed her bottom time. She felt confused, could not see her buddy, and thought she suffered nitrogen narcosis. Panic stricken she ascended "rather faster than usual", perhaps hyperventilating, and decompressed at 10 feet for 10 minutes (USN Tables). Back on board, 20 minutes or so later, while talking to friends she convulsed in a typical epileptiform fit. There was no warning aura. Afterwards she was confused, disorientated, and suffered a headache and her memory was affected. Normality returned in 2 days. Since then she has not dived, has had no further convulsions, has not been on medications and has felt healthy and well.

It was confirmed by other divers that the bottom time did not exceed 22 minutes. According to the USN Tables a 120 feet dive for 25 minutes required decompression of 6 minutes at 10 feet. If the RNPL/BSAC Tables are used a 36 metre dive for 23 minutes requires a stop at 10 m for 5 mins and at 5 m for 10 minutes, a total of 15 minutes. The RAN table for 36 m for 25 minutes require decompression stops at 6 m and 3 m for 5 minutes each.

DISCUSSION

This case is interesting in that this girl suffers from Porphyria varigata, has what may be called "arrested epilepsy" with an abnormal EEG, and has enjoyed 2 years of trouble free scuba diving. The dive introduced several adverse factors, nitrogen narcosis, the stress of separation from her buddy in poor visibility water at depth, possible hyperventilation and increased oxygen partial pressure followed by a "rapid ascent" which introduced the possible factors of decompression sickness and cerebral air embolism. The delay of 20 minutes between surfacing and suffering an aura-less epileptic fit whose ill effects took 2 days to completely resolve further complicates the differential diagnosis. There cannot be many such divers in the world. She had no epileptic attacks for 7 years before this episode and had taken no prophylactic medication for 18 months before commencing her 2 years of trouble free diving.

What was the critical factor? Was it her metabolic condition, the CNS abnormality evidenced by the EEG, stress, nitrogen narcosis, decompression sickness, or cerebral air embolism, or was it a combination of two or more of these factors? A further important question is whether it was reasonable to consider her as medically fit to dive.

AND NOW FOR THE GOOD NEWS

An information booklet available to visitors to the remote Northern Territory township of Nhulunbuy contains a few warnings almost guaranteed to decrease tourism.

Under a heading "Dangers for the unwary" it reads: "There is always the risk of crocodile or shark attacks in the estuaries of Arnhem Land, while the venomous box jellyfish is a deadly threat to all north Australian waters from October to May."

It continues: "Several varieties of cone shells are found on the beaches and among rocks, and although the colours are much admired by collectors, some of the shells can also be killers. By inflicting a tiny wound and pumping virulent poison into it, a cone shell can cause paralysis and death."

After this cheery information the booklet goes on to warn about snakes, water buffalo, and the dangers of eating reef fish. The local Gove Tourist Promotions Association really has its work cut out.

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Those thinking of attending the SPUMS Annual Scientific Meeting in 1986 (4 to 13 June) will be pleased to know that the above does not apply to the chosen venue (IBBIS/KAVEKA Hotel, at Cook's Bay, Morea, French Polynesia).

DIVING SAFETY AWARD

The National Association of Underwater instructors (NAUI) is soliciting nominations for the 1985 Leonard Greenstone Diving Safety Award. The award was developed and designed to encourage contributions toward safety in all aspects of diving. It is administered by NAUI, but is not a program of the association.

The Greenstone Award Committee endeavours to present the award annually to a recipient fulfilling the established criteria. A minimum sum of $500 is conferred.

Additionally, a perpetual trophy of Poseidon is presented. Award presentations occur in conjunction with the International Conference on Underwater Education (IQ). If an award is deemed appropriate in 1985, it will be presented at IQ 85 in San Diego, California, in November 1985.

The Greenstone Award is intended to encourage development of all forms of safety programs, equipment and devices. This award has, as an overall objective, the total elimination of injuries or loss of life, relating to underwater activities.

The initial endowment for the award was provided by the founder, Mr Leonard Greenstone, NAUI 2336. It was his hope that others throughout the sport diving community would join in the pursuit of the award's objective.

The Leonard Greenstone Diving Safety Award is open to ALL persons throughout the world, regardless of their organizational affiliation. Members of the Selection Committee are ineligible while serving on this committee.

The initial contact for nomination should include a statement of reasons for submitting the nomination, with an accurate and precise explanation of the contribution, including sketches or diagrams as appropriate, to substantiate the contribution, as it relates to diving.

Previous award recipients include:

1974	- Merrill P Spencer, MD
1975	- Lee H Somers, PhD
1976	- Glen H Egstrom, PhD
1977	- Charles V Brown, PhD
1978	- William L High
1982	- Jefferson C Davis, MD
1983	- Arthur J Bachrach, MD
1984	- Walter Hendrick III

To submit a nomination, information, contact:

Greenstone Committee
NAUI Headquarters
PO Box 14650
Montclair
California 91763
USA