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SPUMS JOURNAL

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South Pacific Underwater Medicine Society

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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.

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

1 Anderson T, RAN medical officers' training in underwater medicine. *SPUMS J* 1985; 15: (2) 19-22

2 Lippmann J,Bugg S. The diving emergency handbook. Melbourne: J.L.Publications, 1985

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

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will be held at the King Solomon Hotel, Eilat on the above dates. The official language will be English.

For further information contact
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P.O. Box 983, Jerusalem 91009, ISRAEL.
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will be held at Le Lagon Hotel, Port Vila, Vanuatu from May 27th to June 3rd 1989

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

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

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

UNDERSEA AND HYPERBARIC MEDICAL SOCIETY MEETING

in HAWAII from June 7th to 11th 1989 and enjoy and contribute to the proceedings

For further information about this meeting write to
Dr Leon Greenbaum Jr.,Ph.D.
Executive Director of UHMS
9650 Rockville Pike, Bethesda
Maryland 20814, U.S.A.

WORLD UNDERWATER FEDERATION CONFEDERATION MONDIALE DES ACTIVITES SUBAQUATIQUES (CMAS)

The next International Congress of Diving Medicine will be held in Martinique (West Indies) from April 29th to May 7th, 1989.

The main themes will be the theoretical basis and initial treatment for diving accidents, microprosessor based instruments used in diving, fitness for and contra-indications to diving. There will be workshops on cave diving and dangerous marine animals. A one dive a day diving programme will parallel the working sessions.

Enquiries should be directed to
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EDITORIAL

Our readers will notice a change on the cover. After much discussion it was decided at the last committee meeting that the image of the Society would be improved by removing the cartoon from the cover and moving away from a card cover and reverting to a white cover. The latter changes will take about a year as sufficient blue card had recently been bought for at least a year's issues This issue's cover is not necessarily the final choice, opinions from our readers will be appreciated.

Another innovation is that the Society has now a lending library of taped presentations, as a start there are the tapes of the 1988 Undersea and Hyperbaric Medicine Society's 1988 Annual Scientific Meeting and of the recent SPUMS, Royal Society of Tasmania and Royal Hobart Hospital meeting on Hyperbaric and Diving Medicine. The transcripts of this meeting will be published as a supplement to the Journal in due course.

This issue covers various topics of interest. From the Annual Scientific Meeting we publish John Williamson's advice on jelly fish envenomation, essential reading for all diving where jellyfish are to be found. Douglas Walker contributes two case histories detailing the dangers of disorientation underwater and of the need to leave the surface quickly in a current, preferably down a fixed line. Robert Wong contributes a case history of illness of obscure origin following diving. We are privileged to print the abstract of Dr Otto Molvaer's thesis, with its interesting illustration. Dr Molvaer is a member of SPUMS and a leading diving doctor in Norway who has contributed to the Journal over many years. The final clinical contribution comes from the Royal Adelaide Hospital where a pilot study on the efficacy of hyperbaric oxygen (HBO) therapy for burns showed a significant decrease in mortality in badly burnt patients compared with retrospective controls who had suffered comparable burns. Although Gorman and Leitch make the point that a prospective randomised trial of HBO in burns is long overdue their figures, a reduction in mortality from 21% to 4.4%, make it doubtful whether any Hospital Ethical Committee could reasonably counternance such a trial.

Diving gets is fair share of attention with a less than enraptured survey of dive computers by John Lippmann, who also contributes an alteration to the rules for using the British Sub-Aqua Club (BS-AC) tables that have been around for a while. These tables have now been superseded by the introduction of "The BS-AC '88 Decompression Tables". These are described in an article reprinted from "Diver". One wonders why the BS-AC has felt it necessary to produce tables which will undoubtedly encourage decompression diving rather than embark on an educational programme in favour of non-decompression diving. Perhaps the large number of wrecks around the coasts of the United Kingdom and the depressing annual tally of diving accidents led them in a different direction to the rest of the world diving community. The BS-AC medical standards printed in this issue make interesting reading although many Australian diving doctors might be more cautious about who they advise not to dive.

We get an insight into the thoughts of the non-English speaking diving world with the minutes of the Medical Commission (CMAS) of the World Underwater Federation. It is encouraging to see that ideas that have circulated in Australia and New Zealand for years are now being actioned in the world diving scene. It is unfortunate that the finances of the Australian Underwater Federation do not allow it to pay for an Australian delegate to these meetings.

The saga of the safety of diving is continued with more papers reprinted from "Undercurrent". From these it would appear that there are probably fewer divers actually diving than had been assumed in America. In Australia we still have only vague guesses. However the Queensland Government is pushing the diving industry into improving its performance and with luck this might include counting the divers and their dives. More of this in the next issue. In this issue we bring you the conclusions of the Western Australian Government's Underwater Task Force, who have shown common sense and interest in the safety of divers without over-regulation by government. We extend our congratulations to the Task Force and congratulate them on listening so effectively to the advice given by the Western Australian members of SPUMS who gave evidence, to whom the Society, and every diver throughout Australia, is indebted for their hard work. It is certain that the Western Australian conclusions are going to influence other governments.

Finally as the Journal was being put to bed news came that the Australian Standards Association, which had abandoned work on a standard for entry level diving training, is forming a new committee, without other responsibilities, to deal with this question. The first meeting will probably be in Sydney in March and SPUMS has been allocated a seat on the committee for the first time.

SPUMS ANNUAL SCIENTIFIC MEETING 1988

JELLYFISH ENVENOMATION WHAT DIVING MEDICAL PHYSICIANS SHOULD KNOW

John Williamson

JELLYFISHES

The following species have been studied to date: the mauve stinger, hair jelly, Portuguese man o'war, cubomedusae (Figure 1) (including *Chirodropids*), North American sea nettle, and cabbagehead jellyfish. Their distribution is world wide. They are found mainly in salt water, in all oceans and seas and are more numerous in the tropics.

They envenomate those who use the sea, fishermen, divers and tourists, and marine scientists. Children are particularly susceptible (Figure 2). The *Chirodropids* (many-tentacled box jellyfish) (Figure 3) cause the majority of presently recognised human fatalities (Figure 2). However 2 recent confirmed fatalities in the U.S.A. from Portugese man o'war have occured, in Florida and North Carolina.

JELLYFISH VENOMS

These are complex mixtures of polypeptides and enzymes. They include acid and alkaline proteases (elastase, DNase, collagenase, metallopeptidase), haemagglutin, and histamine[3]. The venoms damage humans locally and systematically. They act by both toxic and antigenic mechanisms. The former predominates. The toxins are of high molecular weight in the range 10,000-600,000[6]. There are some labile components; for example there is loss of toxicity from heat (37°C), storage, and some fractionation processes.

HUMAN SEROLOGICAL RESPONSE[4]

Specific IgG serum concentrations appear within a few days following envenomation. IgG titres persist for many months. Reasonable (and improving) correlation is possible between clinical and serological identification of envenomating jellyfish. However significant cross-reacting antibodies do occur to the venoms of other jellyfish.

Titre levels of 1 in 50 are significant. Titres of 1 in 3000 are seen not infrequently. Elevated IgG titres are not protective against the cutaneous pain of jellyfish sting. There is some IgM response, but it is weaker than the IgG response. Following jellyfish envenomation, immunological reaction[1] occurs in both the B and T cell systems.

LETHAL MECHANISMS [1,2]

The pharmacology of jellyfish venoms is largely unknown, possibly they are cell membrane destabilisers. Deaths are mainly toxic, however some are allergic due to anaphylaxis.[5] The toxic deaths are possibly combinations of myocardial toxicity[5,6], central neurological toxicity, and hypoxia from pulmonary effects.[8] Other severe toxic effects include gangrene (Figure 4), renal failure and haemolysis.

Anaphylaxis has been documented for a mauve stinger envenomation[5], and suspected for the Portuguese man o'war or blue bottle. Suggestive evidence is that basophils release

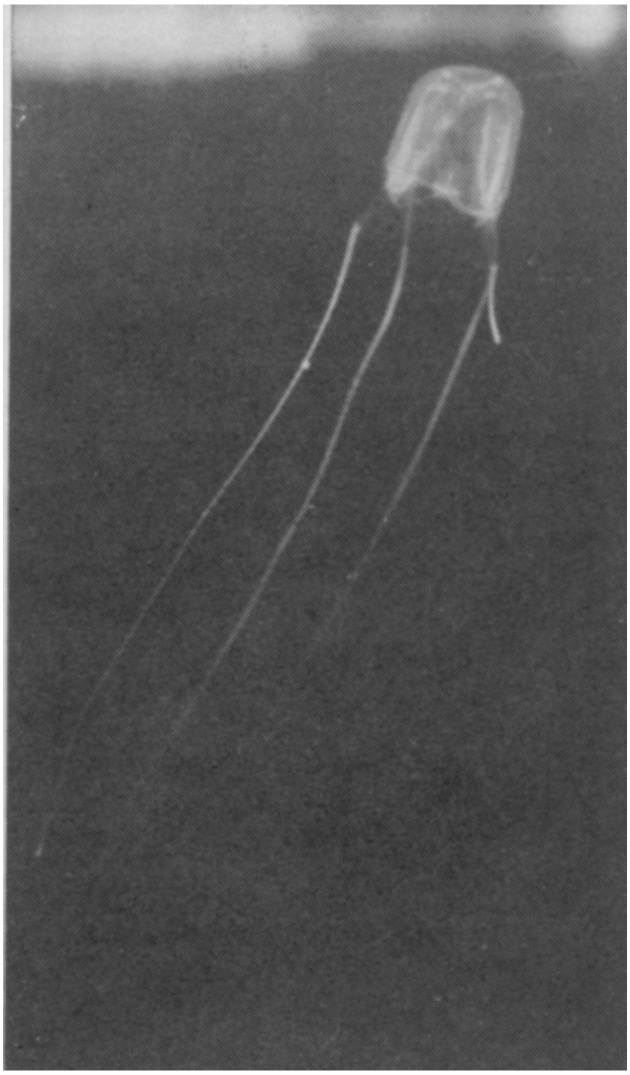

FIGURE 1

A Cubomedusa of the "Irukandji" type (one of the 4 tentacles broken during capture). Divers are at risk from the sting of this group of open water jellyfish. The syndrome may mimic decompression sickness.

histamine in response to venom challenge; sensitivity was passively transferrable in serum, which may have been an unrecognised cause of deaths in the past. Anaphylaxis is more likely in "sensitised" individuals, e.g. those with asthma or allergies.

Venom absorption in jellyfish stings is the most rapid known. This is due to multiple (millions) simultaneous microdoses into dermis. This presents a huge surface area. There may be some direct intravascular deposition. Capillary absorption is enhanced by the muscle pump action of movement. It is not certain that absorption can be stopped by compression/immobilisation bandaging. All other venoms (snakes, spiders, and insects) are absorbed by a combination of vascular and lymphatic capillary flow. The role of lymphatic absorption in jellyfish venoms is unknown at present.

CLINICAL FACTS

Skin reactions to stinging

Cutaneous pain is immediate, and usually severe. The skin pain is savage in *Chirodropid* stinging. There is erythema, blistering (Figure 5), and desquamation. Full thickness skin death may occur. There is increased vascular permeability leading to oedema. Serotonin inhibitors (methysergide) and leukotriene inhibitors (piripost) reduce cutaneous vasopermeability in animals. Initially there are always adherent nematocysts and occasionally adherent tentacles.

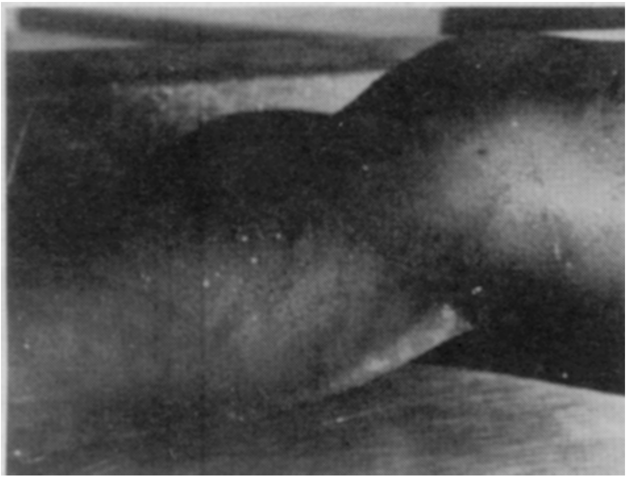

FIGURE 2

A post-mortem photo (12 hours) of a 4 years old aboriginal boy fatally stung by the chirodropid *Chironex fleckeri*. The identity of the jellyfish was confirmed by adherent tentacle and skin scraping examinations. Sadly, the majority of on-going jellyfish fatalities in Australia are now aboriginal children who inhabit remote tropical coastlines *(Photo courtesy of the late Dr Jack Barnes, Cairns).*

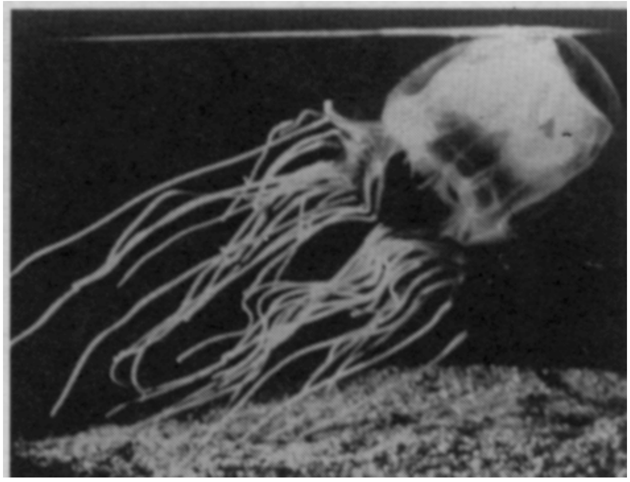

FIGURE 3

An adult chirodropid *(Chironex fleckeri)* under artificially clear conditions, showing the massive armament of tentacles, each laden with millions of venom bearing nematocysts. Entanglement in these by a careless swimmer, or bare-skinned diver produces the most explosive envenomation process presently known. Nematocysts cannot sting (envenomate) through any clothing, including a wet suit, or "stinger-suit".

Cardiovascular responses

These include hypertension, and hypotension, arrhythmias, which may be decreased by Ca^{++} channel blockers. There is myocardial electro-mechanical dissociation[7] and it is said that the heart may arrest in systole.[6] The increased capillary permeability can affect the pulmonary vascular bed leading to pulmonary oedema, which can also be cardiogenic[8]. Local arterial spasm can cause distal gangrene. Apaper on this subject is in preparation.

C.N.S. Effects

Venoms do not cause neuromuscular blockade, nor convulsions. There is impaired consciousness, and respiratory arrest with subsequent hypoxia has been reported. The peripheral pain in "Irukandji syndrome" may be neural. The massive hypertension with Irukandji may be due to catecholamine surge[8].

Resuscitation

In all cases one should not give up resuscitation prematurely as many attempts have been successful. Sometimes expired air resuscitation only is required. The role of specific antivenom *(Chironex)* in potentially lethal *Chironex* stings is at present under examination, but it probably helps. Short-lived venom action is probably due to heat lability. Calcium channel blockers may help the myocardium; calcium will not[7]. Antivenom specificity will improve in the future, for life threatening stings.

Analgesia

Skin pain is eased by direct application of ice. It is also unquestionabily relieved by the specific antivenom for *Chironex*. Intravenous narcotics are used non-specifically (e.g. for the muscle pains of Irukandji envenomation) require expert medical supervision. Evaluation of pain relief is confounded by placebo responses and is inadequate at present.

STILL UNKNOWN

Among the things we still do not know are:-

1. How jellyfish venoms kill humans;[6,7]
2. How much of a dose of venom is absorbed by lymphatics and how much by capillaries;
3. The metabolism and excretion of venoms[8];
4. The in vivo action of existing antivenoms;
5. How to provide simple, safe and effective analgesia for first aiders to use.

THE FUTURE

Better care of patients suffering from jellyfish envenomation can only come from better education of medical practitioners in the subject of marine envenomation.

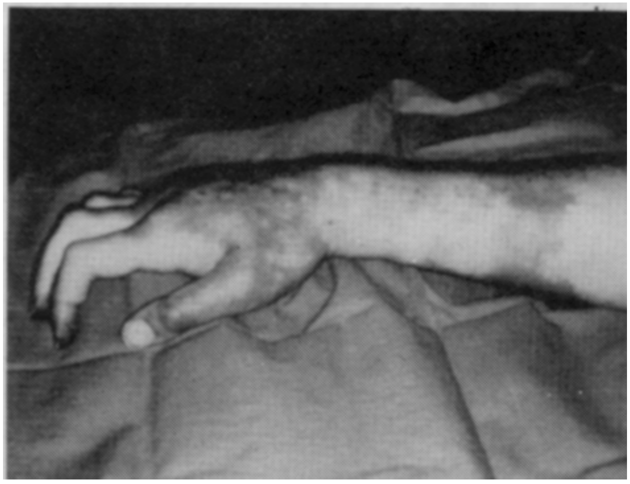

FIGURE 4

The near gangrenous arm of a young female stung by either a *Cassiopea* or *Chironex* jellyfish in the waters off the Goa coastline, in India. This resulted in arterial vascular insufficiency following envenomation on the skin of the upper arm.

FIGURE 5

Severe consequences of the same jellyfish sting shown in Figure 4, 6 days following envenomation; shows blistering and threatened skin death distal to the actual sting site, due to a combination of primary toxic and secondary ischaemic effects. Other jellyfish stings may produce vesicle formation at the site of tentacle contact.

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ORIGINAL PAPERS

THE ROLE OF HYPERBARIC OXYGEN IN THE TREATMENT OF THERMAL BURN INJURIES: A BRIEF REVIEW OF THE LITERATURE AND THE RESULTS OF A PILOT STUDY.

Des Gorman and Ian Leitch

Introduction

Thermal burn injuries are common, and have a substantial morbidity and mortality. Both the treatment in specialised Burns Units, and the rehabilitation of the patient back into the community are expensive[1]. Despite this background, the evaluation of different treatments for burnt patients has been poor. Often studies have inadequate control data and there are difficulties in accurately assessing burn wound depth[2].

Hyperbaric oxygen (HBO) therapy administered systematically may be an effective adjuvant to the conventional care of thermal burn wounds, since it can reduce tissue ischaemia, attenuate interstitial fluid oedema and compartment pressure, improve the micro-circulation, and stimulate both revascularisation and re-epitheliasation of hypoxic wounds[3].

Since the original observation of accelerated burn wound healing in rabbits treated with HBO was reported in 1969[4], data have been collected in a variety of other animal-models to demonstrate at least three ways in which HBO acts directly to promote healing of thermal burn wounds.

The first is a reduction in the eventual depth of the burn wounds (ie. the progression of partial-thickness burns to full thickness is retarded)[5]. This reduction is associated with less extravasation of fluid[6,7], an increase in the ATP concentrations in the burn wounds (even when HBO administration is delayed)[8], and a reduction in overall animal mortality[6]. The second direct action is an increased healing rate of burn wounds in animals treated with HBO[4,5], and the third is an anti-septic effect[4,6]. This anti-sepsis is mediated probably both by enhanced host responses and by direct anti-bacterial action[3].

The beneficial effects of HBO may be enhanced by the concurrent administration of antioxidants, but their use is controversial. For example, while a free oxygen-radical scavenger enhanced the protective effect of HBO on a rabbit lung smoke inhalation injury[9], similar benefit could not be demonstrated in ischaemic skin flaps in rats[10]; and elevated oxygen tensions have been shown to actually antagonise, not potentiate, lipid peroxidation in-vitro[11].

In addition to these direct effects on burn wounds, HBO has also been shown to improve outcome in animals who have inhaled cooled smoke[9], by reducing the fluid extravasation into the lung interstitium. Lung injury from smoke inhalation is common after thermal burn injuries, and is a significant cause of mortality[12]. Carbon monoxide (CO) intoxication has been claimed to be the commonest cause of death of victims dying at the scene of a fire[13;] and HBO has been shown to be the definitive treatment of CO intoxication in a controlled prospective study[14].

In contrast to these controlled animal studies, reports of HBO use in humans with thermal burns are, with perhaps a single exception, poorly controlled. Also, these human studies have used unreliable methods of assessing burn-wound depth[2]. These retrospectively, semi, or uncontrolled studies have reported that HBO: reduces the mortality in severely burnt patients[15]; reduces either the number of areas, or the surface area requiring grafting[1,15,16]; reduces fluid requirements[13,15,17]; reduces hospital-stay time and overall treatment costs[1,13,16]; reduces burn wound sepsis[17]; and increases skin graft survival in patients who have had burn wounds grafted[13,15]. However there has been only one prospective controlled, but not randomised, study of 875 patients with thermal burns, which showed HBO to significantly reduce the mortality of severely burnt patients[18]. There are no human data and only a single report of an inhalational injury in rabbits being improved by the administration of normobaric oxygen (NBO)[19].

There are no reports of adverse effects on burns with systemic HBO, and a solitary report of topical HBO increasing scar thickness[20].

There are then substantial animal and human data to support a role for HBO in the treatment of thermal burns. However, there is an urgent need for randomised prospective and controlled human studies to examine both HBO and NBO.

Pilot Study

We conducted a pilot study from July 1986 to June 1988 at the Royal Adelaide Hospital (RAH), South Australia, to determine the feasibility of administering HBO to burn patients at the RAH, and to determine if HBO produced deleterious effects.

A control group of 113 patients was generated retrospectively by considering all admissions to the RAH Burns Unit from January 1983 to June 1986, when HBO treatment was introduced. We excluded patients with less than 10% total body surface area (TBSA) burns, as the mortality is negligible, and those with more than 75% TBSA burns as many were given analgesia only. The data for age, area burnt, and mortality for this control group are shown in TABLE ONE. All these patients received conventional surgical care only.

From July 1986 to June 1988 inclusive, 67 patients with more than 10% TBSA burns and less than 75% TBSA burns were given HBO as an adjuvant to their conventional surgical care. Their results are also summarised in Table One. The HBO patients did not differ significantly from the retrospective non-HBO control group for age (34.2 + 14.9 (SD) years .v. 38.6 + 17.2 (SD) years; $p > 0.05$) or mean area burnt (28.9 + 20.6% .v. 25.5 + 15.5%; $p > 0.1$). However, the mortality of the HBO patients was significantly lower (4.4% .v. 21.3%; Fisher's exact probability, $p = 0.002$).

Clearly, other factors such as improved nursing could have contributed to the fall in mortality, and it is not possible to attribute this reduction to HBO alone. We could conclude, however, that it was feasible to conduct a prospective randomised controlled study to evaluate the relative roles of HBO and NBO in the treatment of thermal burns injury at the RAH, and further that there was no evidence that HBO adversely affected the outcome of these patients. A prospective study is now being implemented.

Summary

In addition to its beneficial effects on CO intoxication in burnt patients, HBO therapy may also have a positive direct effect on the thermal burn wound. In animal burn injuries, HBO not only speeds the healing of the burn, but also reduces the mortality and reduces the area of partial-thickness burns that proceed to full-thickness. The data from burnt patients is consistent with these findings, but with a single exception, are generally inadequately controlled and

TABLE 1

	Control Group (Non-HBO) 1983-1986	**HBO Group 1986-1988**
Number:	113	67
Mean age (+ SD):	38.6 + 17.2 yrs	34.2 + 14.9 yrs
Mean TBSA burnt (+ SD):	25.5 + 15.5%	28.9 + 20.6%
Mortality:	21.3%	4.4% *****

*** p = 0.002 (Fisher's Exact)**

Characteristics of patients admitted to the RAH Burns Unit with TBSA burns > 10% and < 75% in the period from January 1983 to June 1988 inclusive; and treated with conventional surgery alone (Control Group, January 1983 to June 1986), or with conventional surgery and HBO (HBO Group, July 1986 to June 1988).

are gathered using inaccurate methods of assessing burn wound depth.

A pilot study conducted at the Royal Adelaide Hospital has shown a significant decrease in mortality in severely burnt patients treated with HBO when compared to a retrospective control group. On the basis of these findings, and the positive animal and human literature published already, it is clear that a prospective randomised controlled study of the role of HBO in the treatment of thermal burns injury is long overdue.

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REVISITING KEY WEST SCUBA DISEASE

Robert Wong

"Scuba Disease" which was prevalent between 1955 and 1959 in the U.S. Navy Diving Operations in Key West was shown to be due to contaminated Scuba hoses and regulators. This health hazard was attributed to the aspiration of Gram-negative organisms, especially Pseudomonas.

Bradley and Bornmann[1] compared Scuba Disease with Salt Water Aspiration Syndrome described by Edmonds[2]. Both conditions have symptoms resembling a flu-like illness, viz. chills, anorexia, nausea, malaise, headache, aches and coughs. However, Bradley and Bornmann indicated three major differences between the two conditions:

(a) Length of the prodromal period (two hours for salt water aspiration versus 24 hours for scuba disease);

(b) Less incidence of dyspnoea and production of sputum in scuba disease;

(c) Length of illness (6-24 hours for salt water aspiration versus 24-72 hours for scuba disease).

Furthermore, Edmonds[2] indicated that Salt Water Aspiration Syndrome was more common in the colder months. Bradley and Bornmann[1] deemed Salt Water Aspiration Syndrome a form of Scuba Disease.

Case Report

A 30 year old diver was diving using hookah equipment in the north west of Western Australia. Some 12 hours after his last dive, he developed aches and pains in his knees, elbows and back, which were shifting in nature. He also experienced headache, nausea and a feeling of faintness, as well as hot and cold sensations. There was pleuritic chest pain, marked dyspnoea, aggravated by even the mildest exertion. The shortness of breath continued to worsen, he had to stop on two occasions whilst cleaning his teeth. That evening, some 24 hours after the dive, he was awaken by dyspnoea, whence he started coughing which was dry and nonproductive initially. In the ensuing few days, the coughing became productive of mucoid sputum. Two other divers who used the same equipment had similar symptoms, but these were much milder and without the respiratory component. Because they were at sea, the diver only consulted the local hospital 7 days after his dive.

At the local hospital, there were no significant clinical findings apart from his obvious shortness of breath. The chest x-ray showed a diffuse, granular picture. Due to the lack of laboratory facilities to perform more sophisticated investigations, the patient was transferred to a metropolitan teaching hospital.

Further enquiries revealed that the patient smoked 60 cigarettes per day; his father developed asthma late in life.

Clinical examination showed a suntanned, fit looking male with fast, shallow respiration, at a rate of 28 per minute. There were bilateral inspiratory basal crepitations. Other systems were essentially normal. Arterial blood gases on air showed a PO$_2$ 83, PCO$_2$ 39. Respiratory function tests showed a low FEV$_1$ 3.291 (4.28 ± 0.55), normal FVC 5.47 (5.47 ± 0.74), low FEV$_1$/FVC 60.1% and MMFR 1.94 l/s (4.48 ± 1.12). Lung volumes were essentially normal, however, the Diffusing Capacity near TLC was 19.5 (34.9 ± 5.1) D$_{LCO}$ml/min/mm.Hg. Histamine Provocation Test showed a PC$_{20}$ greater than 16 mg/ml, indicating a normal nonspecific bronchial reactivity. The tests showed a moder-

Table 1

Legionella Pneumophilia	Gp.1	Gp.2	Gp.3	Gp.4	Gp.5	Gp.6
Total Globulin						
Day 7	Neg	Neg	Neg	Neg	Neg	Neg
Day 9	64	—	128	—	—	—
Day 31	512	—	512	64	—	128

ate airflow limitation, but not characteristic of currently symptomatic asthma. The diffusing capacity was suggestive of an interstitial lung disease. Arterial Blood Gases repeated 15 hours later showed a PO_2 110 and PCO_2 28. The P(A-a) DO_2 was within the normal range.

There was a leucocytosis with a count of 15,000 and ESR 31. Extensive studies of fungal, viral and bacteriological examination were normal. The diving equipment was examined but no abnormality was detected. Immunoglobulins were also normal.

With bed rest, he improved with no treatment, albeit marked lethargy was present for over 2 weeks.

Seventeen days after the onset of symptoms, leucocytosis peaked at 23,000, ESR had fallen to five. However, serological examination for legionella showed:

Results are expressed as the reciprocal of the titre or as ‘neg’ when the titre is less than 64. A fourfold rise in titre provides evidence of recent infection.

Seventeen days after the dive, his chest x-ray was clear, the respiratory function tests were essentially normal, although there was still a slight reduction of the diffusion capacity at 27.3. White cell count dropped to 14,000 by the 23rd day. Repeat respiratory function tests done on day 31 were normal.

Discussion

The case presented shared many of the symptoms and signs of Scuba Disease and of Salt Water Aspiration Syndrome. It was unfortunate that the patient did not present to hospital until six days after his last dive and that the other divers did not attend the hospital at all.

Beaty and Pasculle[3] in their discussion on Legionella infections pointed out that cigarette smokers are more susceptible to infection. Symptoms of malaise, headache, fever and shaking chills are common. An early nonproductive cough which progresses in severity occurs and usually becomes productive of mucoid to mucopurulent sputum. Other symptoms include dyspnoea, pleuritic chest pain and myalgia. Gastrointestinal symptoms are present in about 25% of patients. Tachypnoea and tachycardia are also common. The disease becomes worse during the first four to six days and another four to five days may pass before dramatic clinical improvements begin. Many patients experience weakness and early fatigability for weeks after the acute stages of the illness. Laboratory findings show an elevated ESR and leucocytosis greater than 20,000. Abnormal renal and liver function tests have also been reported. Chest x-ray shows parenchymal infiltrates in about 65% of the cases. A firm diagnosis is made by the demonstration of legionellae in the respiratory secretions by either culture or immunofluorescent straining.

The patient, a heavy smoker, had all the symptoms described. In common with Salt Water Aspiration Syndrome, he had a fall in FEV_1 and in P_aO_2; the P(A-a)DO_2 gradient was normal, however. A low diffusing capacity suggestive of interstitial lung disease was present. It was unfortunate that no respiratory function tests were obtained for the patients with Scuba Disease.

Edmonds[1] stated that in the differential diagnosis of Salt Water Aspiration Syndrome, one must consider the possibility of other occupational diseases of divers, e.g. Decompression Sickness, Pulmonary Barotrauma and Scuba Disease. One should bear in mind also the other causes of pneumonitis such as chemical or hypersensitivity.

Legionella pneumophila, a gram-negative bacterium was unknown until the outbreak of a severe respiratory illness in Philadelphia in July of 1976.

Retrospective studies using serologic techniques traced the earliest outbreak of Legionnaires Disease to 1957 among employees of a meat packing plant in Austin, Minnesota.

Key West Scuba Disease was shown to be due to pseudomonas infections, also gram-negative bacteria. Could some of the victims of Key West Scuba Disease be due to infection by Legionella pneumophila?

Summary

A case history is presented of a diver using hookah equipment in the subtropical climate of the Northwest of Western Australia. The symptoms, signs and laboratory findings were similar to those of Scuba Disease and of Salt Water Aspiration Syndrome. Pseudomonas was not isolated from this patient. A diagnosis of Legionella pneumophila infection was made.

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EFFECTS OF DIVING ON THE HUMAN COCHLEOVESTIBULAR SYSTEM

Otto Inge Molvaer

Dissertation abstract

Cochleovestibular barotrauma was seen in all types of divers. A retrospective analysis of 76 cases (83 injured ears) is reported. It is hypothesized that middle ear gas may enter the perilymphatic space of the inner ear during ascent in cases of perilymphatic fistulae. The cochlear injury was classified as permanent in 58% of the cases.

The sound pressure level from the breathing gas in standard hard hats was measured to about 96 dB(A) (re 20uPa), while the level from high pressure water jet lances reached about 145 dB(A) close to the divers' head gear. In living chambers for saturation diving sound pressure levels reached about 106 dB(A). After the environmental control units were moved to the outside of the chambers the highest recorded levels were about 96 dB(A).

Significant temporary hearing threshold shifts were demonstrated in divers participating in two saturation dives of 19 and 34 days duration to 300 and 500 msw respectively. The recovery took up to three days post-dive.

Young, highly selected professional divers had lower hearing thresholds than age-matched randomly selected (standard) controls, but higher than the normality curves of the International Organisation of Standardisation. However, divers in their fourth decade of life had thresholds comparable to the standard controls. Divers who smoked had significantly higher thresholds than their non-smoking colleagues. After an observation period of about six years the divers' hearing had deteriorated faster than that of both otologically normal subjects and of the unscreened controls.

Transient vestibular imbalance was detected by ENG in 25% of the divers participating in four dives to 300-350 msw, but normalisation occurred within a year. The vestibulo-ocular reactivity to bithermal caloric stimulation was significantly reduced in six divers at 250 msw as compared to surface values. Alternobaric vertigo was reported by 33% of 194 professional divers. Although the symptoms usually were mild, in some cases they caused serious disorientation, nausea and vomiting.

By Ed. SPUMS J

The above is the abstract of a doctoral dissertation which was successfully defended by Dr Molvaer (a member of SPUMS) on September 30th, 1988. Readers wishing for further information should contact Dr Molvaer whose address is the Norwegian Underwater Technology Centre A/S (NUTEC), P.O. Box 6, N-5034 Ytre Laksevag, Norway.

DIVE COMPUTERS

John Lippmann

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

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

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

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

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

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

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

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

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

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

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

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

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

COMPARING COMPUTERS TO TABLES FOR NO-DECOMPRESSION DIVES

When no-decompression times allowed by various computers are compared to those allowed by various tables (even those based on the same model) for the same dive, vast differences often appear. These differences become greater for repetitive dives. Tables 1 and 2 compare the times allowed by various computers and tables for two series of repetitive dives that I carried out in a water-filled pressure chamber. I have conducted a variety of other simulated and real dives with similar results. Some of the reasons for these differences will be discussed in this section.

Single Dives

Table 3, below, compares the single dive NDLs of various computers to those of the USN and Buehlmann (1986) tables.

Single Rectangular Dives

It can be seen from Table 3 that the single dive No-Decompression Limits of the computers are more conservative than the USN limits and are generally similar to the limits of the Buehlmann Table. Therefore *for a single rectangular dive these computers will usually give a more conservative no-decompression time than the USN Tables.*

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

Single Multi-Level Dives

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

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

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

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

Repetitive Dives

The dives shown in Tables 1 and 2 were rectangular dives so that the multi-level capability of the computers was minimised and the times allowed by the computers could be compared to the times allowed by the tables.

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

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

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

Because most tables are based on the off-gassing of a single slow tissue during the surface interval they often have a safety margin built into them, whereas the computers carry no such margin. Repetitive Groups and Residual Nitrogen Times given in tables are designed to account for the highest gas loading that is theoretically possible and are usually based on a single tissue compartment only. Since this tissue is a "slow" tissue it out-gasses slowly on the

FIGURE 1

The times given are in minutes unless otherwise specified.

Dive 1

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

Dive 2.

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

FIGURE 2

The times given are in minutes unless otherwise specified.

Dive 1

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

Dive 2

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

The rest of this table is to be found on page 130

surface. The tables assume that all of the tissue compartments are unloading at this rate and so may over-estimate the theoretical gas loads of the faster tissue compartments. This results in shorter repetitive dive times than would be allowed if the actual (theoretical) gas load in the faster compartments was considered. So this crudeness of the table's calculations may lead to longer surface intervals than are required by the model, but introduces a margin of safety by assuming the diver has more residual nitrogen than the model dictates. However many depth and time combinations may lead to the same Repetitive Group although, in reality, the nitrogen contents in the various body tissues are quite different.

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

On some long dive sequences or in situations where repetitive dives are done over many consecutive days, the computers are sometimes slower to unload as they are programmed with slower tissues than are used to determine

Dive 3

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

the repetitive groups in tables. This may lead to the situation where the tables will allow you to begin a new days diving without considering residual nitrogen from the previous day's diving, whereas a computer may still carry over a penalty. *This will normally only apply to the first dive of the day and the computer will then allow longer bottom times for the following dives that day.*

ARE THE COMPUTERS SAFE?

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

The main criticisms focus on the following arguments:

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

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

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

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

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

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

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

More than 200 divers were treated for bends in Australasia in 1987. The vast majority of cases displayed neurological effects. These cases often arose after dives, often repetitive dives, that were conducted in accordance, and at times well within, conventional tables. Some had done a multi-level dive but had surfaced within the NDL specified by the table for the maximum depth.[6]

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

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

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

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

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

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

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

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

Go to the maximum depth early in the dive and progressively and slowly work shallower. End the dive with *profiles.*

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

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

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

THE FUTURE

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

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

SUMMARY

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

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

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

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

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

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

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

at least five minutes at 3-6 m. *Avoid rectangular dive* The safety of dive computers has not been determined as too few validated tests have been done to determine the bends risk associated with their use. However, this is also true for most decompression tables!

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

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

If using a computer it is important to:

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

For multi-day diving rest every third day.

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

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LIMBO DIVING - THE DANGERS OF FREE DESCENT
CASE REPORTS OF TWO FATALITIES

Douglas Walker

SUMMARY

The dangers associated with scuba diving are well documented and the region of maximum danger has been identified as the surface itself. The critical factors influencing the course and outcome of all dives are discussed in all diving manuals and by all who instruct others, but all make the unstated assumption that the diver and his buddy are well orientated in regard to their surroundings. This assumption does not hold true where the descent is made in deep open water in the absence of either a direct sighting of the sea bed below or close contact with some other fixed and recognised object, such as a descent line. Most divers in such circumstances would discover that they were untrained to accommodate to such conditions and would experience a degree of orientation and stress which would impair their responses to the problems they faced. Inappropriate responses due to diver error can very rapidly cascade into a situation of increasing danger. Two fatalities occurring in dives under such circumstances are presented.

Case Reports

Case 1.

All the divers taking part in this club-organised boat dive were trained and had some experience, though not necessarily of this type of dive. The two divers involved in this incident were probationary members of the club but had shown evidence of their training and had been watched during a dive that morning to 18m (60 fsw) for 44 minutes and judged to perform correctly. The afternoon dive was off a rocky reef, in calm water and fine weather. The dive boat had its anchor in 19.5m (65 fsw) deep water a little off the reef and the depth under its stern was 24-25.5m (80-85 feet). As there was some current flowing from the reef towards the boat the divers were advised to swim underwater towards the reef after making their water entry, they were also advised to limit their dive depth to no more than 18m (60 fsw).

The victim and her buddy were the last pair to enter the water and although the dive marshal suggested that they descend down the anchor line it is probable that they failed to follow this advice and made an open water "free descent". As they entered the water the first pair of divers surfaced, having aborted their dive after only 13 minutes, and reported the presence of a down-current which had swept them into 24m (80 fsw) deep water while they were adjusting their equipment underwater. They also mentioned that visibility was so poor that they did not see the sea bed until they reached it. Unfortunately the victim and her buddy probably never heard this report of the conditions they were to experience.

It is not known exactly what happened but it is apparent from the buddy's account that they found themselves forced down by this current, initially to 30m (100 fsw) depth and then deeper still until they found themselves on the sea bed at a depth of 39-42m (130-140 feet). Here the victim seemed to be experiencing a problem with her breathing and gave an "out of air" signal. Buddy-breathing was initiated but shortly afterwards the victim "blacked out" and the buddy "shot to the surface" and called for help. A surface search was maintained but the victim never surfaced, and subsequent underwater searches failed to find any trace of either the victim or her equipment. There was no immediate underwater search because it was recognised that there was no chance of finding the victim alive, and minimal chance of locating her in the low visibility conditions in the presence of the current and depth-dictated short dive time allowable. The duration of the dive had been 8 minutes.

TABLE 1

	Case 1	**Case 2**
Training, Experience	Trained, some experience, actual experience not stated.	Trained, experienced but only dives fairly close to shore.
Experienced in this type of dive	Probably not.	No.
Dive Organised by	Dive Club.	Dive Club.
Pre Dive Briefing	Advised of surface off-reef current, so were to swim underwater to reef.	Briefed about wreck depth and need to descend as soon as water was entered. No advice to ascend if wreck not seen by 18m (60 fsw).
Dive Platform	Boat anchored off the rocky reef.	Boat slowly moving over wreck.
Surface Current	Flow from reef to boat.	Slack water but liable here to strong currents.
Descent	Commenced near anchor line but strong downward current then took them deep in low visibility water. No FNT complaints.	Controlled descent without landmarks, adequately able to equalise ears, Buddy's depth gauge faulty, read 10 fsw (3 m).
Intended dive depth	18 m.	18 m.
Actual dive depth	42 m.	36 m.
At sea bed	Victim air hungry and felt heavy, attempted to buddy breathe then suddenly lost consciousness. Separation as buddy made rapid ascent.	Acute panic overbreathing reaction by victim, regained control and controlled ascent with buddy to 24 m (80 fsw) but then swam away and was lost to view.
Buoyancy vest	Apparently not inflated. Type of vest inflation not stated.	Partly inflated on sea bed. Type of vest inflation not stated.
Weight belt	Apparently not released.	Apparently not released.
Search	Not attempted because of current, depth, poor visibility.	Underwater search unsuccessful.

ADVERSE FACTORS

Poor visibility. Lack of landmarks. Total inexperience at such depth. Failed to realise that there was a serious problem requiring that the dive be aborted. Nitrogen narcosis. Cold. Depth related lack of buoyancy. Anxiety panic. Failed to drop weight belt. Case 1 probably failed to inflate her buoyancy vest. Case 1 felt her air supply to be inadequate and attempted buddy breathing and probably inhaled some water. Case 2 buddy pair failed to follow the instructions to descend immediately.

Case 2.

This also was a club-organised dive. It was made from a boat whose skipper was familiar with taking divers to dive sites, though it was the first time either he or they had visited this wreck as it had been "closed" to divers until recently. There had been warnings issued that it was a dive for the experienced because of the poor visibility and the strong currents which frequently occurred in the area, and divers were still prohibited from any entry into the interior of the wreck. None of this inhibited the frequenting of the wreck by many dive boats. The wreck lay on its side, the uppermost side being at about 15m (50 feet) depth and the sea bed being at about 36m (120 feet) depth.

The victim had been trained several years previously and had dived frequently but her experience had been limited to close-to-shore dives. When the dive boat reached the wreck there were already several other boats there flying the "Divers Down" flag and anchored onto the wreck, so the skipper decided to drop the divers off over the wreck, remaining under slow movement in order to be free to pick up surfacing divers in an emergency without the delays resulting from being anchored. This was a practice he had found useful and safe. There had been a briefing concerning the wreck during the trip out to it and the divers had been told that they should reach it at 18m (60 fsw) or less but had not been specifically advised to abort their dive should they not find it by this depth. It was slack water as the pairs of divers were dropped off but they had been advised to descend at once and not to remain at the surface or they would be likely to drift from above the wreck. The skipper stated later that all save two pairs followed this advice. None of those divers descending at once encountered any recorded problem with their dives. Two couples appeared to delay their descent, that of the victim and her buddy and another pair. The latter reached 22.5m (75 fsw) without sighting the wreck so surfaced but the victim and her buddy continued down to the sea bed. The buddy was unaware of their depth until they were on the sea bed because her depth gauge malfunctioned and continued to show "10 fsw" (3m) throughout the dive. Divers from the anchored boats had the benefit of the anchor lines to guide them down, those from this boat had no such assistance.

When the buddy looked at the victim's depth gauge after they reached the sea bed she was surprised to see that it read 120 fsw (36m). When she showed this reading to the victim the latter reacted with panic and attempted to blow up her "compensator" in order to effect an emergency ascent but was calmed by the buddy and a more orderly ascent was commenced. It is probable that the victim now became aware of being overweighted (for this depth) and again panicked and spat her regulator mouthpiece out, but then replaced it. Her breathing was noted to be hurried "and her eyes showed panic". When they reached about 24m (80 feet) depth (an estimate as the buddy's depth gauge was still inoperative) the victim turned onto her back and started to fin away horizontally or a little downwards, apparently towards the wreck because the buddy saw some ropes in the water. As the visibility was only 1.3m (4 feet) the buddy soon lost sight of the victim so continued to the surface alone, reporting what had occurred as soon as she was picked up by the dive boat. She was given another (full) tank and a diving instructor who was a member of the dive club group descended with her to see whether they could locate the missing diver. They saw some bubbles coming from a rent in the side of the wreck but the instructor recognised that these were evidence of his earlier dive when he had briefly entered the hole, which was at about 60 fsw depth. No trace of the victim or her equipment was ever found.

DISCUSSION

There were a number of factors and actions in each of these cases which adversely effected the safety of the dives concerned. In both the divers were without experience of deep diving (as far as is known) and will have been unlikely to have ever previously descended "into limbo". They must have experienced an increasing degree of stress as they descended without seeing any landmarks with which they could orientate themselves. The divers in Case 2 are known to have descended sufficiently slowly to equalise their ears at all times and there is nothing to suggest that the divers in Case 1 suffered any equalisation problems during their enforced descent.

The critical factor of greatest importance was undoubtedly the inexperience of the divers involved in relation to the type of dive they were making, open water dives being particularly stressful in low visibility conditions. They failed to recognise and respond appropriately to events which indicated that their dive was proceeding in a far different manner than that they had expected, so failed to take the necessary decision to abort their descent by ditching weights or inflating their buoyancy vests, allowing descent to continue unchecked until the sea bed was reached. Had the water been deeper, their predicament would have been worse. Cold, poor visibility, nitrogen narcosis, depth-related loss of buoyancy, and an anxiety-related air hunger, all contributed to a panic response which further reduced their ability to respond correctly. There is no information concerning the equipment worn, none of which was recovered, but it is more likely that anxiety rather than an incompletely opened tank valve was responsible for the victim in Case 1 attempting to buddy breathe, and under such circumstances inhalation of water would be very likely. The method of inflation of the buoyancy vests is unknown but in Case 2 may have been solely by oral inflation. If so the vest was one which was quite inappropriate for use by any diver.

A point of great significance was the failure of those involved in running these club dives to recognise the potential dangers, though this is entirely understandable in Case 1. Had the victim and her buddy followed normal practice and descended holding the anchor line this tragedy might never have occurred. Others can learn from this case that common routine procedures may protect from unrecognised dangers as well as expected ones. In Case 2 there should have been a recognition that a "free descent" into deep water, particularly in an area known to be dangerous by reason of currents and poor visibility, was a procedure not to be undertaken without prior consideration. Possibly the divers had expected to descend a line but had not liked to expostulate when they were told that the boat would not be anchoring. However, the majority of those diving from this boat had no difficulty in finding the wreck, having followed the instructions to descend immediately. A line-holding descent should be treated as being mandatory whenever the "target" of sea bed or wreck is not plainly visible from the surface.

The difference in dive profiles which led to these fatalities in contrast to the successful dives made by their fellow club members was the unplanned depth, lack of visibility, and arriving at an unplanned destination whose location was uncertain in relation to the expected goal. It may be considered fortunate, in the circumstances, that the buddies survived.

A NEW RULE FOR AN OLD TABLE THE BS-AC CHANGES THE RULES FOR DIVES TO 9 M OR LESS

John Lippmann

The BS-AC has recently (March 1988) altered the procedure to be used when calculating the decompression required following a sequence of more than two dives, where the last dive is to a depth of 9 m or shallower.

Previously for a series of three dives where the third dive was 9 m or shallower, the RNPL/BS-AC "concession" (which allows some credit for surface intervals of two hours or more) could be used for the second dive, No further calculations were required for the third dive as it was 9 m or shallower. For a series of four dives where the third dive was deeper than 9 m and the fourth dive was 9 m or shallower, the "Multiple Dive Rule" (adding together all of the bottom times and decompressing for the deepest depth) was applied to the first three dives, and the fourth dive, being 9 m or shallower, did not require any decompression.

However, while researching the forthcoming new BS-AC tables, it was discovered that these procedures were incorrect. **Third (or subsequent) dives of 9 m or shallower must be taken into account**, which means that the "Multiple Dive Rule" should be used.

This will often make a third dive extremely difficult to plan within a day's diving, and can also influence the next day's diving, since the first dive of the next day may still be the third dive undertaken within a 24 hour sequence.

Table A can be used to plan a third dive to a maximum depth of 9 m without the need for decompression stops. It also indicates the surface interval which must follow that third dive in order to re-enter the RNPL/BS-AC table without penalty.

Using the new rule for a third dive to 9m or shallower

1. By referring to the central section of Table A, plan the surface interval preceeding the third dive. The choices are 0-30 minutes, 30-60 minutes, 60-90 minutes, 90 min - 4 hr and more than 4 hours.

2. Read down the column corresponding to the surface interval chosen to determine the maximum no-stop time for the third dive.

3. The final column shows the surface interval required after the third (9 m or shallower) dive so that the RNPL/BS-AC table can be re-entered without a time penalty.

EXAMPLE 1

You are planning the following sequence of dives:

The first is to 20 m for a bottom time of 30 minutes, followed three hours later by an 18 m no-stop dive. If you then wish to dive to 8 m two hours later, and begin a new day's diving 13 hours after surfacing from the 8 m dive:

(i) What is the maximum allowable bottom time for the second dive?
(ii) What is the maximum allowable no-stop time for the third dive?

Since this is a sequence of more than two dives the "Multiple Dive Rule" must be used for the first two dives, but the new additional 9 m table can be consulted for the third dive.

Dive 1 requires no stop and Dive 2 can have a maximum bottom time of (46-30) = 16 minutes.

To find the allowable bottom time for Dive 3, enter Table A from the top at the column corresponding to a

TABLE A

	Surface Interval following 2nd dive					**Surface Interval after 3rd dive**
	minutes				**hours**	
	0	**30**	**60**	**90**	**4**	
No-stop time in minutes for a third dive to a maximum depth of 9 m	-	8	28	115	187	15 hours
	-	-	7	78	147	14 hours
	-	-	-	41	86	13 hours
	-	-	-	-	26	12 hours

surface interval of 2 hours following the second dive. This is the 90 min - 4 hr column. Move down this column to find the time allowed for the 8 m dive. If the dive was to be followed by a 15 hour surface interval, a bottom time of 115 minutes could be chosen. However, since the surface interval following the dive will only be 13 hours, a maximum bottom time of 41 minutes is allowed.

EXAMPLE 2

You are planning to do three dives. The first is to 24 m for a bottom time of 25 minutes, the second, after a surface interval of 5 hours, is to be a no-stop dive to 16 m and will begin at 1645. You then wish to do a third dive to 6 m, and then be able to dive again at 0900 the next morning, without a time penalty.

(i) What surface interval is required after the second dive?
(ii) What is the maximum allowable no-stop bottom time for the third dive?

Again this is a sequence of more than two dives so the "Multiple Dive Rule" must be used for the first two dives, and Table A can be consulted for the third. No stop is required for the first dive. The maximum no-stop bottom time for the second dive is (32-25) = 7 minutes. You should surface from the second dive at about 1653.

If you plan to dive again after a surface interval of say 80 minutes, you would be able to dive for up to 28 minutes but then must wait 15 hours before diving again without penalty. This would mean that you could not dive without penalty until about 0941.

If instead you dived to 6 m for a maximum of 7 minutes, you could dive again 14 hours later, without penalty, which would allow you to dive at 0900 the next morning. Alternatively, if you allow a surface interval of 91 minutes before doing the third dive, you could dive to 6 m for 41 minutes and then dive without penalty at 0900, as you would end up having a surface interval of between 13 and 14 hours.

This new rule seems to make an already complicated system even more complicated. However there is some light at the end of the tunnel. The good news is that the new BS-AC tables will definitely be out this year. They will require no calculations at all and promise to be a far simpler and more practical table.

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ARTICLES OF INTEREST FROM OTHER JOURNALS

THE BRITISH SUB-AQUA CLUB INTRODUCES NEW TABLES

CHANGING THE WAY WE DIVE

Mike Busuttili, Chairman of BS-AC National Diving Committee's Decompression Working Group introduces the BS-AC '88 Tables.

It is now 12 years since the RNPL/BS-AC table was adopted by the BS-AC. In this time there have been many changes in the sports diving scene. Equipment developed has allowed us to stay underwater longer and remain warmer, and we have become more adventurous in our search for diving sites. It has also become increasingly clear that the RNPL/BS-AC table is insufficiently flexible for the patterns of diving required by divers today.

pression Working Group was briefed to look into the question of which table the Club should use for the next 12 years. The study looked at all existing tables suitable for use by sports divers, taking into account also the development of dive computers, and found no existing table which did not require calculations to determine the decompression needs of a repetitive dive. The conclusion was that we should commission a new table which would closely follow the brief to give improved safety, along with greater flexibility and freedom, and without calculations.

Dr Tom Hennessy was asked to carry out this development for the BS-AC. In doing so, he drew on his long experience in the field, having worked on both the RNPL table and commercial tables.

The result of this work is now available in the form of the BS-AC '88 Tables. These are the first decompression tables produced exclusively for sports divers, and are right up to date in their ability to match divers' needs.

The BS-AC '88 Tables are available in the form of a heat-sealed booklet containing instructions, seven tables (A to G), and a Submersible Decompression Table in the form of a plastic card which the diver can take into the water.

Simplicity is the keyword in the use of the tables. For a single dive you simply look down table A to find your maximum depth, look along for the time you plan to spend on the dive, and note whether this is a no-stop dive or whether you need to carry out stops. At the foot of the *Time* column is a letter from B to G. This is your SURFACING CODE. You then look at the SURFACE INTERVAL table for this code and find that as the surface interval increases you will gain a new code (known as the CURRENT TISSUE CODE). When you have decided which code will apply to your next dive, you look at the table carrying the same letter, and you are free to carry out any dive on that table. There are no calculations, no "residual nitrogen times", and no "penalties" to be deducted from your dive time.

In developing the new tables, the opportunity has been taken to incorporate a number of improvements. These are as follows:

DIVE TIME is now defined as the time from leaving the surface to reaching 6 m on the return to the surface. It replaces the previous "bottom time" definition which made no allowance for a dive which included a gradual 'exploratory' ascent.

ASCENT RATE remains at 15 m/min., except that the last 6 m of the ascent must take 1 minute. This avoids the too-fast ascents which are believed to have contributed to a number of accidents in recent years.

DECOMPRESSION STOP TIME is the time to be spent at the stop depth, and does not include any time taken for the ascent.

Decompression stop depths are at 9 m and 6 m, but it is important to remember the significance of the surface 'stop' (i.e. the surface interval), as this bears the brunt of the decompression chore).

A feature of the BS-AC '88 Table is that there has been no need to 'round-up' dive time and depth increments to produce a small and compact table. The compactness of the RNPL/BS-AC table made it easy to carry, but gave excessive penalties for repeat dives, particularly more than two dives, and unnecessarily long decompression stops. As the new tables incorporate 7 tables, a far wider selection of dives can be offered, with decompression schedules closely tailored to real needs. Although the no-stop times are slightly reduced in common with all other new diving tables, the increase in dive time resulting from doing a short (1-2 mins) decompression stop is very worthwhile.

A source of concern to the NDC has been the common practice of doing the maximum no-stop time shown on the table for the planned depth, followed by a direct ascent. In many cases the ascents exceed the laid-down speed of 15 m/min, particularly near the surface, and this greatly increases the risk of decompression accidents. The BS-AC '88 Tables encourage the use of a short stop at 6 m, followed by a slow ascent to the surface. This greatly improved the efficiency of the decompression process, giving a benefit in the form of longer dive times.

Those divers wanting to plan more than two dives a day will find the BS-AC '88 Tables ideal, due to their flexibility and simplicity. The approach used is truly different to that used by any other tables, giving a full set of tables for planning on the surface, together with a submersible table which allows you to make adjustments if you overstep your planned depth or time. On the back of the SUBMERSIBLE DECOMPRESSION TABLE is the DIVE PLANNING AND RECORDING WORKSHEET. This allows you to note down your planned and actual dive data in flow-chart form.

The BS-AC '88 Tables can be expected to have an impact on club diving in several ways:

1. Divers will be able to carry out more dives per day than previously.
2. They will need to plan their buoyancy so that they really can be neutrally buoyant in the 6 m surface zone.
3. Dive organisers will need to make a record of divers' exit times and SURFACING CODES in order to check their repetitive dive possibilities. Ideally, divers with similar CODES should be paired together.

4. Branches should plan to make their changeover to the new table following a 'teach-in' to gain familiarity.

Teaching material has been prepared to assist the familiarisation process, and is already being used by Coaches in your region. This material will also be available for sale to branches.

The BS-AC '88 Tables are available from the BS-AC Shop, or from your local dive shop. Please note that the tables are Copyright and photocopying is forbidden.

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By Editor, SPUMS J.

Copyright restrictions have prevented the publication of the new BS-AC tables. Readers wishing to inform themselves further should write to the BS-AC at the above address.

WESTERN AUSTRALIAN UNDERWATER DIVING TASK FORCE

In March 1987 the Western Australian Government announced the formation of an Underwater Diving Task Force. This committee's report has now been published by the W.A. Department for Sport and Recreation.

Extracts from the report are reprinted below. One individual, George King, of Exmouth and the three organisations - RAN, SPUMS and the Department of Sport and Recreation - were singled out for "a special thank you". The Secretary and other Western Australian members of SPUMS are to be congratulated on their hard work and successful presentations.

TERMS OF REFERENCE

To plan actions which can be immediately implemented to reduce the number of accidents occurring in underwater diving, including:

1. The presentation of appropriate legislation, if necessary.
2. The formation of an education campaign on water safety, in particular underwater diving, for implementation in the summer of 1988/89.
3. To assess the current level of diver insurance and make recommendations on future coverage.
4. To make recommendations on the pricing of the use of the Navy's recompression chamber.
5. To make recommendations concerning appropriate medical examinations for divers.
6. To make recommendations for action on any other issues in underwater diving.

INTRODUCTION TO THE PROBLEM

The Task Force found it very difficult to obtain clear, statistical evidence on either the number of people diving in Western Australia, or the number of dives they performed each year. It was also very difficult to obtain information from other States or countries to allow comparisons.

A study by Brad Mettam, "A Report on the Rise of Scuba Diving Accidents in Western Australia Requiring Recompression and the State Government's Response" (Submission 22) found that the number of scuba divers recompressed in 4 States over the 2 year period 1985/86 and 1986/87 was as follows (see table on next page).

Though Mettam stated that the figures from the Adelaide and the Stirling Chambers were operators' estimates, our own investigations indicated similar trends.

As Mettam's submission was so comprehensive, the Task Force paraphrased or quoted his information in the remainder of this section.

Mettam queried why there had been a sudden rise in two States (WA and Qld) and wondered whether it was linked to the rapid growth in popularity of sport/recreational diving. The three largest sporting diving certification agencies FAUI, NAUI and PADI, reported a consistent growth rate of some 30 to 40% per annum over the past two years. The approximate numbers of divers trained in Western Australia were: 3,000 in 1985, 3,900 in 1986 and 5,000 in 1987. In addition, the SDFA, the largest non-commercial instructor group, has records of some 1,600 people whom they have trained over the last five years in this State.

Mettam believes that a link can be established between the rise in accidents and the increase in numbers of divers being trained. Discussions by Mettam with medical practitioners and examination of dive profiles between June 23 1985, and May 7 1987, for divers recompressed at HMAS Stirling, led him to suggest the following causes:

	HMAS Stirling WA	HMAS Penguin NSW	AIMS Townsville QLD	Royal Adelaide Hospital SA
1985/86	12	49	7	25
1986/87	43	51	26	16
% Increase	250	4	270	-64

Firstly, medical practitioners are more aware of the signs and symptoms of diving illnesses as a result of increased publicity combined with a number of recent diving/medical seminars in Western Australia and other States.

Secondly, divers being better trained, are themselves recognising the subtle signs and symptoms of a "minor bend" such as fatigue, impaired senses, skin rashes and slight joint discomfort.

Very few of the divers treated at HMAS Stirling exhibited obvious signs and symptoms, such as a paralysis or greatly swollen joints.

Information provided by the HMAS Stirling recompression chamber showed a wide range of certification and qualifications of those people using the chamber. The Task Force noted that a large number of untrained divers and commercial divers such as pearl and abalone divers, were using the chamber in a greater proportion than would be normally expected. These figures are discussed elsewhere in the Report.

To obtain some statistical data, the Task Force sent, via HMAS Stirling personnel, questionnaires to every person who had been treated at the Stirling recompression chamber over the last 3 years. This information was used to examine the dive profiles and accidents of some of those who used the chamber.

In addition, two boat ramp surveys were carried out, one on Sunday, 15th November 1987 to coincide with the opening of the Western Australia Rock Lobster fishing season and the second, a follow-up survey restricted to the south-west corner of the State, conducted late in January 1988. This survey asked a number of questions of boat owners and divers in an attempt to study a cross-section of divers, their activities, qualifications, use of dive-tables, etc.

Though the samples were small, 375 in the first case and 158 in the second, enough information was gathered to be able to show some trends in compressed air diving activities.

A more comprehensive survey was conducted through dive stores in February 1988. It was proposed that the results of this survey would be added to the existing body of statistical information.

SUMMARY OF RECOMMENDATIONS

SECTION 1 - PROPOSED LEGISLATION

Recommendation 1

That compressed air diving equipment and services be available only to divers certified to the level of Draft Australian Standard 88026 or higher (its predecessors, or its overseas equivalents), unless training under the direct supervision of a National Coaching Accredition Scheme (NCAS) approved instructor.

Recommendation 2

That any person who supplies compressed air diving equipment and/or services to an uncertified diver (unless under direct scuba instruction or to a wholesaler for the purpose of wholesale distribution), should be charged and penalised appropriately.

Recommendation 3

That any person who uses the certification card of another diver for the purposes of obtaining compressed air diving equipment or services, for use by an uncertified diver, should be deemed to be committing an offence.

Recommendation 4

That no person should teach compressed air diving unless in possession of a NCAS Level 2 Scuba Instructor Certificate.

Recommendation 5

That a register of NCAS-accredited instructors be established and maintained by an appropriate Government agency so that the public can confirm an instructor's qualifications. This register to be updated on a monthly basis by the NCAS-approved instructor agencies.

Recommendation 6

That a register of approved compressed air diving instruction schools be established and maintained by the same Government agency as for Recommendation 5. The contents to be made available to the public as required, and reviewed regularly.

Recommendation 7

That a register of approved retail outlets for the sale and/or hire of compressed air diving equipment be established and maintained by the appropriate Government agency. The contents to be made available to the public as required, and reviewed quarterly.

Recommendation 8

That an appropriate Government agency maintain a register of air filling stations. The contents to be made available to the public as required.

Recommendation 9

That all suppliers of compressed air for divers (including amateur clubs) have their air checked by the appropriate Government department, (currently the Department of Occupational Health Safety and Welfare of Western Australia) at least every six months.

Recommendation 10

That all divers involved in commercial diving should hold a certificate equivalent to, or above, the proposed Australian Standard Dr.88026 or, the appropriate training standard for their particular industry.

Recommendation 11

That the Department of Marine and Harbours develop a course appropriate to all commercial divers not covered by the ‘Submerged Lands Act’, the ‘Construction and Safety Act’, or involved in military operations, and open it to all prospective commercial divers.

Recommendation 12

That commercial diving industry bodies be encouraged to conduct regular seminars on diving health and safety for their divers.

Recommendation 13

That all divers and diving supervisors involved in the pearl, abalone or other shell fishing industries be trained to at least Australian Standard (AS) 2815(a) “Surface Supplied Air Operations” before commencing pearl, abalone or other shell diving.

Recommendation 14

That all diving medicals for shell divers be conducted annually to 2299 by a qualified medical doctor trained in hyperbaric medicine

Recommendation 15

That the Workers Compensation & Assistance Act 1981 be amended to ensure that all commercial divers are covered by workers compensation insurance.

Recommendation 16

That all vessels engaged in commercial diving activities should have a properly certified trained diving instructor who should:

(i) Ensure that all diving practices are kept within the Australian Standards appropriate to the industry.

(ii) Maintain adequate records of each dive conducted from the vessel, with specific reference to any injuries sustained, or incidents that may lead to an injury.

(iii) Have adequate first aid supplies and be prepared to treat any accidents that may occur.

Recommendation 17

That an officer be employed by the Department for Sport and Recreation to keep appropriate records and to assist the diving industry where possible.

SECTION 2 - EDUCATION CAMPAIGN

Recommendation 18

That an Education Campaign on Water Safety, in particular Scuba Diving, be drawn up using appropriate Government agencies, to be ready for the 1988/89 summer.

Recommendation 19

That a media campaign be prepared to convey the following points to a properly identified audience amongst the general public:

(i) That compressed air diving is a fun family sport for people over the age of 14 years and that it contributes to general fitness.

(ii) There is a need to seek training from a properly qualified instructor.

(iii) Diving with compressed air is dangerous if safety rules are not followed.

(iv) For continued safety and enjoyment, continue diving with a club.

Recommendation 20

A campaign using direct media techniques be prepared to remind all active divers of the essential safety factors:

(i) To be thoroughly conversant with a recognised decompression table, and use it.

(ii) To be aware of, and take into account, the predisposing factors that may increase chances of decompression sickness.

(iii) To always dive with a buddy.

(iv) To always use a Divers Flag.

(v) To 'take 5 at 5' (5 minutes at 5 metres).

Recommendation 21

That the Diving Emergency Service and its telephone number (008) 088 200, be actively promoted to all divers and that information sheets, stickers and plastic cards be widely distributed to clubs, dive shops, divers and relevant emergency authorities.

Recommendation 22

That a series of pamphlets be produced which targets specific diving groups. Each pamphlet should outline the dangers of problems each group faces, with particular emphasis on decompression sickness and how to avoid it. These groups include prospective divers, recreational divers, hookah divers, diving instructors and commercial divers.

Recommendation 23

That the diving industry be encouraged to organise regular seminars for all those associated with compressed air diving. In particular, doctors, instructors and dive shop staff should be involved so that they are kept up to date with current scientific findings.

Recommendation 24

That the appropriate Government department initiate action aimed at encouraging qualified divers to update their training and knowledge.

Recommendation 25

That the appropriate Government departments should encourage and assist the diving industry to provide Entry Level Diver qualification courses.

Recommendation 26

That on the acceptance of all or part of this report, the recommended changes within the industry, and the reasons for these recommendations be widely publicised.

Recommendation 27

That a seminar be held for the diving industry representatives to gain their support for the dissemination of the Underwater Diving Task Force education initiatives.

Recommendation 28

That an education campaign using pamphlets and seminars be instigated to highlight the requirements of safe diving practices within each commercial industry.

Recommendation 29

That administrative assistance be made available to the Australian Underwater Federation (WA Branch) to co-ordinate a development plan and to assist with the implementation of the education initiatives proposed by the Task Force.

SECTION 3 - INSURANCE

Recommendation 30

That there be no compulsory personal accident insurance for divers.

Recommendation 31

That all NCAS Level 2 scuba instructors should have adequate professional indemnity insurance cover.

Recommendation 32

That, for registration with the WA Department for Sport and Recreation, scuba instructors must show evidence of adequate professional indemnity insurance cover to a minimum of one million dollars.

SECTION 4 - PRICING OR RECOMPRESSION CHAMBER

Recommendation 33

That the State Government inform the Commonwealth Government of the view that no charge should be placed on civilian divers requiring recompression in the hyperbaric unit at HMAS Stirling.

Recommendation 34

That all concerned with compressed air diving, diving instruction, retailing, or diving medicine, should promote and utilise the Diving Emergency Service as the initial contact in a diving emergency.

Recommendation 35

That, prior to the establishment of the hyperbaric unit at Fremantle Hospital, discussions should be held between the State Department of Health and the Commonwealth Department of Defence to establish appropriate protocols for the interchange of patients between the Stirling and Fremantle Hospital recompression chambers.

Recommendation 36

That the costs for recompression treatment of commercial divers should be covered under the Workers Compensation and Assistance Act 1981.

Recommendation 37

That commercial divers should promote and utilise the Diving Emergency Service as the initial contact in a diving emergency.

SECTION 5 - MEDICAL EXAMINATIONS

Recommendation 38

That all compressed air divers be required to pass, without qualification, a medical examination to Draft AS 88026 standard before being permitted to commence a course of compressed air diver instruction leading to full certification.

Recommendation 39

That, as soon as practical, regulations should be implemented to require all compressed air diving medical examinations to be carried out only by doctors trained in hyperbaric medicine.

Recommendation 40

That all professional/commercial divers have an annual medical examination to the appropriate standard listed below:

AS 2299

- Divers covered by the PDAA
- Pearl divers
- Other fishery divers
- Defence and policy divers
- Other commercial divers.

Draft AS 88026

- Scientific and Investigatory Divers
- Scuba diving instructors

Recommendation 41

That, as soon as practical, a hyperbaric unit should be established at a metropolitan hospital to treat diving accidents needing recompression, and other appropriate medical conditions, and to provide a resource facility for divers, instructors and medical personnel.

Recommendation 42

That regular training courses and seminars be established so that doctors can gain experience and qualifications in hyperbaric medicine. Such courses should be conducted using the resources of the Royal Australian College of General Practitioners, the South Pacific Underwater Medicine Society and the Australian Medical Association.

Recommendation 43

That the Australian Medical Association be asked to make an official approach to the Dean of the Faculty of Medicine of the University of Western Australia to include more information on hyperbaric medicine as part of the medical course.

Recommendation 44

That the Western Australian Health Department approach the Federal Minister for Health requesting that recreational divers be able to claim a rebate for all or part of the diving medical examination fee under Medicare provisions and also, the additional necessary investigations such as chest x-rays, spirometry, electro-cardiograms and audiograms.

SECTION 6 - OTHER ISSUES

Recommendation 45

That the Department of Marine and Harbours contact charter boat operators and advise them of the special safety requirements they need to be aware of when hosting dive groups.

Recommendation 46

That the importance and significance of the Divers Flag be incorporated into diver and public water safety education campaigns.

Recommendation 47

That the State Government communicate with the International Maritime Consultative Body and discuss the possibility of the reallocation of the Divers Flag to Flag ‘R’.

Recommendation 48

That areas of metropolitan ocean waters which are ‘safe’ and ‘interesting’ be set aside for the exclusive use of divers and that there be no collecting (including by line-fishing), or damaging of marine life in these areas.

Recommendation 49

That divers using hookah apparatus be subject to the same controls and laws as for divers using scuba equipment.

Recommendation 50

That diver education seminars include aspects of diver safety and dangerous practices in addition to the problems of decompression sickness.

Recommendation 51

That the practice of emergency free ascents should be discouraged.

Recommendation 52

That the use of a ‘J’ valve to the exclusion of a contents gauge should be discouraged.

Those who wish to study the reasoning which led to the Task Force to make its recommendations should write to:

Lisa Chivers
The Department of Sport and Recreation
10th Floor, Mineral House
100 Plain Street
PERTH, W.A. 6000

MINUTES OF THE MEETING OF THE MEDICAL AND ACCIDENT PREVENTION COMMISSION (CMP) OF THE CONFEDERATION MONDIALE DES ACTIVITIES SUBAQUATIQUES (WORLD UNDERWATER FEDERATION) (CMAS) HELD IN MALTA ON THE 3RD AND 4TH OF NOVEMBER 1987.

The meeting was chaired by Dr Marcel Bibas, President of the Medical and Accident Prevention Commission of CMAS.

Present

Marcel Bibas	(France, President of the CMP)
Ramon Sancho Fuertes	(Spain, 1st Vice-President)
Jean-Pierre Mortier	(Belgium, 2nd Vice-President)
Magnus Almgren	(Sweden)
Jaap Barnard	(South Africa)
Patrizo Carlo Bianda	(Switzerland)
Ramiro Cali Corleo	(Malta)
Martin Calleja	(Malta)
Dominique Guldner	(France)
Krzyztof Kuszewski	(Poland)
Joe Micallef	(Malta)
Abdessatar Nefzi	(Tunisia)
Gerald Wolf	(Austria)

Apologies

Jacques Wolkiewiez	(France, Secretary of the CMP)
Georges Delonca	(France)
Peter Landsberg	(South Africa)

President's Report

This meeting of our Commission is important, although there are no elections, for our Bureau is elected for four years.

The CMP is a full Commission within our World Underwater Federation and it is indispensable for our Commission to be present at the major international events of CMAS. Some years ago we suffered from a lack of integration within CMAS. That stage is completely past and it is up to us to make the necessary efforts to ensure that our actions will be more and more recognised and appreciated.

These meetings provide us the pleasant opportunity of getting to know each other, to exchange opinions and to make plans. It also gives me the opportunity to present to you the general policy of CMAS and the role that our Medical Commission is to play in it. A great many possibilities are offered to us through CMAS and we have to make the very best of them in order to attain our objectives.

We want to extend information to doctors. In order to achieve this we organise international instruction courses. The last took place in Santa Teresa in Sardinia, the next will be held in Martinique.

We are in the process of creating a medical video library; we also intend to publish News Letters and First Aid Manuals for diving accidents.

We need better coordination between the CMP, CMAS and the National Medical Commissions. It is necessary that the information flow is faster. That is the reason why we have asked each Federation to delegate a doctor of its choice to the CMP. We will thus have direct and well-informed contacts who are concerned with our problems.

The Bureau of our Medical Commission has therefore appointed medical advisers with a view to entrusting these specialists with specific activities.

Regarding the development of the promotion of the CMP, I would like to get your opinions and suggestions, for this field is very important for the future of our Commission.

Finally a last point concerning the elections. Those elected to the CMP serve for a period of four years. I think that this period is too long and that we should be in line with the period of service of the Executive Bureau of CMAS, that is to say two years. All CMAS Committees apply this rule.

I therefore propose that at the next General Assembly we propose a motion with a view to shorten the period of service of the elected members of the CMP to two years.

A.Nefzi

National Federations need to be better informed.

P.C.Bianda

CMAS distributes News Letters to Federations, but these News Letters do not come to Doctors or Medical Associations. It would be a good idea to do something along these lines.

R.Sancho Fuertes

In Spain we do not have this problem, for I am a Doctor of the Federation and I therefore circulate the CMAS information to the regional Federations, the medical press and even the Doctors' Association.

G.Wolf

The same applies to Austria where the circulation of information is well done.

M.Bibas

The problem of information flow varies of course from one country to another. It is often a matter of internal organisation. We do want to make efforts however so that a maximum of individuals receive our information in each country.

Secretary's Report

The message which the Secretary General of the Medical and Accident Prevention Commission is anxious to get across to you cannot but reflect his intense satisfaction to see the activity of his Commission being structured and sometimes difficult projects gradually being achieved which reflect the aspiration of its entire membership.

Besides the satisfaction deriving from these results, it is right to be delighted to see the CMAS spirit becoming gradually more marked within our work. With respect to the CMP there is the will to look all around the world for experiences along new lines, not only along the existing lines which are influenced perhaps too much by Europe or even France. The hope is to be able to inform everyone of the whole range of progress achieved by diving medicine and to participate in everything which is likely to improve the prevention of the pathology of our activity.

The principal challenge of our Commission's work is the ambition to truly internationalise the dialogue between diving physicians and to circulate all recent data gathered around the world.

There is no meeting where I do not have to deplore the lack of representatives from beyond Europe and the difficulties that those present at these meetings have in making their Federations share in the travel cost. It is only by sharing these costs evenly and fairly that our international character and the value of actions will be seen.

The Bureau of the CMP does not however expect a miraculous, immediate solution and is getting organised to improve its work. So we attach the greatest importance to the notion of working groups, which will try and gather a maximum of opinions among our corresponding physicians on a given subject; thus the work of integration will be achieved by the members of the Bureau working with advisers interested in the subject.

This is how I think we should plan the future: a significant activity "by correspondence" which is possible thanks to the exceptional quality of work done by the CMAS administrative team, this activity serving as a basis for more collaborative work and Bureau decisions.

Among the work in progress along these lines, I am happy to present the first encouraging results of the worldwide study on means of evacuation and recompression, a long term project which will result in rich data base and will be available to everyone.

It remains to present my apologies to the members of the Bureau for not being able personally to attend this important meeting; I will be busy on another continent, organising a meeting on Diving Aptitude.

I wish the CMP working sessions in Malta every success, which they will certainly have in view of the presence among you of our pleasant and dynamic President Doctor Marcel Bibas.

Evacuation and recompression facilities

This investigation announced in the April 1986 CMAS News Letter has started with the distribution to all members of our organisation of a trilingual questionnaire which I had established with the help of the CMP Bureau in the course of several meetings.

The first results did not take long to reach the Secretariat where they are processed and analysed to shortly set up a computerised data base so that everyone can obtain up-dated information on the means of recompression in the area where he plans to go and practise his activity.

After a relatively slow start of collecting data we are at present delighted to see our map gradually being covered even though one continent is not covered.

There are however still a great many gaps as you will see later. The author hopes that the direct contacts made at the General Assembly in Malta will allow Officers of the countries which have not yet supplied information, to do the necessary so that each diver who approaches us can be informed about facilities for first aid available in each zone before he leaves home.

Present record of data collected by continent:

1. EUROPE : France, Spain, United Kingdom. Information completed.
2. SOUTH AFRICA : South Africa. Information completed.
3. AMERICA ; U.S.A., Barbados. Information satisfactory.
4. OCEANIA : Australia, New Zealand. Information very complete.
5. ASIA / MIDDLE EAST : Israel. Dossier adequate.
6. FAR EAST : Singapore.

Around these areas there are of course significant gaps which we are trying to fill. The information which we have at hand will allow us however to start already now with the computerisation of the data base which will go on improving as we continue our investigations.

P.C.Bianda

In Switzerland there is a telephone service which operates around the clock and a whole network has been set up to ensure the rescue of casualties. It took us four years to organise such a rescue network but it works very well in cooperation with the Swiss Lifeguards.

We have tried to organise a similar network on world level with one single telephone number to dial in the event of an accident. This is a very effective approach.

M.Bibas

I am aware of the difficulties one can come across when one goes global and therefore do not share the enthusiasm of our friend Bianda. I find his idea somewhat utopian although very attractive.

J.P.Mortier

In Belgium we have made an agreement with Heli-Samu. If the weather is fine there is no problem, the operations are very swift but unfortunately when the weather is bad we have sometimes a delay of five to six hours. We also have a lifeguard for diving operational at weekends with an advisory telephone service; the doctor on duty dispatches the various rescue services to the casualties. The list of recompression chambers in published in our News Letter.

G.Wolf

In Austria we have a telephone number to dial in the event of an accident; we have produced stickers bearing the number. We have also a helicopter service which provides transport.

P.C.Bianda

The Swiss Air Guard is linked to all recompression centres and to the clinics and its action is therefore extensive. In our opinion it can be further extended without limit.

D.Guldner

This idea is not necessarily utopian. It could perhaps be feasible on the scale of a continent. There is the anti-poison centre in Zurich which works very well. The same could be done for diving, which would permit centralisation of information on casualties and establish statistics.

M.Bibas

Everything is always possible in principle, but one must be realistic. If we succeed in getting the information we need to complete our study of the means of evacuation and recompression of diving casualties from every CMAS member country, it would already be a success, for we could then publish a booklet which would be invaluable for all divers around the world.

M.Almgren

In Sweden we have one single telephone number to dial in the event of any accident. An ambulance or a helicopter is sent immediately to the spot; and the system is very effective.

M. Bibas

Thanks to everyone for all this information which shows us to what extent the problem of diving casualties and of the evacuation of the injured is important and to what extent Jacques Wolkiewiez's investigation is necessary. We will therefore try to bring it to a successful conclusion.

CMAS medical video library

M.Bibas

I regret that Doctor Delonca is absent for he had been entrusted with the creation of the CMAS medical video library and I know that he has already done a great deal of work on this project. He has written a number of letters seeking volunteers to form working groups on special topics so that each cassette will be the result of team work. These cassettes will be very important to assist the training of doctors and to make a wide distribution of the CMP information by audio visual means.

I know that Georges Delonca has received many answers to his various letters and that several cassettes are already being prepared. I hope that we will have produced a few by the end of next year.

Diving Medicine Congress

M.Bibas

I would now like to take up the subject of international instruction courses or congresses on diving medicine which we organise.

We look upon these international encounters with a great deal of interest for they constitute opportunities to challenge our ideas, to get informed on new discoveries, to appreciate the different practices from one country to another.

The last instruction course was held in Santa Teresa in Sardinia last June. It was a real success. All papers have been written and the proceedings are being prepared.

The next Congress is planned to take place in Martinique and I personally wish a greater participation of physicians from all CMAS member countries. We are already preparing this Congress and I will visit the site in order to obtain the assistance and support from the local authorities necessary for the organisation of such an event. We are going to make a great deal of publicity for this Congress; I hope that you will participate.

Medical publications

M.Almgren

It is indispensable that the information which will be published in the medical News Letter be of high scientific level; we are today confronted with serious competition and we cannot afford information of limited interest.

M.Bibas

Of course it is necessary to avoid publishing just anything but do not let us forget that we are sportsmen, that we have a mission to fulfill and that we will also have to give practical advice to divers around the world.

M.Almgren

That is obvious, but the scientific standard of the medical articles we publish must be beyond all question. We have to publish specialised information.

D.Guldner

There are a great many specialists among us; we should create study groups for each speciality which would allow us then to produce that sort of information.

A.Nefzi

In my country the Federation is very new and we need all sorts of information. Could the CMP not for example publish a yearbook with all diving medicine companies which exist in countries where diving is practiced for example?

M.Bibas

That is not the role of the CMP but rather that of CMAS. We are incidentally going to publish an international yearbook by the end of next year in which we will present that sort of information.

M.Almgren

It would be interesting to survey all CMAS members to discover how they are treating decompression accidents; there are a great many differences from one country to the other. It would perhaps be of advantage for some to know what is done elsewhere. It would be worthwhile for us to share our experience.

M.Bibas

Listening to you I think that you have clearly understood the role of the CMP/CMAS. Your proposal could indeed be the subject of our next investigation, once we will have completed the one undertaken by Jacques Wolkiewiez on the means of evacuation and recompression of diving casualties. We need to know what is done elsewhere in order to improve our techniques, our treatments, in a word - to perform better.

M.Almgren

CMAS has to distribute a great deal of information to all its member countries. One should be able to share our experiences in an easy and not burdensome way.

M.Bibas

That is entirely my opinion as well. Through information we create real links between Federations and CMAS and that is what we strive to do.

K.Kuszewski

I have sent a letter to CMAS regarding diving methods in lakes. We could write a paper dealing furthermore with the prophylaxis of pulmonary overpressure.

M.Bibas

All these suggestions are welcome and we wish to thank you.

Creation of Working Groups

M.Bibas

Amongst our projects we intend to create a working group within the CMP for the updating of our diving aptitude form. Please write to CMAS if you wish to participate in this study.

M.Almgren

Six months ago the Medical Commission of the Swedish Federation established a very detailed, computerised form; we have even included information concerning teeth. We could send you a copy.

M.Bibas

With great pleasure. The CMP/CMAS form is a practical form which has been worked out by specialists. We are, as a matter of fact, often called upon by physicians who need practical information: this form is greatly appreciated but now has to be updated.

We are often asked about the main contra-indications by specialists; so we shall have to establish forms on that too.

M.Almgren

I think that this sort of information would be very interesting in the News Letter. We will never be able to set up perfect standards but if we gather all information that we can receive, we will then have useful documentation. Regarding the contra-indications, I think that most countries are in agreement on the main contra-indications.

R.Cali Corleo

In Malta we have a serious problem because our Commission is not yet a year old. The only diving physician we have works outside the Federation. We have no document, we have therefore used the Australian form to start with. Anything we could obtain from CMAS would be of great help to us.

D.Guldner

To come back to the aptitude form, to the contra-indications. The role of the physician is to know when he can trust his diagnosis and when he should seek the advice of a specialist. In ophthalmology for example, which is my specialisation, it would be necessary to explain to the non-specialist doctor at what stage he has to send his patient to the specialist. It would perhaps be necessary to describe some symptoms. But I think the most important thing for us today is to analyse the situation, to know why divers have accidents, to understand the origin of problems. It is there where the prevention will really start; those answers will facilitate our ability to begin to reduce the number of accidents and their seriousness.

M.Bibas

I entirely share Dr. Guldner's opinion for one of the most important roles that we have to play is in the prevention of diving accidents. A great deal remains to be done in this field and we have in particular to increase and improve the information, for these accidents are often due to ignorance of diving techniques and of course to the inadequate physical fitness of the diver.

We therefore have a long term task for our Commission. I hope that we will be able to count on your collaboration.

By Ed. SPUMS J.

CMAS is a largely non-English-speaking organisation of National Underwater Federations. The Australian Underwater Federation (AUF) is a member of CMAS, but it does not send a delegate to the CMP. We would urge the AUF to send a delegate to the CMP so that the work that has been done in Australia to set standards for medical examinations for divers and to provide an integrated retrieval and treatment system can be brought to the notice of the non-English-speaking world.

We would recommend to our readers the Diving Medicine Congress to be held in Martininque in 1989 (see Back Cover).

The address of the World Underwater Federation (CMAS) is 47 Rue du Commerce, 75015 Paris, France.

HOW MANY DIVERS, HOW SAFE THE SPORT?
The Debate Continues

The two-part article by Robert Monaghan (*SPUMS J 1988; 18: (2) 53-60*) in which he concludes that "diving is not getting safer" has raised high the hackles of the dive industry. To summarise Monaghan's points:

> At the end of 1986 there were fewer than 700,000 active divers, not the 3,000,000 or so claimed by the National Underwater Accident Data Center (NUADC).
>
> Divers today are making half as many dives as did their counterparts 10 years ago.
>
> Deaths are under-reported by 10% or more.
>
> The fatality rate is many times greater than normally assumed, ranking behind only hang gliding and skydiving.

The controversy began prior to publication when we sent drafts to NUADC and the Divers Alert Network (DAN) asking for comments. NUADC responded, challenging several of Monaghan's points, but requested that the letter not be published. We did, however, use many of those points in editing the Monaghan article. We also received a response from DAN, and used comments in that letter to further edit the Monaghan report.

The Monaghan draft found its way to the Diving Equipment Manufacturers' Association (DEMA) and others in the industry, and may very well be the reason why DEMA hired a research firm to conduct a study of diver "erosion" and hurriedly distribute those results at the January 1988 DEMA show. As Monaghan pointed out, since no legitimate industry-wide studies exist, he used a drop out rate of 80%, generally talked about in the industry as the presumed dropout rate. Furthermore, he was handicapped by not having accurate figures for certification, as reporting since 1970 has been sporadic and there is no consistent nor centralised reporting by individual agencies, so he used general industry assumptions.

So that everyone gets a fair hearing, we are publishing the three formal responses we received from the industry, one from John McAniff at NUADC, one from Millard Freeman of the YMCA, and one from PADI's Al Hornsby. Monaghan responds to criticisms, acknowledging one omission in his figures, and therefore revises downward his fatality rate. Finally, we conclude with a thoughtful analysis from reader Laurence Durio in Luring, Louisiana.

The NUADC Response

The NUADC active diver population estimates are purely my guesstimates and have been arrived at without any insider information. I have had neither full nor partial cooperation from the training agencies or the industry in arriving at these numbers. With the threat of lawsuits hanging over their heads we cannot expect the agencies to supply extensive data to us. Therefore the NUADC estimates may well be inaccurate but are honestly arrived at based on my personal insight.

Monaghan uses a 463,000 diver population for 1970, but our data shows that 500,000 was the rough number at the beginning of 1967, and by the end of 1970 there were 693,000 divers, which would boost the total number of active divers in 1986 considerably.

Rumours abound as to a drop-out rate, ranging between 22% and 90%. Monaghan assumes that 80% of the divers stop diving within a year after their certification. In addition, he assumes that 10% of those remaining drop out each year. NUADC, after extensive investigations, has decided that a more accurate rate was 45% per year, which includes not only first-year divers but experienced divers as well. Using our initial figure of 693,000 at the end of 1970, we estimate that by the end of 1986 there were 2,786,000 active divers.

The NUADC further maintains that "active diver" includes all divers in training for that year since each of them will dive at least three times that year.

Monaghan concludes that fatalities are under-reported by 10%, but we believe that we miss less than 5% in a given year and probably pick up any missed cases through successive years' collecting.

If we are to accept Monaghan's numbers of a 700,000 dive population in 1986, then the currently successful diving industry would be nonexistent.

I am the first to admit that our method is crude and may conclude a higher population than some other approach, but, given the lack of data and lack of access to accurate numbers, this is the most honest and sincere estimate we can make.

But Monaghan's presentation is a classic misuse of the statistical approach. One cannot take assumptions, guesses, theories and extrapolation in one paragraph and call them truths and facts in the next paragraph.

We stand by our figures.

John McAniff,
Director, NUADC

The YMCA Responds

Determining the number of active divers is complex. Accurate statistics are difficult to obtain.

As to economic growth as an indicator of active divers, perhaps we underestimate the number of people who purchase used equipment from retiring divers. This is a common practice among diving clubs. In fact, club members lend equipment to new divers (or family members), if they are not making a particular dive. People in some cases have purchased equipment jointly and share it by going on different dive dates.

I also wonder how long the major pieces of dive equipment are used before they are replaced. This would affect sales as, theoretically, a whole new cadre of divers would be required each year to maintain the level of previous sales.

Perhaps we misjudge the impact of equipment sales as related to the economy of the country. The fluctuation of discretionary money or purchasing power and the cost of equipment may influence the decision to rent rather than purchase.

The issue of divers returning to active diving is difficult to address, if not impossible. Divers initially active may "retire" for a few years and then return to diving with or without any refresher training or equipment purchase.

I have sensed an increase in speciality ratings and advanced diver training, at least in their promotion. Dive travel seems to be more popular and *may* increase diver retention.

The interpretation of statistics is as difficult as gathering the data. In fact, the same set of statistics may be interpreted several ways depending upon the circumstances or conditions of the moment.

Millard D. Freeman, Jr.,
National Aquatic Director,
YMCA of the USA

PADI Responds

While we won't take the opportunity to debate a number of the article's very debatable statements and conclusions, there is at least one purely false claim that must be brought to your attention.

The article claims that a PADI survey, as reported in an article entitled "Latest Trends" in the *PADI IDC Candidate Workbook* 1984, supports a 79% dropout rate. This is false. There is no article with that title. Furthermore, the IDC Candidate Workbook states clearly that "PADI student surveys indicate a very different picture" than the widely accepted dropout rate of 80%.

The claim that survey results published by PADI at any time support the 80% dropout rate is absolutely a false claim. There was a study published in 1983 that included dropout statistics. If this is what the author references, then he *misquotes* it. What the survey article actually said was: "the standard dropout rate figure of 80% per year is *not* reflective of PADI Divers. In fact, even if we create a *worst case* situation by counting every 'no response' (a total of 3,604 divers out of 5,700 surveys mailed) as a dropout, we still find that, overall, only 72% would be considered 'dropped out' of the sport.

The article stated further that overall, *94% had been diving* in the past 12 months. The article also made it clear that this survey and the resultant data was based on divers in equal numbers over a *3-year period* and does not represent one-year results in any case. This would lead to a "best case" inference that over 3 years the dropout rate was only 6%. While we do not suggest this rate is low, for it to be reported that this article supports an 80% dropout rate per year is a misrepresentation.

Further, from a logic point of view, even if one were to attempt to claim that each "nonresponse" to the survey indicated a true dropout, then it would mean also that 100% of the active divers who received a survey actually filled it out and mailed it back to PADI. Considering that 5,072 were delivered by mail, such a concept is ludicrous. Neither statistical science nor common sense would allow the assumption that 100% of the existing divers would respond to a survey through the mail within the specified response time (a one-time survey mailing with no prewarning, follow-up or remuneration).

Therefore, based on accurate interpretation of the data, the dropout rate is at best 6% over 3 years; at worst, it *cannot* approach 72% over 3 years (for the reasons given in the paragraph above), much less 80% over 1 year. PADI has taken the position since this study that the actual rate lies somewhere in the mid-range between the two figures (around 40% after 3 years).

The recent Diver Erosion Study commissioned by DEMA and supported by NASDS, NAUI, and PADI is establishing a more accurate figure. The preliminary figures released at the 1988 DEMA Show (by Diagnostic Research Inc.) show a dropout rate of only 15% after 12 months, with 47% of divers still active after 48 months (4 years). The author's model, by comparison, claims only 14.58% of divers are active after 48 months.

Additionally, the statement "One must remember that the agencies do not cooperate with NUADC" is very misleading. PADI, for example, each year provides Mr McAniff at NUADC with a complete accounting of all diver fatalities reported to PADI Headquarters. This includes victim's name, location, and date of incident. Also, we provide Mr McAniff with PADI's certification numbers each year. We have done all of this for a number of years. Additionally, some of the other agencies provide Mr McAniff with similar reports. To characterise the situation by stating the "agencies do not cooperate with NUADC" is simply not reflective of reality.

Al Hornsby,
PADI Vice President,
Education and Marketing

Monaghan Responds

My *Undercurrent* article has become the center of a surprising storm of controversy. But, it has accomplished its goal. It's made the industry face up to its inaccurate statistics and to seek real numbers.

Actually, my models in fact dovetail with the general industry estimates. NUADC's estimates do not. It is NUADC which has had to revise its population estimates dramatically downward. That means fewer divers and higher risks, just as I suggested in my article.

The debate is muddled because people use three different categories of divers, experienced divers, student divers, and resort course divers, and the categories overlap in any given year: some student divers are experienced divers seeking higher levels of certification; many resort course divers soon become student divers.

Even more difficult, we are trying to estimate certification numbers. Training agencies suggest at least 10% of the certifications go to divers above the entry level, with PADI claiming nearly 20%. Moreover, some of those certifications go to the same diver getting multiple certifications from different agencies from one course. In other cases, the same diver gets multiple levels of certifications. The Harvard Report suggests that some 400,000 certifications in 1985 only represented 240,000 new divers. Those sort of figures tend to make my experienced diver population figures even higher than is probably the case. Finally, raising the initial starting population in 1970 as McAniff suggested would have a very small effect on the results of the model, well within the rounding up factor I used to reach 700,000.

We have NUADC's estimate that there are some 400,000 + resort course divers annually. We have DEMA figures, which claim 400,000 to 600,000 certifications annually (but not all new certifications). We have my calculation of 700,000 people who are experienced active divers. And perhaps there are another 100,000 who start a course but fail to finish. These figures add up to 1.7 million, in agreement with various industry figures (although not the figures of NUADC). Updating my model to 1987 and adding the people not included would yield an overall estimate in good agreement with the latest DEMA sponsored Diagnostic Research Inc. figure of two million divers, *that is people who get wet.*

This estimate is less than half that of NUADC, but it is not far off the DEMA Crane report (1.77 million), the Mediamark Inc. 1986 survey (1.75 million), and the 1986 NSGA survey estimate of 1.8-2.2 million reported recently in *Underwater USA*. Of course, we must say then that the term "diver" here means anyone who has made *one* or more dives in the last twelve months. The latest industry survey sponsored by DEMA through Diagnostic Research Inc. yields a current estimate of about 2 million divers. Yet, with these other studies around, it has been the NUADC figure that gets widespread publicity and appears as gospel.

Undercurrent quoted McAniff's estimate that there were "over 3.5 million active divers" in 1987. The latest NUADC figures have revised those estimates downward radically to 2.5 to 2.7 million "active" divers. McAniff claims his figures are simply his best "guesstimates". I suggest that McAniff needs to reduce his personal "guesstimates" by another 700,000. Doing so would bring his "guesstimates" into line with the industry consensus figure of 2 million experienced divers and divers in training or resort courses.

Hornsby's 1983 *Undersea Journal* article on the PADI Diver Survey (reprinted in the IDC Candidate Workbook) reported results on four types of certifications (basic, open water, and two categories of advanced). His figures combine these responses, confusing the result. The article claims PADI's dropout rate is lower than the "industry standard dropout rate of 80%" PADI claimed to represent roughly 50% of the 1983 certification. If the industry standard dropout rate was 80% as Hornsby's article indicated, this would mean that PADI's dropout rate must have been at least 60%, while 100% of the divers trained by other agencies would have had to drop out to achieve the 80% figure Hornsby reports. Given the inbreeding evident in dive course material, the same instructors teaching both NAUI and PADI, and so on, it is hard to see why PADI's dropout rate would be substantially lower than the rest of the industry.

The new Diver Erosion Study suggests that we have cured the dropout problem. We supposedly went from what was once a "widely accepted" industry dropout rate of 80% to the 1988 Diver Erosion Study estimate of 15%. Wow!

If we did cure the diver dropout problem, I must have missed it. The diving industry had a mid-1980s growth rate of 5%-6% (DEMA-sponsored Harvard Report). If the dropout rate declined from 80% to 15%, shouldn't we have had really explosive growth? Why did the dropout rate decline so markedly? Aren't we still using the same modular scuba course (from 1978)? Did equipment prices go down? Was it color-coordinated diving equipment that cured the diving dropout problem? If not, what was it?

Obviously, I do not believe that 85% of last year's diving students are still active divers and customers today. I doubt if many diving retailers or instructors believe it either. Too bad, we'd all be rich if it were true. My models help explain why we have had such limited growth in the diving industry.

The real risks of diving vary with such factors as the number of dives, diving conditions, and your experience as a diver. The low number of reported deaths among a NUADC-estimated 400,000 + resort course divers suggests that such closely supervised diving is relatively safe. Likewise, experienced divers making a large number of dives under familiar conditions are relatively safe. It is the new diver making his or her first few dives who faces the most risk. McAniff's figures through 1984 suggest that 41% of the deaths occur during the first few dives.

My analysis of experienced diver risk erred in merging these first dive deaths with the experienced divers' deaths, while not merging in the entire population at risk. A better estimate of the overall risk of diving can be obtained by using the industry consensus for the number of people who dive (1.7 to 2 million), which would yield an overall diving risk estimate of 5.8 to 6.5 deaths per 100,000 participants. While this is 2 to 3 times the figure arrived at by NUADC using their inflated estimates, it is lower than my estimate for experienced divers alone.

This averages both high and low risk divers in the larger population. Individual risks depend on the circumstances of your dive and your experience. The real fatality rate, however, needs to consider the number of individual exposures. I did make a trial estimate for the risks per dive in my article, fully recognising the need to have a risk per dive figure. I'd also like to suggest a rate for the difficulty of the dive, which would include cave dives, heavy currents, depth, no advanced certification divers present, and other factors which increase risk.

My article in *Undercurrent* is still the best guide to the real risks faced by divers. And my advice remains the same. Be careful out there. It's more dangerous than even the revised official statistics would have you believe.

Robert Monaghan

Summing It All Up: A Reader Responds

Collectively, the two parts of Mr. Monaghan's article constitute probably the best evaluation of diving safety I have ever read. It was a refreshing change from the pious pontification found elsewhere.

While a definite analysis of the apparent increase in diving fatalities appears to be belong the scope of Mr. Monaghan's analysis, he did identify some likely causes. I would like to add my views, which basically expand upon those touched on by Mr. Monaghan. As a scientist, I understand the limitations of anecdotal evidence, but I also understand the likely statistical validity of the number of observations made in the course of twenty years of active diving.

Over the course of my diving career, but particularly in the last ten years, I have noticed a steady degradation of diver quality. When I first began diving, virtually all divers were dedicated and highly motivated, with very strong aquatic skills. Building upon that base, the training was both physically and academically more rigorous. Out of necessity, diving was a skill-dependent, rather than equipment dependent, sport.

After certification, divers of that era dived whenever and wherever they could, under some truly awful conditions. The divers that I have seen who have been certified in the last ten years have been lacking in motivation, dedication, aquatic skills, academic training, and, consequently, meaningful experience.

A class that I was recently involved with (taught by one of the better instructors of my acquaintance) illustrates my point. Approximately half the students were women taking the class under pressure from husbands or boyfriends. The remainder were approximately equally divided between children who possessed neither the discipline nor the intellectual skills to make competent divers and young men who seemed to have something to prove. There was one outstanding student in the class, a woman in her early thirties who was a Red Cross Water Safety Instructor who was fulfilling a long-term ambition. With the exception of the aforementioned woman, all of these students were extremely weak in aquatic skills, with many of them being openly afraid of the water. Substantially less than half of the class had any real grasp of the academic aspects of diving. Gas laws were mystical abstractions, regulators were “black boxes” full of unfathomable magic and decompression tables were written in as-yet undeciphered language and worked by rote memorisation. Not to worry, spend enough on equipment and gadgets, and skills and knowledge become superfluous.

So far as I can tell, only three of the students from that class are still diving. Two are pressured spouses, (one of whom is merely incompetent and the other who dives in a state of abject terror), while the third is the highly motivated woman mentioned earlier. She has turned into an extremely capable diver.

I encounter products of the current training system in widely scattered locations. My experience described in the previous paragraph seems to apply to virtually all of them. It appears that, in an attempt to mass market the sport, the training system starts with poor raw material and teaches equipment dependency in lieu of adequate skill. As a consequence, I usually feel safer diving alone than buddied up with a diver of that type.

A possible explanation for the poor state of diver training is the acknowledged fact that instruction is the “loss leader” that enables dive shops to make money selling equipment. It is a reasonable hypothesis that dive shops find it far more profitable to teach equipment dependency rather than skills. Heaven forbid that the training should be rigorous. Physical and/or academic rigor might weed out too many of the students before they could buy all that expensive color-coordinated equipment.

Until we go back to more rigorous training, we will continue to certify large numbers of divers who drop out of the sport very quickly. While this may benefit the dive shops in the short run through the sale of large quantities of equipment, the resulting accident rate is already beginning to attract regulatory interest.

From the standpoint of a career in a regulatory field, on both sides of the fence, including involvement in the development and initial enforcement of the OSHA commercial diving standard, it is my opinion that getting the government involved would probably be far worse than the lost sales of color-coordinated BCs and wet suits which could result from adequate training. If diving is to remain independent and self-regulating, it had better get on with the fundamental task of producing competent divers.

Laurence R. Durio
Luring, Lousiana, U.S.A.

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By Editor, SPUMS J.

We reproduce yet another episode of statistics swapping on the subject of the safety of diving in order to encourage readers to keep Project Stickybeak (PO Box 120, Narrabeen, New South Wales 2101) informed of non-fatal diving incidents and to pave the way for the gathering of better Australian statistics about the number of divers and dives done. Without this information all estimates of the safety of diving are at best educated guesses.

UNDERCURRENT TRIES OTHER WAYS OF COUNTING DIVERS

Skin Diver magazine reports in April that 60.6% of the divers responding to a survey of its readers indicated that they had travelled outside the continental U.S. in the previous year to dive. Of these, 21.8% said they had gone to Hawaii.

Does the survey reflect the typical diver? Is a travelling diver more likely to be a *Skin Diver* reader than a non-travelling diver? Our hunch would be yes, because travelling divers find useful the kind of information *Skin Diver* provides. If anything, the percentages they report would tend to give a higher figure for the percentage of divers who travel than stay at home.

Now consider this. On May 15 1988 the *Los Angeles Times* reported that 50-70,000 divers visit Hawaii each year. Using the formula (.218)(.606) X = 70,000, we find that if we accept that 70,000 divers visit Hawaii annually, then *Skin Diver* figures help us discover that there are 530,303 divers residing in the 49 states. To get to the 1.6 million figures some sources claim, then every man, woman and child resident of Hawaii would have to carry a C-card.

Tow and Associates, hired by Grand Cayman to handle their press relations, reported to *Undercurrent* that 209,044 tourists flew into the Cayman Islands last year; 40%, or 83,618, they told us, were divers. Using the same formula, we would find that the total number of divers is 439,438.

Monaghan says there are 700,000 active certified divers. He seems pretty close to the truth.

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MEDICAL STANDARDS FOR DIVING WITH THE BRITISH SUB-AQUA CLUB FOR THOSE SUFFERING FROM VARIOUS DISORDERS

The following standards, dated January 1988, copies of which were provided by Dr Peter Wilmshurst, Chairman of the BS-AC Medical Committee, are published for the information of members about what is happening on the othere side of the world. The topic are arranged in alphabetical order, not in order of importance. **Most Australian diving medical specialists would have reservations about some of these standards, especially that on asthma.**

Anticoagulant Treatment

Anticoagulants are used to reduce the risk of pulmonary or systemic thrombosis or embolisation. Clearly some of the conditions requiring use of anticoagulants are in themselves an absolute contraindication to diving whatever treatment is given. This may be because of the serious nature of the disease itself or because even with the use of anticoagulants further episodes are not entirely prevented.

However, some people receiving anticoagulants will be entirely asymptomatic on treatment without any symptoms referrable to the cardiovascular system. Obvious examples are individuals given anticoagulants for deep venous thrombosis, pulmonary embolism or because of the presence of prosthetic cardiac valves.

As far as scuba diving is concerned, in such individuals the only real risk to them is from haemorrhage, if we ignore the risk of an asymptomatic individual having further episodes of their presenting condition whilst anticoagulated. This however, assumes that adequate anticoagulation of that individual is maintained. It also assumes that there is no interaction between anticoagulation and the diving environment (e.g. altered partial pressures of gases). No such interaction is known, but it is known that decompression per se reduces platelet count and may even cause thrombocytopenia, which would aggravate any bleeding diathesis. (This is believed to result from platelet consumption by adherence to bubbles.)

There are a number of situations which could cause haemorrhage when diving. Clearly trauma is likely to result in significantly more haemorrhage in an anticoagulated individual than in another individual. Whether auditory barotrauma will result in greater haemorrhage and hence produce greater residual problems, whether bleeds into sinuses and mask squeeze present greater problems in those anticoagulated and whether pulmonary barotrauma is more likely to result in major haemoptysis than in those not anticoagulated is unclear.

In addition, the postmortem findings of decompression sickness include haemorrhage in the spinal cord, believed to result from venous infarction. It is possible that anticoagulation will increase the risk of major haemorrhage and resulting serious neurological problems.

Furthermore, in anticoagulated individuals spontaneous haemorrhage or haemorrhage after trivial trauma may occur. Heavy nose bleeds are common. This could result in impairment of vision because the mask is filled with blood and confusion in diagnosis of pulmonary barotrauma by producing spurious haemoptysis. Cerebral haemorrhage is much less common but can cause neurological deficits which could be mistaken for diving related illness.

Overall the annual mortality and morbidity for sudden haemorrhage in those anticoagulated are 0.2% and 2% respectively.

The present policy of the BS-AC is that use of anticoagulants are not permissable in new recruits but may be acceptable in established divers, provided no other contraindication exists and they appreciate and accept the risks involved. In such cases, decisions will be made on an individual basis and a limit on depth and number of ascents may be imposed to reduce the risk of spinal haemorrhage from decompression sickness.

It is recommended that any person on anticoagulants seen by a referee is referred to the Medical Committee.

Asthma

Asthma may predispose to air trapping and hence pulmonary barotrauma which may be fatal when diving.

Diving is permitted by asthmatics if they have allergic asthma, but not if they have exercise, cold or emotion induced asthma. Asthmatics may dive if their symptoms are controlled with *Intal Plain* (but not compound) and/or inhaled steriods. Ideally adequacy of control of asthma should be assessed using lung function tests as well as clinical parameters. Asthmatics may also dive if they only occasionally need to take bronchodilators, say the equivalent of 1 *Ventolin* puffer a year. Asthmatics who regularly require drugs containing bronchodilators (e.g. *Ventolin*, aminophylline, *Intal Compound*) or oral steroids may not dive.

An asthmatic who infrequently needs bronchodilators and who is permitted to dive should not do so if he or she has needed to take a bronchodilator in the 48 hours preceding the dive or if he or she has any wheeze or other chest symptoms at the time of the dive.

Head Injury

Epilepsy occurring underwater is almost always fatal to an amateur diver who will lose his mouthpiece and inhale water during the clonic phase of the attack. It is known that hyperbaric oxygen induces epileptiform fits in susceptible individuals and it is possible that the raised partial pressure of oxygen in compressed air breathed at depth may induce fits in someone susceptible to epilepsy.

Anticonvulsants cannot be used to overcome this problem underwater as they are all sedating and potentiate the effect of nitrogen narcosis, leading to disorientation at unexpectedly shallow depths.

Because head injury may be followed by epilepsy, the fitness of divers who have sustained this type of injury needs to be carefully considered. The following guidelines are suggested.

The length of post traumatic amnesia (PTA) including any period of unconsciousness may be used as an index to the severity of injury. Where PTA has been less than one hour, there should be a three week lay off from diving. With PTA of an hour to 24 hours, there should be a two month lay off. Where the period of PTA exceeds 24 hours, there inevitably has been severe brain damage and there is considerable likelihood of subsequent epilepsy and impaired mental functioning. A minimum period off diving of three months is suggested and cerebral function should have returned to normal.

Where enquiries are being made about an incident in the past, the individual sometimes has difficulty in recalling the period of PTA and in such cases the period of unconsciousness may be doubled as a rough guide.

If epilepsy should have developed as a result of injury then further diving is banned unless it was an isolated fit occurring at the time of injury. Likewise if anticonvulsant medication is being taken as a prophylactic measure, diving should be banned, but may be resumed three months after this is withdrawn if the individual never had a fit.

Operative intervention to raise depressed bone or evacuate haematomas should disquality for three months but otherwise may be disregarded except insofar as it may be associated with subsequent fits, anticonvulsant treatment or other factors above.

Hypertension

Hypertension may predispose to pulmonary oedema when diving and is a risk factor for other cardiovascular events, (e.g. stroke and myocardial infarction) which could prove fatal if they occurred in the water.

Diving is permitted by mild hypertensives if their diastolic blood pressure does not exceed 90 mmHg in new entrants or 100 mmHg in established divers and their systolic blood pressure does not exceed 160mmHg. These pressures are acceptable if they are attained without treatment or by means of approved treatment.

Approved treatments consist of dietary measures including salt restriction, diuretic therapy (when being used to treat hypertension but not if also being used to treat cardiac failure) and low doses of mild vasodilators (e.g. prazosin, nifedipine). Occasionally a medical referee may approve the use of a low dose of a beta-blocker (preferably cardioselective) or other antihypertensive agent to control hypertension provided the heart rate response to exercise stress is unimpaired. The diver should be able to attain a heart rate which is at least 90% of (220 minus his age in years) beats/minute. If beta-blockers are used there must be no evidence of bronchospasm, preferably assessed by lung function tests performed on and off treatment.

Diving is not permitted even if blood pressure control is adequate if there is evidence of end organ damage resulting from hypertension (i.e. renal, eye or cardiovascular complications, including cardiac enlargement).

Ischaemic Heart Disease and Exercise Testing

Ischaemic heart disease is the major cause of mortality in middle aged men. A major ischaemic event underwater could prove fatal and endanger a diver's buddy.

However, the value of "screening" exercise tests in apparently normal populations have now been largely discredited because of the appreciable false positive and false negative results in such groups. Furthermore, we have no control over the quality of equipment or type of standardisation on which the Exercise ECG's on our members would be performed. This only compounds the possibility of false reporting of the test.

Questions being inserted in Section A of the medical form will enquire about chest pain and other cardiac symptoms. Those with symptoms suggestive of ischaemic heart disease should undergo exercise testing or referral to a local cardiologist as appropriate.

In the case of individuals with a poor family history or hyperlipidaemia but no cardiac symptoms, exercise testing is appropriate, particularly if they smoke, but needs to be interpreted with caution.

Multiple Sclerosis

The symptoms and signs of multiple sclerosis and optic neuritis are very similar to neurological decompression sickness and arterial gas embolism. Any neurological symptom arising within 24 hours of surfacing from a dive must be considered dysbaric in origin and the only method of establishing the diagnosis is by assessing the response to therapeutic recompression. Instances have occurred where new neurological symptoms have arisen following dives in indivudals who have had suspected or confirmed multiple sclerosis. These have proved very difficult management problems for the attending diving physicians. The BS-AC medical committee therefore must debar the above group from taking up sport diving.

The position with isolated optic neuritis remains unclear, but a recent episode of isolated optic neuritis would also disqualify.

The variable depths enountered in sport diving where the individual breathes air, rather than 100% oxygen, cannot be considered a satisfactory menas of prescribing hyperbaric oxygen treatment.

Neurological Decompression Sickness

Individuals who have had neurological decompression sickness are thought to be generally more susceptible to subsequent episodes. In addition, subsequent neurological insults are more difficult to treat and leave greater residual disability.

Therefore, it is felt that as a general policy any person, who in the opinion of the doctors treating the individual at the time of the diving incident, has suffered from neurological decompression sickness, should be considered unfit for future sport diving. Normally these cases would be referred to the BS-AC medical committee for a final decision.

Obesity

Obesity may exclude a candidate from diving as it indicates a lack of general physical fitness. Increased body fat mass predisposes to an increased nitrogen uptake under pressure, hence it predisposes to decompression sickness.

A weight 20% in excess of desirable body weight as laid down in actuarial tables, is taken to preclude diving. Due regard should be taken to weight distribution and frame size. Excessive obesity may also be calculated by using Harpenden skin fold thickness calipers at left biceps, left triceps, left subscapular region and left iliac crest which should total less than 60 mm.

A weight of less than 20% in excess of desirable body weight does not necessarily mean a candidate is fit to dive.

Pacemakers

Patients with antitachycardia pacemakers and automatic implantable defibrillators may not dive with BSAC.

Patients with pacemakers implanted for treatment of bradyarrhythmias may dive under certain circumstances:

(a) Since implantation of the pacemaker the patient should have been free of cardiac symptoms, notably syncope, dizziness, chest pain and inappropriate dyspnoea.

(b) The patient should be free of significant cardiac disease other than sinus or atrioventricular node disease. There should be no suggestion of significant coronary artery disease, valvular disease or cardiomyopathy.

(c) The patient should be able to mount an appropriate heart response to exercise, i.e. should be able to achieve a heart rate of 80% of (210 minus age in years).

(d) Pacemaker implantation should not have caused any other contraindication to diving, e.g. serious lung damage during subclavian vein puncture.

(e) The pacemaker should be a modern resin filled pacemaker rather than a gas filled model which could result in pacemaker compression at depth.

(f) Ideally the pacemaker should have been tested under hyperbaric conditions to ensure reliability.

(g) Because some pacemakers are known to malfunction at depths greater than 30 metres, no pacemaker patient should be allowed to dive beyond this depth.

Pulmonary Barotrauma

Individuals who have had pulmonary barotrauma are thought to be generally more susceptible to subsequent episodes.

Therefore, it is felt that as a general policy any person, who in the opinion of the doctors treating the individual at the time of the diving incident, has suffered from pulmonary barotrauma should be considered unfit for future sport diving. Normally these cases would be referred to the BS-AC medical committee for a final decision.

Prosthetic Cardiac Valves

It is assumed at the outset that no other cardiac or non-cardiac contraindication to scuba diving exists. It is important to rule out conditions which may be related to cardiac disease (e.g. arrhythmias or cardiac muscle dysfunction) or cardiac surgery (e.g. post bypass lung or neurological damage).

It is also felt advisable that the individual should also have had the prosthetic valve in place and functioning satisfactorily for a period of time prior to any consideration of fitness to dive. A one year period of satisfactory valve function is thought advisable, particularly since those with significant left ventricular hypertrophy from conditions such as aortic stenosis are known to have a significant one year mortality from sudden (presumed arrhythmic) deaths.

The problem then arises, which prosthetic valves, if any, are acceptable. In considering this, we need to consider the different problems that may be experienced with prosthetic valves.

Potential Risks:

1. Embolisation

   (a) Right Heart Valves. Embolisation from right heart prosthetic valves are unlikely to cause incapacity in the water, but could cause chest discomfort similar to chokes, but this seems of very low risk.

   (b) Left Heart Valves. Embolisation from left heart valves could cause neurological symptoms and unconsciousness which might cause incapacity underwater or mimic diving related illness after surfacing. The risk of systemic embolisation for the various valve types are approximately 4%/year for mitral prostheses (either mechanical prosthesis in a patient on anticoagulants or bioprosthesis in a patient not on anticoagulants) and approximately 2%/year for aortic prostheses (mechanical prosthesis with anticoagulants or bioprosthesis without anticoagulants). Patients with atrial fibrillation, large left atrium, known left heart thrombus or previous history of systemic embolisation are at higher risk whilst those without these factors are at slightly lower risk.

2. Anticoagulation.

   Mortality 0.2%/year, Morbidity 2%/year from sudden bleeds. (See separate discussion on anticoagulants).

3. Mechanical Failure of Prosthetic Valves

   (a) Right heart valves. Failure does not usually produce catastrophic problems.

   (b) Left heart valves. Failure usually produces catastrophic pulmonary oedema/cardiogenic shock with a 30-50% mortality on land. Such an event underwater would be almost certainly fatal and could endanger the buddy. The failure rate varies with different prosthesis but is approximately 1-2 per 1000/year.

4. Degeneration of Bioprostheses.

   This results in restenosis or regurgitation but can be assessed at annual review of fitness to dive.

5. Mechanical Haemolysis.

   Causes chronic anaemia. Can be excluded by blood test.

Decisions about the advisibility of individuals diving with prosthetic valves will be made on an individual basis by medical referees or the medical committee.