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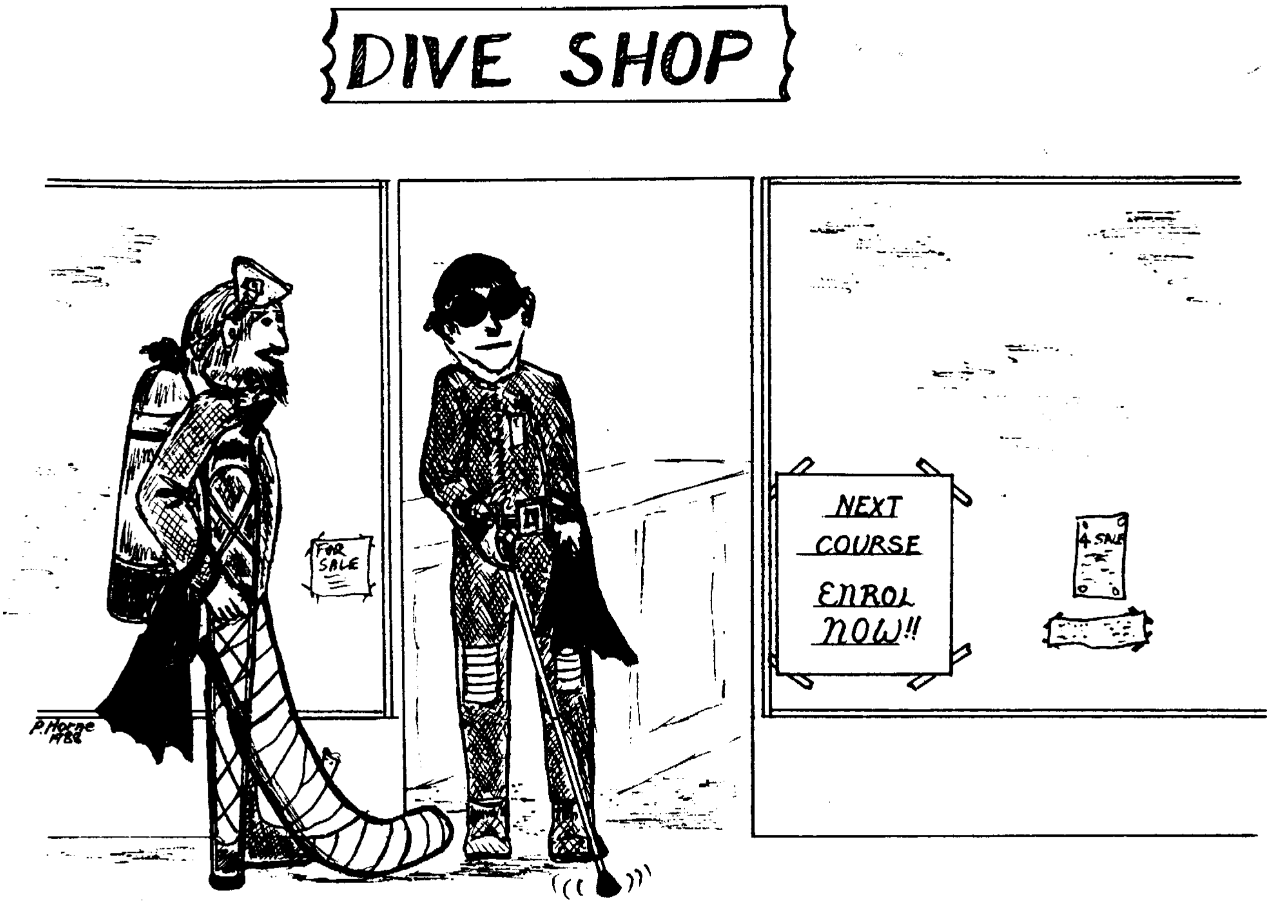

"YOU COMING ON THE COURSE, TOO?"

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To publish a journal.
To convene members of the Society annually at a scientific conference.

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EDITORIAL

There is an important practical difference to be noted between a person who has some disability anbd someone who is "disabled" and the critical element is the personality of the subject. However one cannot afford to believe that mere determination to overcome some disability will thereby elimate its effects. These thoughts arise from consideration of not only the report on the Townsville Experiment (which has been previously reported by Welliamson et al [1]) but also of the paper "The right to dive". There has been a remarkable absence of comment on the Townsville and similar projects whose primary objective often appears to be to enable underwater activities by those seemingly completely unfitted to undertake them except when accompanied by a number of very highly trained and motivated instructors. Such people could be shown the wonders of the underwater world far more simply by being given a short period of instruction and then taken on an escorted tour.

Disabilities are of many types and degrees and their relevance to safe scuba diving can be deduced logically by applying a knowledge of basic diving medicine. It is not correct to state that no guidelines exist, although their application to a particular person may call for a one off clinical assessment. It is somewhat ironic that, in a sport where apparently fit applicants are "failed" on medical grounds. doctors with a training in diving medicine can proceed to totally ignore these standards of fitness to dive when confronted by obviously disabled persons. A basic weakness in the enterprise appears to have been a failure to define the objective of the training before commencing. While it is stated that there was no preconception that full, unrestricted diving certification would be granted to "successful" candidates at the end of the course, and at the present time certification can only be granted Yes or No and not "Condityinal on" specified limitations, neither it is it spelled out what the trainees expected if they were successful.

The Townsville report indicates clearly the diversity of problems classed under the heading of "disabled" and there is a significant and important difference in the suitablity for diving of those in the different groups. It is obvious that an amputation has a practical rather than a medical assessment factor while a person with a severe personality or memory disability woude be unsafe in many more situations than merely in diving. The inclusion of the four head injury cases appears unjustifiable. Blindness in divers is a matter where debate can continue. There has been a story of blind commercial divers working in Scandinavian waters where the nil visibility conditions gave them a psychological advantage, but the truth of this report has not been confirmed. The spinal cord dsysfunction group illustrate the correctness of the ruling that traumatic lesions do not necessarily prohibit diving but a lesion following spinal decompression sickness is an absolute bar to any futhrer exposure to diving. This advice is based in part on an awareness that severe cord damage remains after even an apparent "cure" of spinal decompresssin sicikness. Diver GP had suffered non-traumatic spinal cord damage weich undoubtedly involved a considerable portion of the cord. This could logically have been regarded as falling more toward the the risk assessment of a post-decompresssion sickness status than that of simple trauma. Events appear to support this logic. Naturally NO sports divers should dive near the no-decompression limits. There is no mention of diver BH having a test of bronchial response to nebulised saline despite his history of childhood asthma. Indeed the whole subject of asthma in divers is overdue for an honest investigation, but that is another problem and will no be discussed further now.

This should not be construed as meaning that those who have some disabilty should not be permitted to dive but rather that there should be a more logical approach to defining fitness to dive. It may be that grades of fitness and of scuba training certification should be devised so as to permit a trainee to dive if he or she is accompanied by one (or two) specially certificated companions. The interesing paper on the Larkel illustrates the possibilities of such a flexible approach to fitness to dive. However there remains in the background a well founded awareness of the legal dangers of certifying a person as :"medically fit to dive" when all the accepted medical standards continue to state the reverse.

The diverting and highly unusual report from New Zealand of a case of ear pain in a diver is a welcome item with which to relax after the stern necessity of considering the reports on diving incidents from the UK and the USA. The No Panic Syndrome litany of ways to kill oneself is enough to convince most non-divers that ALL divers must have a death-wish as part of their persona. In refutation we present the information which will assist avoidance of such tragic incidents, and any crayfish who read this issue of the Journal will now be alerted to the dangers of taking refuge in a human external auditory passage !

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1 Williamson J.A, McDonald F.W, Galligan E.A, Baker P.G, and Hammond C.T. Selection and training of disabled persons for scuba-diving. *Med J Aust* 1984; 141: 414-418.

SPUMS ANNUAL SCIENTIFIC CONFERENCE 1987

DIVING FOR THOSE WITH DISABILITIES A GUIDE FOR SCUBA DIVING INSTRUCTORS

W. A. Williams

In 1981, the International Year of the Disabled Person, the Australian Underwater Federation (AUF) sought to encourage its member clubs to introduce some people with disabilities (mainly amputees) to our sport of skin and scuba diving.

Little was known at that time on the dangers (if there were any) and difficulties of teaching the disabled this sport. Some overseas organisations, such as the BSAC, had indeed conducted some courses, but little was known of the results and even less had been published.

Around Australia, this encouragement from the AUF met with little enthusiasm if not downright refusal. Nobody wanted to be first to attempt this in Australia. Nobody, that is, except the Townsville Recreation for the Handicapped Committee, which acts as a sub-committee of the Area Committee of the Queensland Recreation Council. This committee has always maintained an interest in recreational activities involving the water, and who would't with the warm waters of the Great Barrier Reef at your doorstop.

In 1981 the committee decided to take their interest in water sports one step further. With the help of local members of the Federation of Australian Underwater Instructors, who donated both time and equipment, a scuba course was conducted for six disabled people. The disabilities included paraplegia, amputation, spina bifida, polio, cerebral palsy and brachial plesus injury. The course was only aimed at getting the candidates trained to a sufficient standard to allow them to dive safely on the reef without supervision. Eventually, 5 of the 6 candidates dived with instructors in the open sea.

In the ACT I was involved in a similar, though less ambitious programme, with three amputees. Unfortunately, our programme folded half-way when two retired because of personal reasons and the third, who was a Vietnam veteran, was so determined to pass he ruptured an eardrum rather than let us know he was suffering pain. He was then posted to the USA so the course did not finish on a high note. I mention this only to show the problems which can occur in such courses.

Back in Townsville however, the course had stimulated interest in a large number of areas. Young disabled people began to ask when the next course was to be conducted. The instructors concerned had received tremendous personal satisfaction from the original course and had developed an interest on the problems and the true grit of disabled people.

All concerned were impressed by the fact that, despite the advantages of the sport for various types of disability, the little published works on teaching the disabled to dive, related only to those with amputations or spinal cord injuries.

The Townsville Recreation for the Handicapped Committee therefore decided to organise another course. It was decided to seek financial assistance from the Australian Government to conduct the course with the basic aim of finding out more about the disabled and scuba diving.

In August 1982, a joint submission from the Townsville Recreation for the Handicapped Committee and the North Queensland Region of the Federation of Australian Underwater Instructors was forwarded to the Department of Home Affairs and the Environment requesting assistance. As the body representing the sport, this submission was then forwarded to the Australian Underwater Federation by the Department for comment.

The AUF gave its enthusiastic support to the project provided a report was produced which could be turned into a handbook to guide scuba instructors on the teaching of the disabled. The Department of Home Affairs and the Environment granted the sum of $10,000 for the project to be conducted in 1983.

The project had four aims and objectives:

1. To conduct a suba diving course for a sizeable group of disabled people which would include a wide spectrum of common types of disability, and in so doing, to assess the need for providing further specialised opportunities for disabled divers.

2. To examine the problems involved in selection of divers, teaching techniques, safety and equipment.

3. To provide a report outlining possible solutions to the problems encountered, suggestions regarding selection, safety, teaching and equipment, and recommendations regarding standards and possible alternative qualifications for disabled divers. It was anticiated that sections of the report may be later adopted into a manual for diving instructors, and/or an Australian Standard.

4. To foster ongoing opportunities for disabled people to participate safely in the sport of scuba diving.

At the very onset of the project, it became clear that there was little literature on the subject of the disabled scuba diver. The only article which gave any guidance on selection of the disabled was a report from Flemming and Melamed [1] which gave information on their experiences with teaching six persons with paraplegia and lower limb dysfunction.

The course was widely advertised in Northern Queensland and twenty-two disabled persons applied for selection. However, only eighteen presented for a diving medical assessment. Of the four who did not present, three did not follow up their initial application and the fourth person, a young man who had a head injury, was advised not to dive by a non-diving medical officer before he had the opportunity to present for assessment by the committee's medical examiners.

The primary medical assessment was conducted to the standard set by the National Qualification System of the AUF which was designed with the strong support and assistance of Dr John Knight some years ago.

The report by Flemming and Melamed [1] suggested eight factors additional to a normal diving medical, which should be considered when examining the disabled who wish to scuba dive:

1. The respiratory system should be completely normal. All the respiratory muscles should be under control, and the spinal lesion not below T5 and preferably not above T8.

2. It is of extreme importance that the skin condition of a paraplegic is proper without any injury or that pressure sores for amputees and scars should be completely healed or perfect, ie at least three months after amputation.

3. The paraplegic should not have any urinary tract infections, and should have full control of urine and bowel movements, with or without artificial aids.

4. Fullest consideration should be given to the personality of the disabled person; he or she should show self discipline with a full knowledge of his/her abilities and disabilities. He/she should be of steady character with the capability of withstanding anxiety and panic and should also be of a co-operative nature, acccepting orders and directions from instructors without resentment.

5. The disabled person should be an excellent swimmer who participates regularly in intensive swimming including swimming in the sea.

6. He/she should pass physical tests and exercises concerned in preparation for the course and if necessary undergo special physio-therapy training.

7. If the disabled person is a paraplegic, the disability should not have been caused by a spinal bend, by arterio-vascular malformation or by transvers myelitis.

8. It should be made plian to the applicant with partial lesions, from whatever cause, that there is a possibility that diving could make the lesion complete. There is no record of this ever happening, other than with bends cases, but it is a possibility.

Sturges and Clatworthy [2], and Bethune and Menary[3], also conducted courses for people with lower limb dysfunction (five in all), and their courses were based on the work of Flemming and Melamed.[1] The literature detailed course content and method.

Upon review of this literature, the committee considered Flemming and Melamed's [1] points 4 (ie personality), 5 (the need to be an excellent swimmer), 6 (the need to pass physical tests), and 7 (the limits on what caused the original paraplegia), and decided that the risks implied for some of the potential students were not prohibitive but would not be discounted. I might stress here that the committee was breaking new ground as the available literature mentioned above gave guidance on the medical examination and scuba training of eleven cases of amputees or people with lower limb disfunction only.

Thus, the medical assessment of the eighteen hopeful candidates differed from those previously described in published disabled diver courses [1,2,3] in several significant aspects.

Firstly, absolutely no selection of applicants occurred on the basis of previous athletic achievement or independence of mobility. The sole criteria for an applicant to be considered was interest and motivation.

Second, no preconceptions existed that full, unrestricted diving certification of the "successful" candidates was a necessary end point of their training.

Third, people with neurogenic bladder and bowel were included.

Fourth, the group included a range of medical disabilities hitherto regarded as absolute contro-indications to diving, ie brain stem damage, blindness and myelitis.

Consequently, medical decisions conerning diving safety had to be taken in the absence of any known pre-existing guidelines. In the light of the experiences recorded by Flemming and Melamed[1] and recent training in the McMillan-Halliwick methods [4] of teaching the disabled to swim, intra-thoracic trauma did not constitute a reason for automatic rejection on medical grounds. Similarly, neither chest radiography nor air condutction audiometery were regarded as mandatory for this group of recreational divers. Each individual case was dealth with on its merits.

Of the eighteen hopefuls, only one was rejected on medical grounds because of an incompletely healed neck fracture. Seventeen candidates passed their medicals and were regarded as fit to dive subject to assessment by the course psychologist. One of the seventeen was rejected by the committee on the grounds that she was not sufficiently disabled - her sole disability being a congenitally absent hand.

The sixteen disabled candidates that were accepted had medical profiles as detailed on the handout available on request.

In summary, the course started with four persons with head injries, three with some form of special sensory deprivation, four with spinal cord dysfunction and five amputees.

I will not go into details of timings, lessons, etc, as these will come out in our handbook, but sufficient to say that five months later nine of the sixteen candidates completed the open water training programme. Four students withdrew and three were not available for the dive trips.

On the basis of the experience gained in the course, and taking into account the information contained in the previously published courses for the disabled, the Townsville medical team reached the following conclusions:

1. General guidelines presently adopted for the medical assessment of recreational divers appear to serve equally well for the disabled.

2. The medical assessment of the significance of a specific disability in a prospective disabled diver requires knowledge both of diving medicine and diving practice.

3. It would seem advisable not to ask a disabled person to embark on a diving course too early in his or her rehabilitation programme following the injury. Apart from surgical and tissue healing considerations, it is important for the candidate's experience to be overall a postive one, both physically and psychologically.

4. The interpretation of any medical tests requiring a degree of muscular co-ordination needs to be careful and patient with disabled persons with neurological deficiencies. The main risk appears to be underestimation by the doctor.

5. The concept that disabled divers should never be permitted to dive beyond safe no-decompression limits is supported.

6. Because of the complex nature of the problems confronted by some disabled people, especially a head injured person, further investigation is warranted in a person with a history of this type of injury. Follow up of the acute and rehabilitation treatment records is advisable and contact with the appropriate persons involved is recommended.

   In the Townsville project, such persons were actually involved in the project team and their knowledge of three of the head injured students proved invaluable.

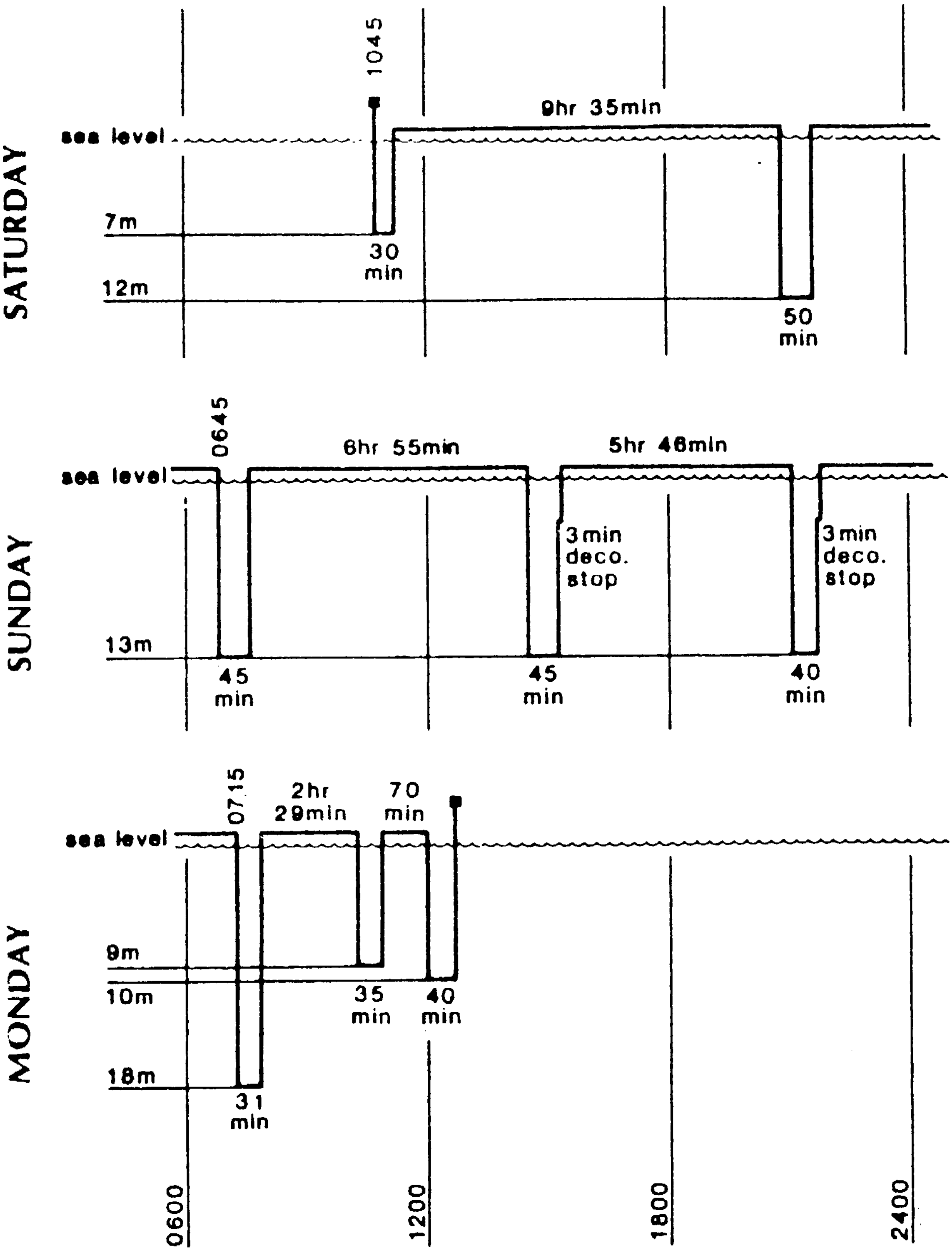
One of the notably enthusiastic students (G.P.) whose medical details are set out in the Table, developed symptoms of spinal decompression sickness about 8 hours after his last dive. He had eight dives over a period of three days and his dive profile is set out. By present sport diving standards this is a relatively conservative profile and is within the limits set by repetitive dive tables presently in common use by sport divers world wide (US Navy Diving Tables). However, the dive profile is less than ideal.

He presented for medical attention 32 hours after the last dive, and 24 hours after the onset of his first symptoms. He had symptoms and signs of spinal decompression sickness involving all four limbs, with those in his lower limbs superimposed on his pre-existing paraplegia. He also had an acute viral upper respitory tract infection, when he presented. In telephone consultation with diving medical officers of the Royal Australian Navy School of Underwater Medicine he was treated vigorously over the next 8 days. This included 5 recompression sessions in Townsville's recompression chamber.

The treatment was successful. He had an area of enlarged numbness on the inner aspect of his left thigh and residual paraesthesiae in the left leg. Other signs and symptoms disappeared during treatment. Six months later no deterioration had occurred.

The committee produced a complete report on the project in 1984.[5] At this stage, the AUF had applied for a further grant to produce a text book guide, based on the results of this course and on the other minimal existing material. The book is designed as a guide to qualified scuba instructors on the problems and techniques of teaching the disabled to scuba dive.

Let me state at this point that the AUF is not setting itself up as an expert in this field. Rather, we are attempting to disseminate the experience and lessons learned during the Townsville courses to as wide an instructor population



Three-day dive profile of the poliomyelitis paraplegic diver who developed spinal decompression sickness. Deco stop = decompression stop; conducted at a designated depth and time, at the end of the ascent but before actually surfacing.

as possible. We are not trying to make judgements, set standards or justify actions, but are hoping that by publishing such a guide we can further the knowledge in this field and, perhaps, stop scuba instructors from turning away a disabled individual who can, with sympathetic help, be taught to dive safely.

We were successful in obtaining a grant for this project from the Department of Sport, Recreation and Tourism, and immediately were obliged to call tenders for the writing and production of the handbook. Unfortunately, for those members of the Townsville Recreation for the Handicapped Special Committee, they were not successful with their tender being beaten by an organisation with a proven record of editorial work and production of diving related publications.

This has in the long run, caused delays in the production of the handbook as the team of writers felt the need to first run a course for some disabled persons in order to get a feel for the subject. Thus, the In Depth Diving Club in Melbourne ran a training programme for some disabled people before the text was started.

We now have the last draft of the textbook which requires only a final polish before publication. When complete, it will be available to all certified national coaching accredited sucba instructors.

Let me finish with two quotes which deal with the vexed question of should we get involved at all with the teaching of the disabled in what is, after all, a risk orientated sport.

First the inevitable question of why teach a blind person to scuba dive in what is basically a visual sport. The report states “The reasons for this person participating in the course were therefore closely examined. At first, it seemed that the main reason for her participation was to prove that it could be done when it was being said that it was impossible or unreasonable”.

“As this (the Everest Syndrome) has been an acceptable motive in many sporting endeavours, it was accepted. As the course progressed, it became obvious that there were more reasons involved. The desire to master enjoyable and complex skills was very much in evidence and the element of enjoyment became the dominating motive. The committee is now aware of the many sensory experiences of diving, eg tactile experiences, weightlessness and freedom.”

And finally a quote from our own Dr Douglas Walker in a discussion on his 1983/84 New Zealand Diving-related Fatalities Report. One of the cases involved a young man with the Wolf Parkinson White Syndrome, who had been advised by his specialist to lead a full active normal life and as a consequence had been a keen scuba diver for over two years. Unfortunately, he suffered acute chest pain during snorkelling and subsequently died of cardiac failure. In his summary Dr Walker states:

“In the case of the unfortunate youth with the Wolf Parkinson White Syndrome there is much to be said for the advice he received that he should choose to live rather than to follow a cautious, fearful existance. Whether scuba diving as such was a critical factor or merely the trigger of the fatal episode is debatable and opinions will reflect each person’s philosophy on life.”

I hope that, should a disabled person approach you with a request for a diving examination you will approach the task with a sympathetic and open minded attitude, and not summarily reject the request and thereby stop an individual from the chance of experiencing our sport.

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In the table of **Medical Profiles** opposite the following apply

* Did not complete course.
VC= vital capacity. FEV = forced expiratory volume in 1 sec. RFT = respiratory function tests.
All respiratory volumes are recorded in litres. Predicted values are shown in brackets.

Medical Profiles

Diver Age Sex	Date and disability	Respiratory function assessment	Comment
Head Injury			
IM 24 M	1980 Brain stem injury	VC 4.0 l (5.6) FEV_1/VC = 83%	Apparent air conduction deafness. Ataxic. Overconfident. Ear equilisation proved difficult. Close supervision advised.
DM 33 M	1978 Brain stem injury	VC 4.7L (5.9) FEV_1/VC = 87%	Severe ataxia. Poor water ability. Highly motivated. A supreme challenge!
*GO 32 M	1981 Brain damage	VC 5.3L (4.8) FEV_1/VC = 83%	Features of frontal lobe dysfunction. Aggressive. Accepted for course (with misgivings) because of extensive diving experience prior to to accident. Subsequently withdrew volunarily from course.
SW 23 M	1981 Brain damage	VC 4.6L (5.0) FEV_1/VC = 83%	Principal disability relates to learning, memory and judgement. Reputured right lung in accident1981. Chest radiography normal.
Special Sensory Deprivation			
TA 15	Congenital deafness (rubella). 1982 Blindness one eye (trauma)	VC 3.9L (4.0) FEV_1/VC = 80%	Very high intelligence and motivation. Speech close to normal. Ear equalisation OK.
RF 18 F	Congenital deafness	VC 3.0L (3.7) FEV_1/VC = 80%	Speech defect. Requires sign language. Confidence and basic understanding seems lacking. Ear equalisation OK.
LT 39 F	Congenital blindness (buphthalmus)	VC 3.3L (3.6) FEV_1/VC = 83%	A real achiever! Full of interest and enthusiasm. Tertiary education level.
Spinal Cord Dysfunction			
BH 25 M	1977 Incomplete paraplegia T12-L1	VC 4.6L (4.7) FEV_1/VC = 82%	Strong personality. Well adjusted. Childhood asthma. Bronchodilators produced no change in RFT. Athletic, very fit. Neurogenic bladder Impaired bowel control.
PM 30 M	Congenital spina bifida L1 Below knee amputation	VC 5.0L 4.2) FEV_1/VC = 80%	Completed previous disabled dive course but was apprehensive in open water. Lacks self-confidence. Requires vision correction. Neurogenic bladder. Partial paralysis of lower limbs
GP 24 M	1960 Poliomyelitis L2	VC 5.0L (4.2) FEV_1/VC = 84%	Long sighted. Wears glasses. Physically strong. Full bladder and bowel control. Partial paralysis of left lower limb.

SS 19 M	1980 Complete traumatic paraplegia below T9	VC 6.0L (5.4) $FEV_1/VC = 86\%$	Upper limbs powerful. Recurrent urinary infections. Urine collection system and partial incontinence of bowels.

Amputees

RB 24 M	1976 Bilateral amputee Left arm above elbow Right leg below knee	VC 4.5L (4.9) $FEV_1/VC = 78\%$	Left leg with fracture deformities but good function. An unstoppable character! Fixed left shoulder joint. Left brachial plexus injury
*PN 25 M	1980 Amputee Above knee	VC 4.6L (5.2) $FEV_1/VC = 80\%$	Numbness right elbow area. Requires equalisation practice and reassessment. Smoker. Dental attention required.
SP 32 M	1981 Amputee Above knee	VC 4.1 (5.0) $FEV_1/VC = 90\%$	Very strong, fit. Regular swimmer and snorkeller. Temporary withdrawal from course to permit reconstructive surgery to amputation stump.
*ER 19	1982 Amputee Above elbow	VC 5.5L (5.4) $FEV_1/VC = 75\%$	Recent amputee. Rehabilitation in early stages. Withdrew from course early.
*KS 34 M	1982 Amputee Through knee Severe leg injuries	VC 4.5L (5.2) $FEV_1/VC = 80\%$	Fit and well adjusted person. Weak scars on legs. Withdrew for social and personal reasons.

ORIGINAL PAPERS

MID WATER AIR EMOLISATION CASE REPORT

Douglas Walker

SUMMARY

The victim was a 13 year old girl making her first open water scuba dive after certification. It was her fifth open water dive. As the dive master on the boat was aware that she was a novice great care was taken in choice of a suitable buddy. While swimming, with the buddy a little in advance, in the mid water zone she was for a short time out of her buddy's view and lost consciousness during this period. This seems to indicate the time when she suffered her arterial air embolism. The condition was clearly demonstrated at the autopsy.

THE INCIDENT

This boat dive was organised by a dive shop to a reef that ran between two off-shore islands. There was a dive master aboard and he was aware that the victim had only just completed her dive course so he selected for her buddy a diver with over three years of experience who had achieved a dive master qualification eleven months previously. The buddy checked their tank contents gauges. When he saw that her tank had 2600 p.s.i. while his had 3100 p.s.i. he told her that when either diver's gauge reading fell to 300 p.s.i. they were to ascend together. He also reminded her of the teaching that if separation occurred there was to be a one minute search before the divers surfaced to rejoin each other. The skipper anchored at the reef and told the divers that the depth below the boat was 15 m, which pleased the buddy as he knew novices should not dive deeper than 18 m.

There was a reaonably strong current so the buddy planned to make a compass dive into the current, which would result in an untiring drift back. When they descended to 15 m. they discovered the sea bed was still far below. The buddy signalled that they should level off, which she managed without requiring any help. He then started the compass course swim. The visibility was good and they could see the sea floor 6-9 m below. The buddy led with the victim close by and he made frequent checks of her condition, exchanging "OK?" signals. He checked his bottom time and saw that 10 minutes had elapsed, then looked round and saw the victim above him, one arm held up in the manner adopted when about to reach the surface. He swam to her and saw that her regulator was out of her mouth and there was a green liquid pulsing from her mouth: He thought this was vomit but later realised was blood. He placed his own regulator in her mouth, and commenced using his reserve regulator, trying to keep it at the side of her mouth to allow escape of the apparent vomit. While he was doing this they sank down to the sea floor, at a depth of 27 m. He was uncertain whether she was conscious or not at this time. He brought her to the surface with her head back, the standard procedure he had been taught. He observed that there was no sign of breathing and that it was blood, not vomit, emerging.

As soon as he surfaced he gave a distress signal, which was quickly acknowledged from the boat, which was about 50 m away, then inflated her buoyancy vest and started to tow her. The divemaster had ditched his gear and dived in from the boat as soon as he saw the need for assistance. When he reached them he noticed the pink froth at the victim's mouth, then ditched her weight belt and took over the towing while the buddy gave EAR as he swam alongside. On examination in the boat no pulse or breathing was noted. CPR was started and this was continued during the return trip, death being formally declared when they reached the wharf. She had been scuba diving for 14 minutes before being brought to the surface, dead.

The autopsy was correctly managed. X-ray films of both head and chest were taken before commencing the internal examination. Air was shown in the heart chambers, especially the left ventricle, and in the aorta, and possibly in the pulmonary arteries. There was no pneumothorax. The lungs appeared dense. Air was present in the arteries of the Circle of Willis at the base of the brain. These findings support a diagnosis of cerebral arterial gas embolism (CAGE), so her loss of consciousness is readily explained. The blood vessels on the surface of the brain contained many small bubbles. Both of the lungs showed marked oedema and the posterior visceral pleura showed petechial haemorrhages consistent with anoxia. The trachea and bronchi contained slightly blood-stained foam consistent with drowning. There was no obvious area of lung rupture indicative of major barotrauma. Histology revealed the presence of a widespread intra-alveolar extravasation of blood. Such would not be expected in simple drowning.

DISCUSSION

The critical path of this tragedy included several adverse factors and these became greater in their influence on the course of events than the positive factor of having a well trained buddy who attempted to maintain good contact with the victim. There may be doubt about the wisdom of certificating such young persons but no details are available concerning the emotional maturity of the victim, a factor of importance in a discussion of this matter. Of most immediate effect on this dive was the factor of being in mid water far above the security of a nearby sea bed. It was only her fifth open water scuba dive so it is probable the situation would be stressful, particularly as she was swimming against the current and trying to keep close to her far more experienced buddy. There was indeed frequent “OK?” check contact but, as the buddy told the coroner, no buddy keeps constant sight of his companion as he will on occasion look at the underwater scene and check his own gauges. The fact that he was swimming a little ahead of the victim was an adverse factor. There is uncertainty concerning the time for which the victim was out of his sight, but the fact that she was not far from him and above him implies that it cannot have been long as otherwise his swimming would have put him far ahead of her. So it is unlikely that she had time to ascend far before she lost consciousness and started to sink.

It is obvious that even the presence of a careful buddy is not a complete safeguard for a novice diver swimming in the never never depth of mid water in the open sea. Once again air embolism has been shown to occur without the victim (apparently) ascending a significant distance and without coming to the surface.

THE RIGHT TO DIVE, A CASE STUDY

Douglas Walker

SUMMARY

For sheer determination, albeit misdirected, the victim of this incident must be awarded full credit. He was not only overweight with extremely poor sight but had suffered from an accident which so scarred his forehead it made obtaining mask sealing difficult. In addition he had a medical history which he partially suppressed. A consideration of his contacts with a series of medical practitioners and conscientious, reputable diving instructors forms the core of this report. None of the latter regarded him as fit for certification, all informed him of this fact, and on the fatal dive he was being “specialed”, a degree of supervision given only to disabled persons having a visit to the underwater world but not regarded as being scuba divers. That he died was probably not a consequence of diving but rather an event which could have occurred at any time. But he was diving at the critical time and the efficient response of the instructors illustrated the value of the training they receive and the responsibiient response of the instructors illustrated the value of the training tncommon fact of an autopsy report which disregarded relevance to the circumstances. This was made almost unavoidable by the practice of including only minimal information to the pathologist performing an autopsy. An additional element was the presence as an “expert witness” of a representative of a government department. His evidence, as has been the pattern in previous instances where there has been a similar assistance offered to a Coroner, was based very firmly on an interpretation of the Diving Law and had minimal relevance to the actual circumstances of the case. The report is divided into sections dealing with the diving instructors, the actual incident, the medical examiners, and the pathologist reporting the autopsy. Throughout there is The Pupil, a victim of his medical problems but struggling to achieve his aim, the freedom of scuba diving.

THE PUPIL/INSTRUCTOR INTERACTION

Joe first attempted to obtain entry to a scuba course in 1983, presenting a medical certificate which mentioned this was a “conditional approval”. It is not known what conditions were stated. This particular dive shop had a policy that each pupil must be unconditionally fit and he was told to obtain a further medical check. He returned in November 1984 but again the medical approval was “conditional”. When he was examining brochures about the course he was noted to hold them close to his eyes in order to read them. The instructor therefore felt that if the applicant ever returned carrying a certificate to state he was medically fit he, the instructor, would demand his further assessment, by a “diving” medical practitioner.

In April 1985 he attended the first lecture of a dive course run by another dive shop. He was instructed to bring a medical fitness certificate and the staff noted his extremely poor sight, excessive weight, and a deformed forehead which had the effect of making it difficult to fit a mask. He was noted to hold a paper 4 inches from his eyes to read it. The diving instructor spoke to him after the second lecture, pointing out to him that diving was not in his best interests and would be a safety risk not only to himself but to others. He got quite upset and stated it was unfair, that he had a right to choose whatever he wanted to do. He brushed aside the suggestions of alternative sports he might undertake. It was agreed he could attend the first pool training. It was with difficulty that a suitable wet suit was found, and the size of his abdomen was a problem in finding a weight belt. The pool was only 4 ft deep and the day sunny but he was unable to read the gauges or his diving watch. He seemed slow to learn and it was difficult to obtain a water tight seal for his mask. He appeared to accept the verdict that he discontinue the course but arrived at the next lecture. He was again told he was totally unsuitable for scuba diving and a danger to himself and others, was spoken to at some length of the problems of scuba diving, even told that he was a candidate for a heart attack, and offered a refund if he attended a diving medical centre and brought a certificate stating he was “unfit to dive”. The instructors were entirely confident such a certificate was appropriate. Then he claimed the right to attend the remaining lectures as he had paid for the course. He was not allowed to sit the written examination at the end of the lectures, a precaution designed to prevent a later attendance at another dive shop claiming to he required only the practical portion of a course. He produced a medical certificate of fitness for scuba diving at the first lecture, this so surprising the instructors that they checked that the doctor existed as they could not believe a doctor could reach such a conclusion!

This did not quench his determination to learn how to scuba dive and in May 1985 he got a friend to enquire whether a diving instructor he knew would accept as his pupil someone who had poor eyesight and was keen to dive: he received back a message that such a person might be allowed to dive if he was accompanied by a person with good sight. A week later he made contact by phone with this instructor and said he had already completed the theory and pool work of a course but the diving school then seemed not interested in completing his training. He was told he should bring a medical certificate and said he would get one, that his original certificate and documentation of his course had been lost by the dive shop concerned. There was an impression conveyed that his poor sight was the reason for his problems with the former instructor.

In June 1985 he attended for instruction bringing the necessary medical certificate. He was seen to be a large man with deformed eyes and "was possibly somewhat overweight". The instructor who supervised his first pool dive noted there was no sight in one eye, poor sight in the other. This made use of hand signals almost impossible. He was also clumsy. Despite a full awareness of these adverse factors one instructor allowed him to attend two shore dives but attended on him personally, a one-to-one care. He was found to have no problems with mask clearing but to be clumsy in the water. Throughout these dive lessons the instructor maintained hand to hand contact. After this he failed to attend until April 1986 because he had been injured in a motor cycle accident. No details of his injuries are recorded, neither is it explained how he managed to obtain a motorcycle licence. He was allowed to resume his attendance at the training dives, making two shore based dives and a boat dive before the index dive. Maximum depth of the dives was 10 metres and he was closely supervised because he tended not to stay with the diving group but to wander off by himself.

THE INCIDENT

On the morning of the fatal dive the chief instructor discussed with the instructor and assistant instructor due to take the group of pupils for this dive the need to take extra care in watching Joe. He intimated that, although he might not be granted certification, because he was so keen to scuba dive he would be permitted to continue attending dives at which an instructor was in charge. At no time did the instructors have any significant reservations concerning Joe's health although well aware of his obvious visual problem.

There were eight students on this boat dive under the supervision of an instructor and an assistant instructor. The skiper and the boat hand remained on board through the dive. The instructor entered the water first, collecting everyone in a group as they entered the water after an equipment check by his assistant. Joe was the last pupil to enter the water, then the assistant joined the group and was detailed to buddy Joe. Before commencing their descent they allowed the seven divers with the instructor to descend, then they followed after their first descent was aborted at 4 ft depth because Joe needed to resurface to clear his mask. After reaching the bottom of the anchor line they swam to join the others, and Joe managed mask clearing calmly after knocking his own mask off. His contents gauge was checked by his buddy and the pair then swam over to a rock ledge to cllect sea urchins to feed to the fish, about 15 to 20 feet distance. Here Joe gave a thumbs-up signal that showed he wished to surface and his buddy, who maintained hand contact with Joe from the time of his sea bottom mask problem and was now facing him, tried to find the reason for this wish to ascend. Although the buddy did not discern signs of panic, one of the other divers reported that he was breathing rather rapidly at this time, a sign of agitation. His weight belt now slipped down to his hips and despite his efforts and the help of both instructors it could not be replaced round his waist. The instructor had noted on previous dives Joe's shape caused his weight belt to fall down over his hips but only before he entered the water. This was the first time that it had caused any problems during a dive.

The instructor decided that to get Joe to the surface safely his weight belt had to be retained, so he allowed it to descend as far as Joe's knees, which he had flexed and thereby prevented it from falling off. Both he and the buddy now took hold of Joe and, their buoyancy vests inflated, by finning hard slowly brought him to the surface. Joe was able to calmly deflate his buoyancy vest as needed during the ascent although, for obvious reasons, he was unable himself to fin. Once at the surface the instructor let go of Joe's legs to permit them to straighten and so allow the weight belt to fall free. Instead it caught on his fins, but this created no problems as both of the instructors were with him and his buoyancy vest was inflated. The instructor checked that the buddy could now manage before he descended to rejoin the other pupils. He checked all their contents gauges, brought up one who was getting low on air, and then made a final descent to bring up the remaining six pupil divers. They were instructed to inflate their buoyancy vests, then he escorted them back to the dive boat.

The buddy noted that Joe appeared to be tired but did not foresee any problems in him back to the dive boat 100 feet away. His contents gauge showed that he still had 1000 psi of remaining air. As a precaution the boat hand was summoned and he helped support Joe while the buddy duck-dived and released the weight belt, then he towed him back to the dive boat where the buddy instructed Joe to hold onto the side of the boat as the boat hand boarded the boat and the buddy removed his back pack. He was helped into the boat and orders given for him to be placed in the recovery position and his breathing checked: the buddy was told he was all right but found a short time later, after coming aboard, that he was not answering questions which were directed to him, only groans being elicited, and there was an apparent deterioration occurring in his breathing.

A radio call for emergency medical assistance was now made, then his condition rapidly worsened and breathing ceased but resumed after he was placed on his back in preparation to commence mouth-to-mouth resuscitation so they rolled him back into the recovery position. There was fluid escaping from his mouth. His breathing again ceased and expired air resuscitation was commenced, which was applied in turn by several of those present. The dive boat took the victim to shore as soon as the Coast Guard boat came and picked up the pupil divers. Cardiopulmonary resuscitation resuscitation was kept up during the return to land where paramedics waited to continue resuscitation attempts, but these were unavailing. A doctor in the dive group diagnosed the cause of the fatality as being a myocardial infarction with cardiac arrest, not an air embolism or diving-related illness. The maximum depth was 15 m and the duration was 20 minutes. Visibility was at least 15 m.

THE APPLICANT AND THE DOCTORS

The several medical certificates he had obtained were produced at the inquest. They showed comments on the presence of poor sight, an old middle ear infection (no other details), poor vision, and mild hypertension (Nov. 1983, 140/90 and in Nov. 1984 150/95). His statement concerning of his previous health added nothing to this. When he was examined in December 1984, his first attendance on this doctor, he had BP 150/90 but this had fallen to 140/90 when seen two weeks later after taking a Betaloc 50 mg tablet once daily. It was then that he requested a Fit to Dive certificate. When his poor visition was mentioned he assured the doctor that he would be diving with a group of partially sighted people and would be under close supervision at all times. This statement was accepted. He had no problems with his ears or chest and denied having suffered from asthma or other respiratory complaints. A chest X-ray taken 15th May 1985 was reported as being completely normal. However it came to light during the investigation that his regular doctor had refused to provide a fitness certificate in December 1984, but could not recall why although he reported that the victim was in receipt of a blind pension, had been injured when a car hit his motor cycle, and attended frequently for Mogadon and Valium scripts, being addicted to these preparations. He attended the Allergy Clinic of a major hospital and suffered from migraines, eczema, allergies, and obesity. He developed an allergic wheeze particularly to redwood in January 1983 and suffered a severe asthmatic episode in March 1985, and again in November 1985, on the second requiring hospitalisation. His asthma in December 1985, was considered by this doctor to be mild and not to be a contraindication to recreational diving. He had suffered from further asthma since November 1985 for which he required oral steroids. Not surprisingly Joe was far from frank when he was asked about his health record.

PATHOLOGICAL OPINIONS

The pathologist who conducted the autopsy noted there was evidence of myocardial infarction, coronary artery atherosclerosis and hypertensive heart disease but decided that the death resulted from drowning. The coroner called a RAN diving medicine specialist to give evidence and he, tactfully, made it clear that the history and the findings both indicated little basis for the drowning diagnosis. On reflection, therefore, one of the colleagues of the pathologist admitted that it was the practice to provide the pathologist with only minimal details of the cases. This is the probable reason for autopsy reports which blandly assume asphixia results when a scuba diver runs out of air underwater. The coronary vessels were all involved by atherosclerosis but narrowing never appeared to exceed 40-50% at worst. Microscopy showed a slight increase in fibrosis within the ventricular wall. Areas of increased eosinophilic staining of myocytes were found, cardiac stains confirming the presence of widespread ischaemic changes with some areas that showed focal changes with lymphocytic infiltrate. The changes were taken to indicate he had suffered an undiagnosed cardiac infarct a couple of days before this dive with ischaemia such that cardiac decompensation occurred when there was need to support the increased physical demands which result from the restrictions of a wet suit and buoyancy vest, weight belt and back pack. Both the lungs were described as heavy and congested, with fluid flowing quite readily from the cut surfaces: there was no focal abnormalities to be seen and microscopy showed a congested, oedematous lung. No mention was made of any changes suggestive of asthma.

THE VOICE OF AUTHORITY

A representative of a government department which had responsiblity for commercial diving was also called to offer expert advice to the coroner. He had in previous times been a RAN diving instructor and admitted that the department wished to apply Australian standards to sport diving and implied the dive charter boats were irresponsibly managed, failing to have oxygen aboard or to check the training of the divers who they carried. Neither point was relevant in this case. He appeared to have a strong belief that regulations necessarily increase safety, but presented a valid argument that diving instructors would find it far easier to refuse an unsuitable applicant if it was possible to say "The law does not allow me to instruct you to dive as you have failed the medical fitness standard". As in this case the applicant showed no signs of respiratory, or cardiac, inadequacy when examined, and concealed his medical history, it was not necessarily unreasonable for these doctors to consider him fit to dive, subject to careful supervision in view of his poor vision. The significance of the obesity when deciding on fitness to dive is far from defined, although easy to assume the reverse. Alexander Lambert was famous for feats of daring diving in the days of Fleuss and Siebe Gorman diving suits but was also known for his beer belly. Although all subscribe to generalities concerning medical fitness for diving, when it comes to particular cases there are likely to be many where a serious division of opnions will be found. Indeed the victim made it plain that he did not wish to accept any advice which said he was unfit, and his death could have occurred regardless of his chosen activity.

INQUEST FINDINGS

There was some criticism directed at the dive shop as there had been no attempt made to contact the persons who the victim stated had provided him with the theory training. This was valid criticism but irrelevant because of the decision to provide one-to-one in-water attention and to refuse him scuba certification. It was noted that while both instructors were assisting the victim to ascend their other pupils, unattended, remained on the sea bed. But these pupils were far into their training, the visibility was good, the emergency real. Possibly all should have ascended together but this would have been an unsupervisable ascent. The victim had successfully taken part in previous dives with the same instructor support and diving companions and nobody regarded him as a candidate for a heart attack. The cause of death was acute cardiac failure two days after a (presumed) "silent" myocardial infarction and occurred despite excellent supervision and care by the instructors who were present.

DISCUSSION TOPICS

1. How great a freedom should a person be permitted to follow some activity for which they are not fully physically fitted. This question must be faced by medical examiners, those having the responsibility of training, those who accompany them later and insurers of any of these. A person cannot be permitted to put others at risk (or undue expense?) through his activities and there must be a protocol to prevent risk of legal actions being taken subsequently by relatives should death occur.

2. Is the level of medical expertise expected the same from a doctor without a special knowledge of diving medicine as from one so trained.

3. Should it be mandatory to have a diving medical from those doctors only who have obtained special training in connection with diving medicine.

4. What evidence is there that such medical examinations play a significant part in increasing diving safety.

5. Many instances will arise where the decision on fitness to dive will be debatable (such as in diving for the disabled). Who is to give a deciding opinion in such cases. How certain are the criteria of fitness, how high a "medical guarantee" is beling claimed. In this case neither his obesity nor a history of asthma was relevant to his death, and careful management by his instructors saved him for drowning.

6. Should pathologists be better informed of the case history before performing and reporting on an autopsy or would this too influence their conclusions. Do they require reminding of the need for considering the implications of their findings.

7. Should expert witnesses be expected to directly relate the opinions they offer to the actual incident under examination.

8. Can fitness standards be defined with absolute certainty or can conditional grades be permitted.

9. As the analysis of cases had demonstrable value will you in future report diving-related information to the DIVEDATA PROJECT (Project Stickybeak).

PROJECT STICKYBEAK

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

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

ARTICLES OF INTEREST FROM OTHER JOURNALS

THE NO-PANIC SYNDROMES IN UNDERWATER DIVING

Michael B. Strauss and Stephen L. Shane

SUMMARY

The no-panic syndromes probably account for more deaths in breath-hold dives than any other cause. The primary characteristic of the no-panic syndromes is the rapid loss of consciousness under water without warning, panic, or a struggle for air. This article reviews the pathophysiology of blackout and lists more than a dozen aetiologies. It is important to determine the cause of every underwater blackout so that the diver can be treated properly.

The no-panic syndromes are a diverse group of medical disorders in divers that receive little attention in standard diving medicine references.[1-13] Their primary characteristic is rapid loss of consciousness under water without warning, panic or struggle for air. The syndromes tend to occur in experienced divers who use special techniques to extend their diving times and depth limits (Table 1), but there are more than a dozen syndromes, depending on the cause and the type of diving equipment used. This paper reviews the no-panic syndromes and discusses predispositions, pathophysiology, and prevention.

TABLE 1

Diver predispositions for No-Panic Syndromes

Experience	Poor conditioning
Hyperventilation	Challenging dives
Breath-holding	Special equipment

Loss of consciousness in the water is always serious, because clinical death may occur in seconds. Without rescue and resuscitative measures, biological death will follow shortly. If panic precedes the loss of consciousness, there is usually evidence of struggle or righting procedures, such as a released weight belt, an inflated buoyancy compensator, or a bared knife.[4] In the no-panic syndromes there are no such signs, and the most deaths of this sort are unfortunately attributed to drowning. Consequently, statistics on the syndromes are imprecise.

PATHOPHYSIOLOGY OF BLACKOUT

Cerebral hypoxia from hyperventilation is the most frequent cause of loss of consciousness in the syndromes. Normally, hypercapnia determines the breath-hold break-

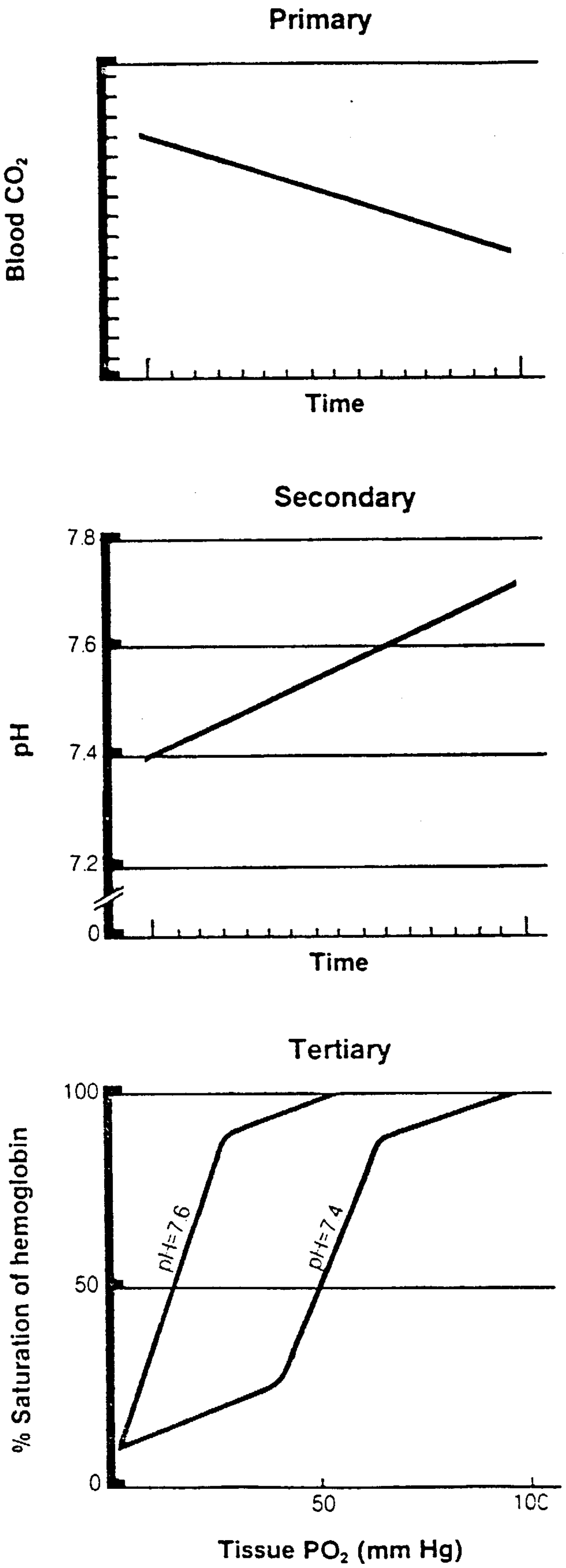

Figure l.
Primary, secondary and tertiary effects of hyperventilation

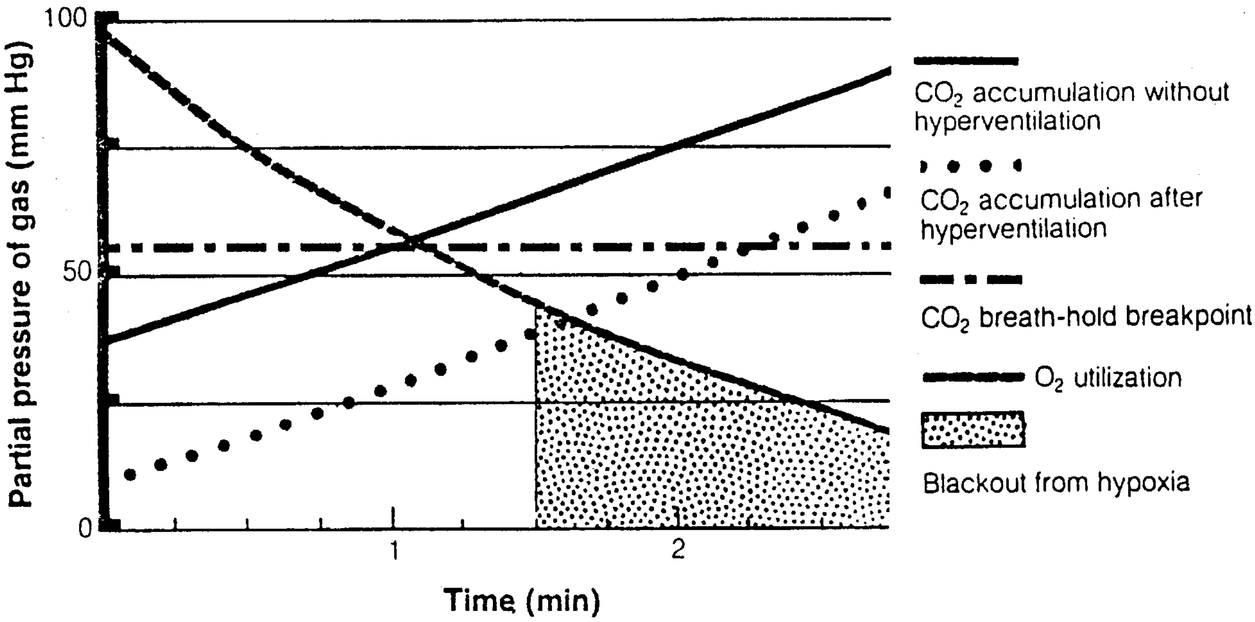

Figure 2. In breath-hold without hyperventilation, the breakpoint occurs before blackout. After hyperventiliation blackout occurs before the breakpoint.

point, i.e. the carbon dioxide (CO_2) level that stimulates a diver to breathe. If the diver hyperventilates, CO_2 levels decrease and alkalosis developes as CO_2 is blown off. This causes vasoconstriction and a leftward shift of the oxyhemoglobin dissociation curve. Blood oxygen (O_2) stores are not improved. The tertiary effects of hyperventilation make O_2 delivery less efficient (Figure 1). As the hyperventilated diver breath- holds, the brain and other body tissues use the O_2 stored in the blood, and CO_2 accumulates; however, because of hyperventilation the starting point of the CO_2 accumulation curve is so low that the diver loses consciousness from cerebral hypoxia before CO_2 levels reach the breath-hold breakpoint (Figure 2).

The second most frequent cause of blackout in divers is cerebral hypoperfusion of either cardiac or vascular origin. Even brief interruptions in cerebral blood flow can cause loss of consciousness: Adams- Stokes syndrome, vasovagal syncope, and Valsalvic- hyperventilation blackout are examples. Poor conditioning, age and underlying cardiovascular disease predispose divers to cerebral hypoperfusion blackout. The tertiary effects of hyperventilation also contribute to cerebral hypoperfusion. Because of the rapid onset, loss of consciousness occurs without warning.

Hypothermia, drugs, nitrogen narcosis, and carbon monoxide exposure are other causes of loss of consciousness in divers. They depress cerebral function and may cause the diver to become oblivious to impending danger or blackout.

AETIOLOGIES OF NO-PANIC SYNDROMES

The no-panic syndromes and their aetiologies are summarized in the Memory Jogger.

Breath-Holding Blackout

This exemplifies the no-panic syndromes.[5,6] In the past this problem was called shallow-water blackout;[7] but since that term originally referred to blackout caused by CO_2 accumulation with rebreathing equipment, breath-holding blackout is preferred.

A typical scenario in breath-hold blackout is the same as the cerebral hypoxia mechanism with hyperventilation: The diver intentionally hyperventilates to extend breath-hold time. The starting point of the CO_2 accumulation curve is lowered. The diver begins to dive preoccupied with a goal or distracted by the underwater environment. As the breath-hold continues, O_2 stored in the blood is used while CO_2 accumulates. However, because of hyperventilation and the lowered starting point of the CO_2 accumulation curve, unconsciousness from hypoxia occurs before CO_2 reaches the breath-holding breakpoint (Figure 2). The loss of consciousness occurs without warning or air hunger. Once the person is unconscious, spontaneous respiratory movements resume and drowning may result.

Distractional Blackout

Distractional blackout is a variation of breath-holding blackout. It represents an intermediate situation in which the diver is near the breath- holding breakpoint but

MEMORY JOGGER

Aetiologies of the No-Panic Syndromes

	Breathing Method			Experience Level		
	Breathhold	Open-Circuit	Mixed Gas	Inexperienced	Experienced	Comments
Hypoxic						
Breathhold	X				X	The prototype
Distractional	X			X	X	A variant of breath-hold blackout
Diffusional	X				X	Deep breathhold dives
Dilutional			X		X	CO_2 absorbers
Valsalvic		X	X	X		Skip breathing
Tank		X	X	X		Rusted tanks
Cardiovascular						
Cardiogenic	X	X	X	X		
Carotogenic	X	X	X	X		Tight hood
Narcotic						
Carbon monoxide			X	X	X	X
Narcotic	?	X	X		X	Nitrogen narcosis
Drug	X	X	X	X		
Hypothermic	X	X	X	X	X	
Miscellaneous						
Vasovagal	X	X	X	X		Fright
Concussive	X	X	X	X	X	Head trauma

voluntarily delays surfacing because of preoccupation with the underwater environment. The diver continues breath-holding to the breakpoint, then bolts for the surface. Hypoxia may cause loss of consciousness during the time required to swim to the surface.

Diffusional Blackout

Diffusional blackout is another variation of breath-holding blackout and occurs in deep breath- hold dives because of the effects of increased ambient pressure on the gases retained in the lungs. During descent the lung volume decreases in accordance with Boyle's law. This concomitantly increases the partial pressures of the gases in the lungs. For example, at a depth of 66ft (3 atmospheres absolute), the partial pressure of O_2 in the lungs is three times that on the surface. Since alveolar capillary O_2 diffusion is a function of O_2 partial pressure, there is increased alveolar O_2 diffusion at this depth compared to the surface. However, during ascent the reverse process occurs, and alveolar partial pressure of O_2 may drop so low that O_2 diffused from the blood to the alveoli. Blackout then occurs from cerebral hypoxia.

Dilutional Blackout

Dilutional blackout refers to situations in which divers lose consciousness from hypoxia because of mechanical failure or technical errors in setting up closed or semiclosed-circuit diving systems that use CO_2 absorbers. The inert gas is rebreathed while O_2 is added at the approximated rate of use. Hypoxia may develop if oxygen is added too slowly because of miscalculation or equipment failure. This will lead to unconsciousness without warning or air hunger since the CO_2 in the system is being removed by the scrubber.

Valsalvic Blackout

Valsalvic blackout is also associated with the use of scuba gear. In this type of blackout the diver "skip breathes" in order to conserve the air supply. Skip breathing refers to the technique of delaying breathing until the breakpoint is nearly reached, exhaling explosively, and then inhaling deeply. Exhalation increases intrathoracic pressure, which reduces venous return and cerebral perfusion. If the diver is near the blackout point, the reduced return and perfusion can lead to blackout. Scuba regulators with abnormally high exhalation resistance compound the Valsalvic effect, further delay inspiration, and increase the likelihood of the diver blacking out.

At one time skip breathing was advocated as a method of conserving air supply. Divers in training were graded on the basis of how much air they "conserved" during the dive. Fortunately, this potentially harmful practice has been curtailed in scuba training.

Tank Blackout

Tank blackout is a third type of blackout associated with scuba gear. If water gets into a steel tank, and the tank is stored with air in it, the inside of the tank rusts. The oxidation process depletes the O_2 content of the air in the tank. When the tank is used the diver breathes a hypoxic mixture. CO_2 does not accumulate since it is exhaled via the open-circuit regulator. Blackout occurs as the brain's O_2 supply progressively decreases because of the hypoxic gas mixture in the tank. Deaths from this mechanism have been reported.[8,9] Divers should follow all tank safety procedures regarding storage, filling, and inspection in order to prevent this type of blackout.

Cardiogenic Blackout

Cardiogenic blackout refers to loss of consciousness from cardiac dysfunction, such as arrythmia or infarction. Stress factors associated with diving, such as hyperventilation, breath- holding, cold-water immersion, vasoconstriction, and vasovagal reflexes may also cause arrhythmias in the sensitive myocardium.[10] The most stressful part of a dive is usually donning the gear and the initial immersion in water. Cardiogenic blackout is most likely to occur in poorly conditioned divers and is a diagnosis of exclusion.

Carotogenic Blackout

Carotogenic blackout or carotid sinus syndrome, is included as a no-panic syndrome even though a diver is likely to experience symptoms before blackout occurs. This problem results from wearing a hood that fits too tightly. Symptoms of nausea, dizziness and light-headedness develop shortly after putting it on. These symptoms can progress to unconsciousness if the hood is not loosened or removed. Once the hood is removed, the symptoms spontaneously disappear.

The mechanism is presumed to be that the tight-fitting hood causes excessive pressure on the carotid sinuses. This in turn causes excessive stimulation of the sinuses and their associated autonomic responses. Another theory is that the tightness of the hood causes venous congestion of the brain.

Carbon Monoxide Blackout

Carbon monoxide (CO) poisoning is another possible aetiology for blackout in divers. Although this problem is rare, it must be considered whenever a diver is found unconscious after breathing compressed gases. In such cases, gas supplies must be checked for CO. Malfunctioning compressors and surface-supplied diving rigs that draw their air supply to near the engine exhaust are possible ways that CO can enter a compressed gas supply.

Narcotic Blackout

Narcotic blackout refers to blackout from nitrogen narcosis, which results from descending too deeply while breathing compressed air. Nitrogen breathed under pressure acts like a narcotic agent. Euphoria frequently precedes the blackout, and the diver may make foolhardy moves or may become sleepy. The depth at which a diver experiences narcosis, varies with experience, physical condition, type of diving equipment used and the diving conditions.

Drug Blackout

The effects of increased hydrostatic pressure on medications are largely unknown, and this may be a more important cause of blackout in diving than previously realised. For example, stimulants under pressure show reversal effects in animals.[11] Diving in warm water immediately after smoking marijuana has caused sleepiness.[12] Anecdotal reports indicate that in some divers the use of vasoconstrictor-anti- histamine combinations and antiemetics made them so sleepy that they could not continue to dive. Alcohol lowers the threshold for narcotic blackout and has been implicated in 50 per cent of drowning deaths in the United States.[13] Diabetics using insulin may experience hypoglycemia if they fail to anticipate the exertional requirements of the dive. Tricyclic antidepressants occasionally cause arrhythmias. Individuals who require these medications should be discouraged from diving. If diving accidents occur, the diver's medication use should be checked as a possible contributing cause.[14]

Hypothermic Blackout

Exposure to cold water rapidly lowers core temperature, especially in the absence of thermal protection. The discomfort of the cold water is soon replaced by dullness as core temperature declines or hypoglycemia depletes energy stores. Progressive obtundation of the sensorium leads to loss of consciousness. Cardiac arrhythmias may develop as the core temperature approaches 33.3°C (92°F). At 17.8°C (88°F), respiratory function ceases because the respiratory control centre of the brain is depressed.

Vasovagal Blackout

Although not documented in diving, this aetiology for blackout is listed because its counterpart exists on land. Divers may encounter many frightening situations, including sighting a shark, becoming lost in a cave, surfacing in the pathway of an oncoming vessel, or being bumped by a marine animal in murky water. Individuals subject to vasovagel syncope could blackout from such experiences and be found unconscious in the water. The tentative diagnosis would be drowning or near drowning, and the underlying cause of the blackout could be established only if the victim recalls events preceding the blackout.

Concussive Blackout

Concussive blackout refers to loss of consciousness in water because of concussion. Head trauma to divers can occur from falling equipment or ascending under a boat or fixed object. In these situations, physical examination should indicate the cause of blackout. The immediate loss of consciousness qualifies concussive blackout as a no- panic syndrome.

Arterial gas embolism and oxygen toxicity can cause rapid loss of consciousness in divers and therefore could be considered no-panic syndromes. However, loss of consciousness is usually preceded by panic and struggling in arterial gas embolism and tremors, anxiety, and visual field narrowing in oxygen toxicity, so these disorders will not be discussed further.

TREATMENT OF NO-PANIC SYNDROMES

There are similar aspects in the management of the no-panic syndromes, since almost all cases present as drownings or near drownings. The first step is rescue. The second step is basic life support at the dive scene. The third step is transportation to a medical centre while life-support measures are continued, the fourth is advanced life support, and the fifth is instituting specific therapies. Remarkable recoveries have occurred after near drowning.[15] The absence of struggling present in the no-panic syndromes may conserve oxygen and improve the chances of recovery. Syndromes requiring specific therapies are as follows: stopping the dive and breathing surface air corrects dilutional, Valsalvic, and tank blackout; removing the tight-fitting hood corrects carotogenic blackout; and rewarming corrects hypothermia. Hyperbaric oxygen is useful for treating CO poisoning, and surgery may be necessary for subdural or epidural bleeding. Finally, recompression must not be overlooked if the victim used compressed gas during the dive and decompression was omitted.

CASE REPORTS

Case 1

A well-conditioned 16-year-old swimmer attempted a new underwater swim record. He hyperventilated until his hands and toes were numb. He easily exceeded his old record but lost consciousness a few moments later while still swimming. A swim buddy immediately rescued him and he regained consciousness without sequelae after a few moments of coughing and retching. In this case, the numbness indicated that hyperventilation made the diver alkalotic. The CO_2 level was so low after hyperventilation that blackout from hypoxia occurred before CO_2 accumulated sufficiently to signal the diver to surface and breathe.

Case 2

A certified scuba diver in his 30s was diving with two buddies. He had practiced skip breathing on previous dives and told his buddies he wanted to save his air supply. The diver became separated from them and was found dead on the bottom approximately two hours later. There was no evidence of struggling or self-correcting measures: he still clenched a pry bar and shell-collecting bag, had his weight belt in place, and had not inflated his vest.

A post-mortem investigation revealed no apparent cause of death, including coronary occlusion. He had used less than one third of the air in his tank. The gas supply was pure. The death certificate was signed out as a drowning. However, a check of the victim's regulator revealed high exhalation resistance. This finding, coupled with the victim's comment about skip breathing, suggests that Valsalvic blackout was the cause of his loss of consciousness and death.

Case 3

A 24-year-old man was swimming at a depth of 10 ft with a closed-circuit pure oxygen (Emerson) diving rig. A few minutes into the dive he lost consciousness. He was brought to the surface by his dive buddy, and consciousness returned immediately. The diver recovered without sequelae. Inspection after the dive revealed that the gas cylinder had been filled with air rather than pure oxygen and the blackout was caused by hypoxia. This case is a classic example of dilutional blackout. The scrubber removed CO_2 from the breathing circuit. The gas flow rate calculated for pure oxygen was insufficient to maintain consciousness when air had accidentally been substituted. In the absence of CO_2 accumulation the diver had no warning of an impending problem.

Case 4

An inexperienced, poorly conditioned scuba diver in his early 50s was swimming through the surf zone in a training dive when he suddenly lost consciousness. Although the victim was rescued and life-support measures were instituted on the beach, he subsequently died. The death was signed out as drowning, although coronary artery disease had been noted on post-mortem examination. This diver's loss of consciousness was likely the result of cardiogenic blackout. The stresses of suiting up, passing through the surf zone, and becoming acclimatised to the relatively cold water, probably precipitated arrhythmias or coronary vasospasm.

Case 5

A 25-year-old man wore a borrowed neoprene wetsuit jacket and hood while scuba diving. He surfaced and complained of feeling uncomfortable and seasick.

When his symptoms quickly progressed to headache and light-headedness, he terminated the dive. His symptoms disappeared immediately after removing the hood. This diver exhibited all the signs of a carotid sinus syndrome that did not progress to blackout.

DISCUSSION

When a diver loses consciousness in the water, drowning is inevitable unless the diver is quickly rescued and resuscitated. The underlying cause for the loss of consciousness must be established to ensure the most effective treatment and to improve the reliability of statistics regarding loss of consciousness in water. Systematic investigations and deductive reasoning are often required to establish the aetiology. Drowning or near drowning should be secondary diagnoses.

The no-panic syndromes can interact to make the victim more susceptible to underwater blackout than would otherwise be expected. For example, if a breath-hold diver hyperventilates to extend diving time and becomes distracted by the underwater environment, then ascends (adding the diffusion variable), all three factors interact in the blackout. Alcohol and sedatives lower the tolerance to nitrogen narcosis and make divers more susceptible to hypothermia. Tank, carotogenic and cardiogenic blackout are prone to occur in divers who dive infrequently, are in poor condition, and do not maintain or inspect their equipment properly.

The most effective way to deal with no-panic syndromes is to prevent them. Divers must be aware of them and of their predispositions. Breath-hold dives should be timed so that ascent is completed before the breath-holding breakpoint or hypoxic blackout is reached. Fitness must be maintained. Diving should never be done when the diver is under the influence of drugs. A dive plan, brief and equipment inspection should precede each dive. Finally, the buddy system must be used throughout the dive. In most instances the diving buddy is the only person who can prevent the disastrous consequences that may result from loss of consciousness while diving.

CONCLUSION

Any situation in which a diver loses consciousness in the water without warning, panic, or a struggle for air is a no-panic syndrome. No- panic syndromes tend to occur in experienced divers. Hyperventilation, poor conditioning and drugs predispose the diver to loss of consciousness in the water. These syndromes probably account for more deaths in breath-hold divers than all other causes. However, they are also associated with the use of scuba gear and special types of diving equipment. The unifying factor in all of the no-panic syndromes is a change in the diver's responses to the usual stimuli to breathe or to signals that indicate trouble.

When divers lose consciousness under water it is important to establish the specific cause instead of classifying it simply as a near drowning, so that the most appropriate treatment can be instituted. The most effective way to deal with the no-panic syndromes is to prevent them by educating divers.

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WHY AMERICAN DIVERS DIE

AN ANALYSIS OF 1983-1984 FATALITIES

The task of the National Underwater Data Accident Center (NUADC) at the University of Rhode Island is the acquisition, investigation and statistical analysis of all United States underwater diving fatalities. This includes all U.S. citizens wherever they may be diving worldwide.

The NUADC has been supported since 1969 by several federal agencies. The National Oceanographic and Atmospheric Administration (NOAA) has administered the grant since 1972 with additional funding by the U.S. Coast Guard and, for a time, from the National Institute for Occupational Safety and Health (NIOSH). Due to extensive federal budget cuts, the U.S. Coast Guard discontinued its funding of the NUADC in early 1985. NOAA could not fund the entire program, so it became necessary to search out new funding. After extensive efforts, a commitment was obtained from both DEMA (the Diving Equipment Manufacturers Association) and PADI, who with NOAA matching 50/50, are now the source of funds for NUADC, the smaller donations from others.

Since the inception of *Undercurrent* eleven years ago, we have published edited data from the NUADC report. It's our belief that by informing the diving community about the causes of deaths of fellow divers, we'll be providing critical information about how to dive more safely. *Undercurrent* takes all responsibility for editorial changes.

Here is the report:

Sources of Data

The figures and tables in this report are derived from the study of more than 2400 fatalities since 1970. This report will concentrate on 1983 and 1984 underwater diving fatalities, and will include a preliminary assessment of 1985 deaths. We receive information from professional press clipping services, unsolicited press clippings, the US Coast Guard, the Consumer Product Safety Commission, health departments, training agencies and search and rescue teams.

Totals of Underwater Diving Fatalities

Since the beginning of this statistical analysis in 1970, the fewest sport diver deaths were recorded in 1982: 74. However, the number of fatalities jumped to 110 in 1983 but dropped even lower in 1984 to only 70.

NUADC investigated 148 underwater diving fatalities in 1983: 110 sport diver or nonoccupational fatalities, 12 were occupational fatalities and 26 were skin diving fatalities.

In 1984, underwater diving fatalities dropped to 83. Of these, 70 were nonoccupational diving deaths, 11 were occupational, and only 2 were skin divers. (We find it impossible to get a good report on skin diving deaths simply because many do not get into the press or are recorded as simple drownings or swimming deaths. We don't consider our data here to be statistically valid.)

Based on information obtained from all of the national training agencies, approximately 5.48 million divers have been certified since 1960. Allowing for dropouts, cross certifications, etc. the NUADC estimates the active diver population (someone who dives more than three times per year) in the United States at the end of 1983 at 2.6 to 2.8 million active divers, and at the end of 1984 at 2.7 to 3 million divers.

We find that 1983 had a fatality rate per 100,000 between 3.78 and 4.07. In 1984, the fatality rate would be the best ever recorded by the NUADC at 2.33 to 2.59 fatalities per 100,000 active divers. These figures support

Table 1
Summary of All Underwater Diving Fatalities, 1970-84

Category	1970 M	1970 F	1971 M	1971 F	1972 M	1972 F	1973 M	1973 F	1974 M	1974 F	1975 M	1975 F	1976 M	1976 F
Nonoccupation underwater fatalities	99	11	104	8	107	12	118	7	129	15	123	8	137	1
Occupational, scuba diving	3	0	2	0	2	0	0	0	6	0	4	0	6	0
Occupational, surface-supplied air or mixed gas	6	0	2	0	2	0	4	0	8	0	8	0	7	0
On-duty military	0	0	0	0	0	0	0	0	2	0	1	1	1	0
Skindiving	18	1	17	0	15	1	22	0	25	2	16	1	11	0
Total		138		133		139		151		187		161		175

Category	1977 M	1977 F	1978 M	1978 F	1979 M	1979 F	1980 M	1980 F	1981 M	1981 F	1982 M	1982 F	1983 M	1983 F	1984 M	1984 F
Nonoccupation underwater fatalities	98	4	95	21	112	18	98	11	88	15	63	11	104	6	59	11
Occupational, scuba diving	4	0	5	0	1	0	14	0	6	0	9	0	8	0	3	1
Occupational, surface-supplied air or mixed gas	7	0	6	0	7	0	6	0	8	0	4	0	4	0	2	0
On-duty military	2	0	1	0	0	0	0	0	0	0	5	0	0	0	1	0
Skindiving	18	1	13	3	12	0	19	1	19	1	9	1	25	1	2	0
Total		144		144		150		149		137		102		148		79

Table 2

Depth of Fatal Accident Dive or Depth at Which Body was Recovered, Sport Diving Fatalities
Depth (in feet) at or Above Which Percentage Occurred

% of All Cases	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
25	17	18	15	15	18	23	17	17	16	17	5	16	10	30	28
50	30	40	48	40	43	40	30	26	29	30	30	50	60	80	55
75	60	75	90	70	78	78	65	58	54	80	63	99	77	100	86
90	130	140	250	120	125	120	100	110	101	125	120	126	240	121	110

the position that diving is becoming safer, especially when compared to the peak year of fatalities in 1976, in which year the NUADC reported a rate of 8.62 per 100,000. (See Table 1).

We have made an exceptional effort to verify this fluctuation, contacting all of the agencies who have been involved with fatalities to ascertain if the figures presented here are accurate. In Florida, a fluctuation from 14 deaths in 1982 to 33 in 1983 and down again to 11 in 1984 can be partially accounted for by the number of cave diving deaths. In 1982, only 3 cave deaths were reported. In 1983, this number jumped to 16 and dropped again in 1984 to only 4 cave diving deaths. Hawaii, which recorded 5 deaths in 1982, had 12 fatalities in 1983 and 8 fatalities in 1984.

California had its worse year in 1973 with 36 fatalities. In recent years, California diving has proven much safer with only 14 deaths in 1982, 10 deaths in 1983 and 15 deaths in 1984. The state of Washington, which had as many as 17 deaths in 1979, recorded 9 deaths in 1982, 3 deaths each in 1983 and 1984.

During 1983 and 1984, deaths of Americans were recorded in four new areas of the world: The Fiji Islands, Grand Cayman, New Caledonia and Western Saudi Arabia.

Environmental Aspects of Sport Diving Fatalities

During 1983, 74 scuba fatalities occurred in an ocean, bay or sea. That represents 67% of the 110 fatalities. In 1984, 55 fatalities occurred in oceans, bays or seas, 78% of the total.

Six fatalities occurred in rivers during 1983. In 1984 two fatalities occurred in swimming pools - the first in ten years.

A total of 16 cave diving fatalities occurred during 1983, up from the all-time low of three in 1982. Twelve of the 16 cave fatalities in 1983 occurred in Florida, with three incidents alone accounting for 7 fatalities.

The fluctuation in cave diving deaths in Florida and elsewhere may be due to the varied intensity of spring rains. Heavy spring rainfall may cause rivers to overflow, resulting in a reverse flow of the springs and muddy conditions, making it practically impossible to dive. Since there is no diving during these periods of poor visibility, there are likely to be fewer fatalities.

Between 1970 and 1986, the NUADC recorded a total of 219 cave diving fatalities. Virtually all of these involved persons who lacked any cave diving training and did not have the proper equipment and lights for such ventures. The National Speleological Society has told us that they haven't a single fatality involving a properly trained and equipped cave diver.

Most diving fatalities occur in waters that are quite shallow (see Table 2). However, if a diver dives deeper than 50 feet, many insurance companies insist on increasing the cost of insurance by two or three times. However, our statistics have repeatedly shown that such increases for scuba divers are unfair. In fact, we find no basis for the fifty-foot limit set by some companies. Such a limitation seems to imply that most diving deaths are occurring in deeper than 50 feet of water, but our records indicate just the opposite. In most previous years, well over half the cases have occurred in less than 50 feet of water. However, in 1983 and 1984, roughly 30% of the deaths occurred in less than 25 feet of water. In 1983, 50% occurred in less than 80 feet of water and in 1984 50% occurred in less than 55 feet of water.

The NUADC advice to scuba divers seeking life insurance is that they shop around to find the companies that are not using depth to determine the policy price.

[*Undercurrent* comments: The NUADC report is correct, but there seems to be a trend toward fatalities in deeper water. In the eleven years between 1970 and 1980, at no time did more than half the deaths occur in water deeper than 48 feet; in the four years since 1981, 50% of the cases were in depths greater than 50 feet, which reflects the trend toward deeper diving.]

Weather or tough environmental conditions were cited in several deaths. Six 1983 cases involved strong currents, while one fatality occurred under ice in 193 and two in 1984. In 1983 and 1984, we recorded ten cases with a wave height of more than two feet or where heavier or more dangerous surf may have played a part.

During 1983, the NUADC recorded 53 fatalities occuring while diving from a shore. Fourteen persons died while diving from a chartered diving vessel during 1983, while 18 deaths were recorded from private vessels. In 1984, a total of 35 fatalities were noted as having occurred while diving from shore, 7 were recorded from a chartered diving boat, and 11 fatalities occurred while diving from a private vessel.

Training Deaths

In the sixteen years of this study, there have been an average of 10.5 deaths per year in formal training. In 1983, six fatalities occurred during formal training and four occurred the following year. Formal scuba diving training appears to be getting safer with each successive year. In 1984, more than 300,000 individuals were reported to have been formally trained.

Following are a few of examples of training fatalities.

A formal training dive in a New Mexico cavern resulted in the death of a 42-year-old male who, upon ascent, struck his head on a ledge about 20 feet from the surface and then fell back to the bottom of the cavern in about 70 feet of water.

A 26-year-old died while undergoing ascent training in an Arkansas' lake. The victim came up, bobbed at the surface and submerged again. Although the coroner's office ruled this as a drowning, the NUADC, on the basis of other reports, believes that this was a probable air embolism.

There were two deaths during formal ascent training. In a private lake in Arkansas, a 24-year-old male was practicing emergency swimming ascents from a depth of 27 feet. Upon reaching the surface, this victim collapsed and despite extensive resuscitative efforts, he could not be revived. The probable cause of death was an air embolism.

Table 3
Experience of Sport Diving Fatality Victims
Percentage of Cases

Experience	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
First dive ever with scuba	11	16	8	4	11	8	10	10	9	6	11	4	12	6	1
First dive in open water	6	7	4	5	6	6	5	1	1	10	4	3	5	3	1
Early open water	31	24	21	34	37	25	30	26	34	21	37	23	20	12	5
Someexperience	33	19	37	16	24	20	34	40	45	39	33	32	23	14	10
Considerable experience	13	23	14	21	16	28	16	19	7	18	12	26	17	17	6
Very experienced	6	1	16	10	6	13	5	4	4	6	3	12	23	10	5

Table 4
Sport Diving Activity at Time of Fatality
Number of Fatalities

Activity	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Spearfishing	14	6	8	11	7	3	4	7	3	1	6	8	2	4	1
Photography	2	2	0	1	2	0	1	0	1	0	2	0	0	0	0
Ice diving	0	1	3	3	1	4	3	2	3	3	2	5	0	1	2
Cave diving	10	9	19	17	25	20	21	7	13	12	10	17	3	16	7
Wreck diving	2	3	2	1	6	5	9	0	4	6	2	7	1	8	2
Night diving	0	0	2	4	3	2	2	2	2	2	4	5	0	1	0
Research	3	0	0	0	1	0	2	0	0	0	0	0	0	0	0
Underwater search	2	3	2	2	3	4	6	2	1	1	2	3	0	1	0
Abalone diving	6	7	7	2	7	3	1	0	3	1	0	1	2	0	1
Lobster fishing	5	3	2	0	5	4	6	4	5	1	2	4	4	3	5
Attempting to save diver	2	2	0	0	1	0	0	1	0	0	0	0	0	1	0
Testing equipment t	3	1	1	0	2	0	0	0	0	0	0	0	0	0	0
Underwater maintenance	0	0	0	0	0	0	1	1	0	1	0	2	0	0	0
Unspecified recreation	46	61	58	67	59	59	73	57	67	88	69	43	51	68	46
Instructing	4	0	0	2	2	3	0	1	0	0	0	0	0	0	0
Under instruction	11	14	15	15	20	24	18	18	14	14	10	9	11	7	6
Total	110	112	119	125	144	131	147	102	116	130	109	104	74	110	70

A 29-year-old female practicing emergency swimming ascent in a lake in Travis County, Texas, suffered ruptured lungs and a cerebral air embolism. The exercise had been conducted from a depth of 40 feet.

A lake near Pompano Beach, Florida was the site of a drowning of a 21-year-old female who apparently became tangled in vegetation twenty feet below the surface. Her body was recovered two days later. A suit brought against several parties was apparently settled out of court a year later for $1.8 million.

A 33-year-old male tourist from California lost his life during a scuba training program off the island of Maui in Hawaii. This victim apparently became caught in the current, which took him away from his boat. He became exhausted and drowned in twenty feet of water.

A 29-year-old male suffered a probable air embolism during his first open water dive for certification in a lake in the state of Washington. This victim practised buddy breathing in ten to twelve feet of water and then swam with the instructor and two other students to a depth of 42 feet. Fifteen minutes were spent at this depth and then all involved gave an OK sign to start for the surface. Upon surfacing, the victim yelled for help, replaced his mouthpiece and sank. He was then reported to have surfaced a second time and yelled for help before sinking. The victim was recovered from a depth of twelve feet and taken approximately 50 feet to the beach where resuscitation efforts were started, but the victim could not be revived.

Three people in training died of heart attacks. In one case, a West German tourist died while undergoing scuba instruction in the Florida ocean. The victim had completed a dive and was on the surface snorkelling back to shore when be became panicky and had to be helped. Upon reaching the shore he was unconscious and never recovered despite extreme CPR efforts. This victim was reported to have died from asphyxiation due to drowning and no autopsy was performed.

A popular radio personality collapsed and died on the side of the swimming pool in which he had been taking scuba lessons in St. Louis. He died of a heart attack, probably brought on by strenuous exercise. A 52-year-old male died of a heart attack during his final certification dive in a Utah lake.

The NUADC must once again emphasize the need for very careful screening of the physical condition of any individual entering into scuba diving training who is older than 35.

One fatality occurred in an Alaskan lake while the victim was being instructed by a close friend. The 22-year-old male victim was said to be in five or six feet of water when he suddenly began to scream for help and then submerged. The would-be instructor attempted to help, but a struggle ensued and the friend was pulled underwater. He gave up his efforts to recover the victim and several other people made attempts to locate the body. He was eventually pulled from the bottom of the lake, which had a depth of 15 to 20 feet, and rushed to a hospital, but pronounced dead on arrival.

THEY DIE IN TWOS AND THREES, WITH AND WITHOUT THEIR BUDDIES

Activity Of Victims During The Fatal Dive

Table 4 presents the activity in which the victim was engagaed at the time of the accident.

During 1873, 68 of the 110 diving fatalities reported were engaged in unspecified recreation. There were 16 cave diving fatalities, a high increase over the previous safest year of this study, 1982, in which only three cave diving deaths were recorded. Eight 1983 victims were wreck diving, while six were receiving instruction. Four of the fatalities in 1983 occurred while the victims were spear fishing, and three while gathering shellfish or lobster.

Unspecified recreation accounted for 46 of the 70 fatalities occuring in 1984. Seven victims were engaged in cave diving, down from the 16 in 1983, but still higher than the safest cave diving year of 1982. Six individuals were receiving instruction, while five others were reported to have been shellfish or lobster gathering. Two of the 1984 fatalities occurred while the victims were diving on undersea wrecks and two while diving beneath a cover of ice without proper safety lines and tenders.

Each year the NUADC records several instances in which more than one person dies at the same time while engaged in nonoccupational underwater diving. During 1983 we discovered four double fatality incidents and one triple fatality. In addition, we recorded one double fatality while the participants were skin diving.

Two of the double deaths and the one triple event occurred while the divers were cave diving in Florida. Another double diving death occurred in the ocean off Kauai, Hawaii and another off the Indian River Inlet in Delaware.

In the Hawaiian case it seems that the two victims became stranded offshore by strong currents and tides and were unable to make it back to the beach after running out of air.

The double fatality off the coast of Delaware occurred while the two partners were conducting a 140-foot deep decompression dive on an old wreck. It was reported that the divers had been buddy breathing prior to the actual event. Autopsy reports indicate that one suffered an air embolism and the other drowned. The two bodies were recovered from a depth of 80 feet on the deck of the old wreck.

All of the multiple deaths while cave diving in Florida followed a classic scenario. None of the victims had received cave diving training or certification. All of them entered the caves without the proper cave diving equipment, such as back-up lights and proper guide reels. It is suspected that in each of the three separate instances, silt was kicked up and the divers lost their way and ran out of air.

Diving Partners And Their Activities

Table 5 presents the number of divers in the water at the time of a fatal accident. Once again, we must emphasize the need to practice the “buddy system”. The buddy system does not mean having several buddies in the water with you, but rather, a one-on-one buddy pair each looking after himself and being available to assist his buddy if the need arises.

Medical Aspects Of Scuba Fatalities

The results of autopsies on nonoccupational underwater diving fatalities for the years 1970- 1984 are presented in Table 7. In 1983, the NUADC managed to obtain autopsy information on 74 of the 110 fatalities, but we are concerned about the accuracy of some of these cases despite the publication and distribution of the special autopsy protocol. A medical examiner/prosecutor who may lack any knowledge of diving physiology or hyperbaric medicine is very likely to miss cases of air embolism or barotrauma. We believe that of the 48 cases in 1983 which listed the cause of death as drowning, at least 8 were probable air embolism cases.

Nevertheless, autopsy protocols in 18 cases revealed the cause of death as being barotrauma or air embolism.

Of the five cases listed in Table 7, under cardiovascular syndrome, three were reported to have been the result of a heart attack. The three victims were 41, 52 and 54. Of the four cardiovascular cases in 1984, three were listed as heart attacks and the fourth victim suffered from severe arterial sclerosis. The victims were 43, 52, 55 and 60.

Table 5
Number of Sport Diving Partners during a Fatal Accident
Number of Fatalities

Number with victim	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
None (diving alone)	12	11	10	21	13	18	8	6	22	18	14	15	14	12
One other (Buddy)	54	41	60	51	67	63	46	64	52	64	24	24	38	18
Two others	20	20	25	27	20	27	12	17	9	17	12	5	12	5
Three others	10	4	2	14	11	9	6	12	12	17	1	7	6	1
Several others	16	33	14	11	27	15	6	22	12	7	2	4	6	12
Unknown	0	10	14	11	9	11	7	13	4	8	10	19	34	22
Total	112	119	125	144	131	147	102	116	130	109	103	74	110	70

In Table 6 we indicate what type of activity the buddy took in the role of the diving accident fatality. Upon examining these tables the reader should not assume that because of the difference in numbers between those fatalities that occurred while diving alone and those which occurred while diving with a buddy, diving alone is safer. In fact, what these numbers mean is that there are situations in which it is impossible for the buddy to affect a rescue simply because of lack of training or lack of experience.

In 1983, one 25-year-old male victim suffered from a burst blood vessel in the brain. Attending physicians indicated that this could have happened at any time and was not necessarily associated with the activity of scuba diving.

Two autopsy reports in 1983 indicated decompression sickness as the cause of death. However, the NUADC believes that both were due to embolisms because in each

Table 6

Buddy activity during a Fatal Accident
Number of Fatalities

Buddy's activity	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Stayed with victim	25	27	22	40	20	39	24	32	25	26	21	9	20	9
Lost victim underwater	24	25	38	36	52	34	12	18	25	23	20	15	21	11
Tried to buddy breathe	15	14	7	11	14	15	14	8	6	10	8	3	6	1
Had left water	9	4	4	3	6	11	4	2	6	2	8	1	9	4
Lost victim on surface	12	15	14	11	12	7	6	9	11	8	5	8	9	2
No buddy	12	11	10	21	13	18	24	22	23	25	14	16	14	12
Unknown	15	23	30	22	14	23	18	24	34	15	27	22	40	31
Total	112	119	125	144	131	147	102	116	130	109	103	74	110	70

Table 7

Results of Autopsies
Number of Autopsies

Primary Complaint	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Asphyxiation or Drowning	25	26	22	32	29	29	39	45	49	61	60	45	44	48	26
Barotrauma, Embolism etc	9	12	9	8	14	12	10	16	12	17	12	13	11	18	11
Head injury (often with drowning)	5	2	2	0	2	0	2	0	2	3	2	0	0	0	0
Cardiovascular Syndrome	5	1	3	6	5	4	8	2	5	4	6	3	4	5	4
Aspiration of stomach contents	3	1	2	1	1	1	0	2	1	2	0	0	1	0	0
Acute decompression sickness	0	0	1	1	1	0	0	0	0	1	0	0	0	2	1
Intestinal disorder	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Bilateral eardrum rupture	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Gas contamination	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Major bleeding or trauma	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1
Cerebral siezure	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total	47	42	40	48	53	57	65	65	70	89	80	61	62	74	44

instance the victim had not been diving deep enough or long enough to have suffered from decompression sickness.

One unusual event during 1983 involved a 25-year-old female who, upon exiting at a beach, was struck from behind by a large wave. She fell forward and landed on her equipment, dying within minutes. At the autopsy it was determined that she had suffered a severe bruising of the heart.

The results of 1984 autopsies showed 26 cases attributed to asphyxiation due to drowning, 11 cases of barotrauma or embolism, four involving cardiovascular syndrome and one case each involving decompression sickness, body trauma and a case that was reported as cerebral seizure.

The NUADC believes that 5 of the 26 reported asphyxia due to drowning cases should have been classified as embolism cases. Two of the eleven reported air embolism cases occurred during emergency swimming ascent training.

The one case reported of decompression sickness involved a 37-year-old male, with extensive deep diving experience, who had made a dive to 240 feet for 20 minutes on the wreck of the Andrea Doria off the coast of Massachusetts. This victim apparently used up all the air in his double tanks, but was unable to reach the regulator on his pony bottle which was mounted in an awkward position, well behind his shoulder blades. He apparently made a rapid ascent from a depth of about 50 feet and was unconscious when he reached the surface, having skipped all of his required decompression time.

A 37-year-old female died off the coast of Cozumel, Mexico from multiple injuries after being hit by the propeller of a speeding boat.

A 37-year-old female was found in 35 feet of water in Narragansett Bay, Rhode Island, where she had been scuba diving for shellfish, Her Boyfriend was diving with surface-supplied air which enabled him to stay down for almost an hour and a half. She was reported to have been undergoing a neurological evaluation for "spells" and had been advised by her neurologist not to engage in diving or swimming. The autopsy revealed an intrinsic central nervous system abnormality which made her prone to seizure activity.

THE MYSTERY OF THE SUDDEN DROWNING SYNDROME

Causes of Underwater Diving Fatalities

Table 8 lists the probable starting causes of nonoccupational underwater diving fatalities for 1970 through 1984. When the starting cause is impossible to determine, no witness was present or the body had not been recovered. In many instances the local law enforcement department jhad little or no knowledge of diving accidents, and therefore failed to do a thorough investigation.

The percentage of cases on which autopsies are performed continues to increase as medical examiners and coroners become more familiar with this effort. Some areas have nothing more than a politically appointed coroner who looks at the body and, if it is blue, pronounces the victim dead and signs the death certificate. In some other jurisdictions we have had difficulty in obtaining police reports since they cite privacy of information. In a few states, the law prevents the access of autopsies by third parties. In an effort to overcome this stumbling block the Chief Medical Examiner of the State of Rhode Island has appointed the Director of the NUADC as a special consultant with "authority to secure records from other jurisdictions."

The category of possible exhaustion, embolism, or panic, may include cases which have exhibited panicky behaviour, confusion, disorientation, etc. Also included in this category is the condition described as "sudden drowning syndrome" (SDS).

SDS was first noted by the NUADC several years ago and a number of cases appear each year. Typically, they involve a diver who has been to a depth of 50 feet or more in considerably cold water. Upon returning to the surface, he is apparently all right, though he might be shivering. He gives his buddy the okay sign and they start returning either to their boat or to shore. After a few strokes, the buddy turns and looks, only to find that the victim is lying face down, dead, on the surface. There has been no outcry, no splashing, no panic.

To get to the bottom of this syndrome, the NUADC has consulted several medical experts. At best, we can still only guess at the cause of SDS. One hypothesis is that it may begin with a slight hypothermic condition and, when coupled with the slowing of the heart rate upon immersion of the face in cold water (the well-known mammalian diver reflex), the result is cardiac arythmia and sudden unconsciousneses, followed by drowning.

For 1983 the NUADC has 20 cases which fall under the category of possible exhaustion, embolism or panic, while 19 cases were recorded as diagnosed air embolism.

One death can be attributed to acute alcoholic intoxication and in another an asthmatic attack was the starting cause.

Possible exhaustion, embolism or panic were the contributing starting causes of at least 11 cases in 1984. Seven of the 1984 underwater diving fatalities were the

Table 8
Probable Starting Causes of Sport Diving Fatalities

Number of Cases

	Estimated Cause	1976	1977	1978	1979	1980	1981	1982	1983	1984
A. Medical and Injury Causes										
1	Possible exhaustion, embolism,or panic	24	25	24	33	28	12	13	20	11
2	Diagnosed air embolism	10	16	12	14	10	8	11	19	7
3	Cardiovascular event	8	4	4	5	6	3	4	5	4
4	Nitrogen narcosis	1	0	0	2	3	2	0	0	0
5	Hit by boat, extensive injuries	2	2	2	3	1	0	2	0	1
6	Aspiration of vomitus, etc.	1	2	1	2	2	0	0	0	0
7	Intoxication	1	1	0	0	3	1	0	1	0
8	Possible choking, wad of gum	1	0	0	0	0	0	0	0	0
9	Decompression sickness	1	0	1	1	0	0	1	0	1
10	Cramps at depth/cold	0	1	0	0	0	0	0	0	0
11	Ruptured eardrum	0	0	1	0	1	0	0	0	0
12	Ruptured stomach blood vessel	0	0	0	1	0	0	0	0	0
13	Gunshot	0	0	0	1	0	0	0	0	0
14	Epileptic seizure	0	0	0	0	0	0	0	0	0
15	Asphyxia/regurgitated food	0	0	0	0	0	0	1	0	0
16	Possible suicide	0	0	0	0	0	0	1	0	0
17	Asthmatic attack	0	0	0	0	0	0	0	1	0
18	Struck head on ledge	0	0	0	0	0	0	0	1	0
19	Brain seizure	0	0	0	0	0	0	0	0	0
Total Medical Causes		49	51	45	62	54	27	33	47	25
B. Environmental Causes										
1	Lost or out of air in cave	21	7	11	12	10	17	3	16	7
2	High waves or surf	3	4	3	7	1	7	4	3	2
3	Strong current	7	2	3	0	1	1	7	0	2
4	Entangled in kelp or weeds	6	2	2	3	4	5	1	0	2
5	Lost under ice	3	1	3	3	2	6	0	2	2
6	Suspected shark attack	1	0	0	0	2	1	1	0	0
7	Entangled in external lines/ ropes, etc.	3	3	3	3	1	3	0	1	1
8	Night dive, lost sight of shore lights or lost buddy	1	0	1	1	0	0	0	0	0
9	Foot wedged in rocks	0	0	0	0	1	0	0	0	0
10	Sucked into dam gate	0	0	0	0	0	2	0	0	0
11	Lost in wreck (silt)	0	0	0	0	0	1	0	0	0
12	Lost at sea, boat drifted away	0	0	0	0	0	0	0	1	0
Total Environmental Causes		45	19	26	29	28	43	16	33	16

result of a diagnosed air embolism and an additional four deaths were attributed to a cardiovascular event.

Medical and injury causes in 1983 represented 43% of the caseload, and in 1984 such cases were identified in 36% of the cases reviewed.

One underwater diving fatality in 1983 was the result of the victim being left at sea when his boat drifted miles away from an inexperienced individual sitting in the boat. After several hours, authorities were notified and made an extensive air and sea search over several days, but were not able to find the victim.

Under equipment-related causes, the NUADC recorded three deaths that could be attributed to out of air at depth in 1983. One fatality was caused by the victim being very much overweight and another the result of a poorly maintained regulator. In the latter case, the regulator hose burst at the point at which it leaves the first stage. This occurred while the diver was at a depth of about 60 feet.

One additional cause of an equipment-related death was added in 1983 when it was discovered that one victim died because the inflator to his dry suit became detached and he was unable to locate the hose and reattach it.

During 1984 the NUADC located only one case attributable to being out of air at depth. Another victim died as a result of an attempt to drop his weight belt, which became entangled in his tank strap.

One additional underwater diving fatality in 1984 was the result of an extremely badly-maintained regulator. A second stage diaphragm was severely dried up and broke its seat, causing a free flow.

The NUADC did not discover a malfunction of a personal flotation device or buoyancy compensator during either 1983 or 1984, although several occurred in prior years.

WHERE'S THE BC?

Occupational Fatality Statistics

During 1983, the NUADC recorded a total of 12 occupational diving fatalities. For 194, 11 occupational fatalities were recorded. Eight of the 1983 fatalities were using scuba gear and the remaining four deaths occurred while using surface-supplied air. Seven of the 1984 occupational underwater fatalities were using scuba diving gear.

At the entrance to Cape Cod Canal, the 39-year-old victim was making a 20 foot dive alongside a tanker in an effort to determine the source of a diesel oil spill. He apparently experienced stomach cramps, swallowed oil and got oil in his eyes before making too fast an escape to the surface and suffering a probable air embolism.

After completing his day's work, a diver at a Mississippi River power plant in Louisiana dropped some of his equipment and went back into the river to retrieve it without a safety line. He was apparently sucked up against the screen of an intake pump and held for several minutes before the pump could be shut off. By that time, the victim had drowned.

A 33-year-old professional diver lost his life while working on a California dam. The victim was reportedly sucked into an intake pipe and carried through the dam. His body was found a mile and a half below the dam structure.

A 26-year-old male succumbed to an air embolism in a Virginia river while diving on surface- supplied air. It was reported that his air hose became pinched while he was at a depth of 80 feet, and he attempted to make a free ascent without his air.

In California, the body of a 22-year-old male victim was found nine days after he disappeared from the end of his surface-supplied air system while commercially harvesting sea urchins. His lines had become severely entangled in a kelp bed.

An air embolism caused the death of a 24-year-old scuba diver attempting to retrieve scallops off the coast of Maine during 1983. This fatality occurred on the victim's third dive of the day, when he failed to surface. His equipment was lost over the side as the body was being brought aboard his vessel.

A 30-year-old police officer died during the testing of an underwater communications system in 60 feet of water. Upon completion of the test, the victim proceeded to dive deeper and deeper. Between 125 and 135 feet, the victim's buddy attempted to get him to the surface. The victim ceased swimming at about 15 feet from the bottom. His buddy attempted to bring him to the surface but was unable to do so, then dropped his own weight belt and made it back to the surface alone. Other members of the dive team immediately responded to the emergency, finding the victim at a depth of 125 to 135 feet and returned him to the surface. Total elapsed time from when the buddy was forced to leave the victim until the time the body was recovered was approximately 9 minutes.

During 1983, a 45 year-old professor of zoology was conducting research on shrimp among black coral off Hawaii. He was reported to have been at a depth of 130 feet, diving without a buoyancy compensator, when he failed to surface. The body has never been recovered.

In Los Angeles harbor, the 42-year-old male victim was standing on a ladder on a barge with all of his diving equipment on except the helmet. The ladder broke and the victim fell into 30 foot deep water. The victim apparently dropped his 40-pound waist belt and tried to walk some distance while carrying the remaining 140 to 150 pounds of metal diving gear. His body was not recovered until 35 minutes after the accident.

A 29-year-old victim was cleaning a retention pond drain when he was sucked up against the grate. He was pulled in by a safety line only after excessive force was used to bring him to the surface.

A 27-year-old male victim died in Tampa Bay, Florida, while using scuba gear to clean a ship's bottom. It was reported that this was the victim's first day on the job.

In Rhode Island, a 22-year-old male was diving in 35-40 feet of water using surface-supplied air while fishing for shellfish. The compressor, its hose and all connections were in bad repair and very loose. It is also possible that the gasoline engine ran out of fuel. The victim drowned.

A 40-year-old male died of a heart attack after overexerting himself while scuba diving for sea urchins. The autopsy report indicated that this victim had also suffered another heart attack in the past six to twelve months.

A 28-year-old man was employed to feed fish beneath a glass-bottom tour boat. He had been observed for more than half an hour before he disappeared. The body has not been recovered.

A 29-year-old police scuba team diver was searching for the body of a boat crash victim in a depth of 70 to 75 feet. The victim signaled his partner that he was having difficulty breathing, so he was assisted to the surface, where he was unconscious and pronounced dead a short time later.

The death of a 27-year-old marine biologist which occurred off New Caledonia in French Polynesia was suspected to have been caused by bad air. This individual had been diving to 125 feet for about 10 minutes when he was observed unconscious on the bottom with his regulator out of his mouth. He was brought to the surface immediately but efforts to resuscitate him with CPR were unsuccessful.

A 30-year-old female college student and a partner were gathering specimens in "blue water", off the California coast. Since the bottom is nowhere in sight, blue water divers use a float at the surface with a line going vertically down with a heavy anchor at the end. The divers are clipped to this anchoring line at whatever depth they select (in this case, 50 feet). Somehow this anchoring line came loose from the surface float and the heavy weight then started falling toward the bottom, 3,000 feet below. The victim's partner was able to unclip himself from this line at 200 feet and ascend rapidly to the surface. The victim, however, was unable to disencumber herself and was never seen again.

Conclusion

Undercurrent offers the NUADC report in the hope that divers who read and understand the causes of fatal accidents will become safer divers, not making the same mistakes made by others.

We wish you safe diving.

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

DIVER'S EAR PAIN OR CLAWS TWO

Noel Roydhouse

The patient was a male aged 34 years who had been scuba diving for 10 years.

HIS STORY

"On 9th of January 1987 I went down for my second dive descending to 6 m and had no difficulty in clearing my ears. I then gradually descended to 13 m where I caught a crayfish and noted that there were more available including one big red one and many small undersized crayfish. I surfaced at a normal speed and put my crayfish into the dinghy. I then began descending again but had some difficulty in clearing my left ear, the first time in my 10 years of diving. In fact it began to get paintful, so I ascended 1 or 2 m , tried to equalize but although the pain persisted I thought I had cleared my ear and went down to 10 m when the left ear became more painful so I ascended and climbed aboard my dinghy and returned to shore. The left ear still felt blocked or as if there was water in it. A sort of feeling of pressure. That night I had earache all the time. On the 10th of January the earache persisted but by night time it was less, but still there, so I decided to go home from the Great Barrier Island."

Complaints at consultation on 11th of January

Pressure in left ear. A ringing noise in the ear, worse than it was prior to the dive. Earache still there but getting less.

Past history

While snorkling to 5 m on 27th October 1986, during which he may not have equalized at all, on returning to the surface he noticed his left ear to feel blocked. A ringing tinnitus came on the same day after the dive. He was seen by an ENT surgeon who diagnosed an external otitis and possible middle ear effusion. He was given ear drops and nose drops and advised that a myringotomy would be performed if he did not improve. At his second visit he was correctly diagnosed as a sensori-neural deafness, given no treatment and told to give up diving. He sought a second opinion two months later which showed that in comparison to an audiogram performed on 5th February 1986 that he had a high tone senori-neural deafness. In fact for the 6 & 8 kHz notes his hearing threshold was 90 db and no response to 120 db. He was counselled on the cause of inner ear membrane tear and told he could continue diving but if anything untoward happened to his ears he was to ring immediately. Accordingly he had been diving on 7 occasions since the 27th October.

THE DOCTOR'S VIEW

Examination

Right ear, a minor 2 mm exostoses and an injected handle of malleus. Left ear, after removal of a crayfish, 35 mm. from tip of feeler to bottom of tail with a 20 mm body, a minor external otitis was seen. Nose, a deviated nasal septum to the right, minor nasal congestion. Temporo-Maudibular joints, minor clicking on the left with wide opening of his jaw. Audiometry, right ear the same as 3rd of December 1986 and the left ear 5 db greater loss since 3.12.86, in each frequency of the speech range whilst the 6 & 8 kHz were 85 db and no response (masked audiometry).

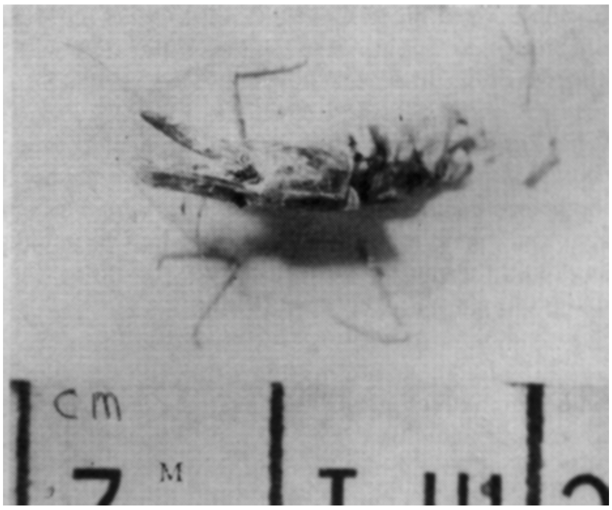
Treatment

Colymycin Otic (Warner) drops for 4 days followed by Vosol (Smith Biolab) for 4 days.

DISCUSSION

This diver developed a sudden sensori-neural deafness following a snorkling dive to 5 m. in October 1986. Although he was seen promptly, a misdiagnosis resulted in no treatment being given. About half of those divers treated with prednisone (60 mg per day), oxypentifylline either intravenously or orally (800 mg per day), oxygen therapy and bed rest, within the first week, recover from the deafness. Of about 100 divers seen with this condition, a few have given up diving, 3 had recurrences, and the rest have continued diving with no ill effect. Of the recurrences 2 had treatment again and recovered fully to go back diving. The third turned down the treatment as he wanted to go home to a town 400 km away and he, at that time had been diving in excess of 20 years.

As for this diver's recent problem, anyone who has ever seen a crayfish looking out of a hole would have immediately recognized the sight through the eyepiece of the microscope. The normally translucent baby crayfish had been coated with wax to a small extent although the yellow colouration may have been the very earliest of pigmentation. His feelers were up and his legs, thinner than an eye lash, were on the body until it was removed. A small piece of the carapace was left adherent to the ear-drum to be removed at the second attempt to "clear the ear". This diver never wore a hood, so in grappling into the crevice for his prize he would have disturbed the nursery at the entrance. What better place than a dark earhole to settle in? The pain on his second descent would have been due to the crayfish with the drum moving in with pressure and out with clearing the ear. The live crayfish no doubt dug his legs in to prevent being pushed about. This ear could have been more sensitive than usual due to the Mandibular Dysfunction Syndrome and hence the continuation of the earache. Divers do develop diverse disorders. Perhaps crayfish should be included amongst dangerous marine animals.



Crayfish after removal. The scale is in centimetres

Reprinted, by kind permission of the Editor, from The New Zealand Journal of Sports Medicine, December 1987, p. 67.

Dr Noel Roydhouse's address is 118 Remuera Road, Auckland 5, New Zealand.

OH, WHAT A 'LARKEL'

Marilyn Bitomsky

People who have had a laryngectomy can now look forward to swimming again, thanks to a relatively new device consisting of a snorkel with attachments to fit it snugly both onto the wind pipe and onto the head. As well, Australia's first swimming course for laryngectomees, (people who have had a laryngectomy), was being run by Brisbane's Princess Alexandra Hospital.

This swimming course does not teach the usual swimming techniques, but rather techniques of how to fit and use the device. The course was being run by one of the speech therapists at Princess Alexandra Hospital, Lynell McFeeter, and Kerrie-Ann Thornber, a speech therapist at Greenslopes Hospital.

Both therapists have just returned from a course at the Mayo Clinic, where they observed the techniques involved in using the device. Ms McFeeter also attended a similar course at the Voice Institute in the United States.

Since swimming was fraught with risks for laryngectomees, by virtue of the fact that their wind pipe had been brought to the surface of their neck, precise training in how to fit the device and how to use it was vital.

The device used in this Brisbane training program was called a Larkel, and it has two main sections, a mouthpiece ending in an inflatable tube with a safety valve, and a snorkel (which can be stuck into the mouthpiece) with a headband. Also necessary for the fitting were a 10 cc syringe, a neckband, and a clip.

The Larkel comes in eight sizes, with the outside diameter of the trachael tube varying from 8 mm to 16 mm, and costs about $280.

Ms McFeeter described the Larkel and other similar devices as an exciting development in laryngectomy rehabilitation, since it allows patients to exercise through swimming. She said that for several decades it was considered unthinkable for a laryngectomee to attempt water sports because of the risk of drowning. However, since 1974, when a prototype device was first demonstrated, swimming clubs have been set up throughout the United Kingdom, the United States, Europe and now it was available in Australia.

Quality of life for such patients could be greatly improved, she said, because these people can now safely participate in activities they enjoyed before their operations. There were other advantages, too, she said. Improved lung capacity, with deeper breathing, and physical exercise, particularly for those who had undergone a

Figure 1. The larkel fits over the tracheostomy.

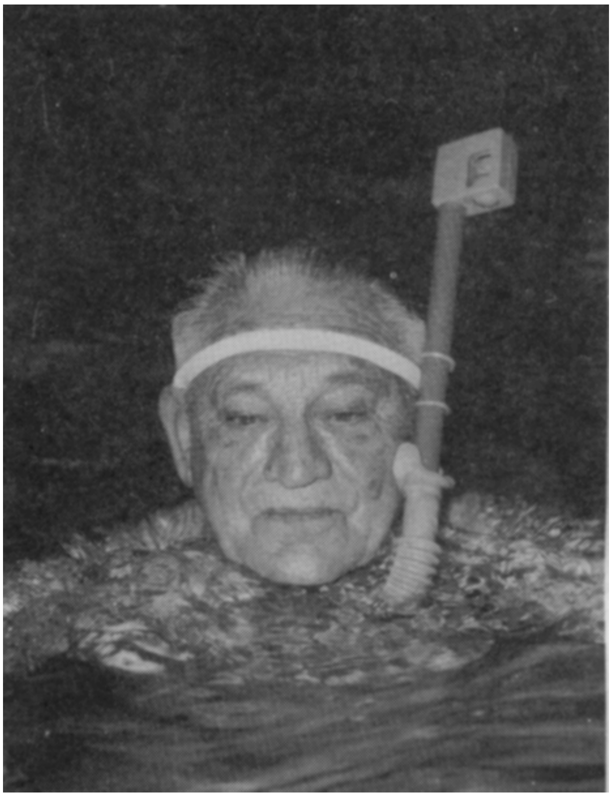


Figure 2. Laryngectomee, Roy Coulter, can enjoy swimming again thanks to the Larkel device.

radical neck dissection resulting in reduced range of shoulder movement, was a giant step forward.

The course was being run over four days, with instruction every day. According to Ms McFeeter, by the end of the four days, patients should be able to go out and swim safely in uncontrolled areas.

At first, swimming strokes were slow and careful, and were often accompanied by awkwardness. The longer air passage via the mouthpiece and rubber hose, together with unaccustomed use of certain muscles, could cause difficulty if training is not precise.

The Queensland Cancer Fund has been so impressed with the results that it funded Ms McFeeter's and Ms Thornber's trip to the first National Laryngectomee Rehabilitation seminar in Melbourne at the end of August. People from all over Australia attended the seminar and a swimming course where these two speech therapists trained others in use of the device as a rehabilitation aid.

Ms McFeeter was obviously delighted with her results, but the last word belongs to her patients. They are thrilled, she said. "They didn't think they would ever be able to swim again, and now they can".

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The address of MEDICAL OBSERVER is Unit 13,98 Old Pittwater Road, Brookvale, New South Wales 2100, Australia.

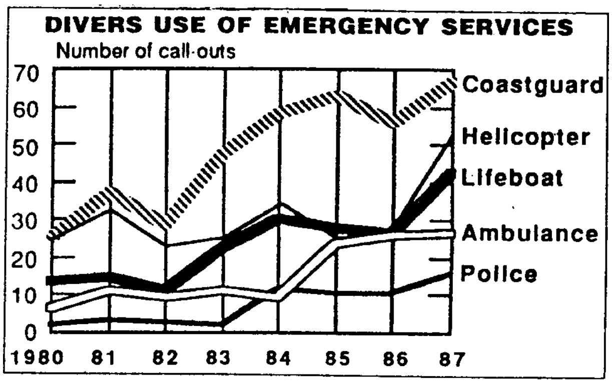
BS-AC INCIDENTS REPORTED IN 1987

Dave Shaw

Lost divers up 50 per cent, decompression cases up, coastguard and helicopter call-outs up, deaths down.

In 1987, we had a very strong message about novice divers diving in conditions and to depths beyond their capability. Last year's trends have shown a big improvement in this area, but there have been worrying increases in several other areas. These include the number of lost-diver incidents, and, with evidence that deeper diving has not decreased, the number of divers being treated for decompression sickness.

As the yearly analysis graph shows, decompres-



sion sickness and boating/surface incidents still lead the table. There has been an increase in the number of reported bends in 1987, but this is probably explained by the full details of all treatments at recompression chambers for the year, an increase in data capture.

Diving deaths went down from a total of 15 in 1986; but of the 8 reported last year 6 were BS-AC members. All but 2 of these deaths occurred in less than 10 m of water. Three of those who died were at the surface, two of these drowning in rough surface conditions.

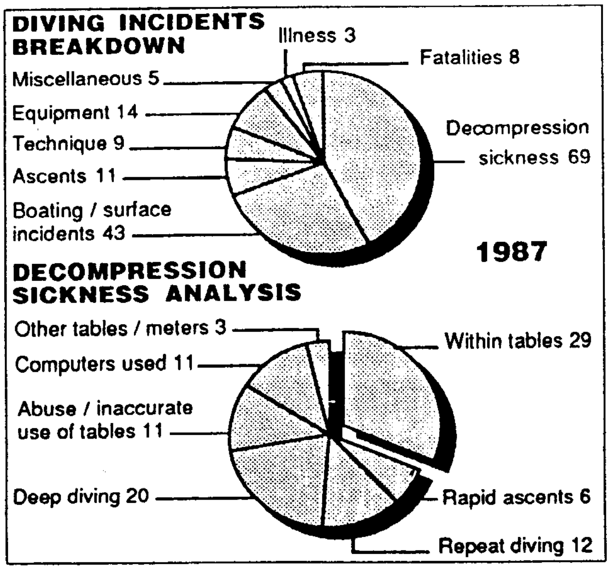
One of the other deaths was the result of diving while embarking on an illegal commercial operation. Another occurred when an experienced diver abandoned his novice buddy and, against all advice, entered a "dangerous" shallow wreck without a guideline.

A successful rescue of a female diver from 53 m averted a double tragedy in a deep lake. The surface team successfully restarted her heart three times. Her husband, however, failed to surface.

As mentioned above, greater Coastguard involvement and a sharp increase in the use of helicopters in diver rescue leads to a very strong message regarding dive planning.

Forty-two helicopter call-outs were reported last year, and although many of these were precautionary moves by the Coastguard the BS-AC is very concerned at this level of rescue services activity. There is a considerable lobby by those who would make us pay for such services, and the figures do nothing to help us defend ourselves in these arguments.

The number of 'lost' divers has risen 50 per cent on the previous year's total, and if you also remember the above level of rescue helicopter involvement during 1987 you will understand our concern. I don't have to spell out the adverse publicity such incidents cause, soon wiping out any favourable press we receive for good deeds.



Some divers go missing through bad luck, as in the case of the divers who, unbeknown to them, had a surface marker buoy (SMB) buoy deflate and sink, causing the surface boat cover to lose them. In another incident, the boat broke down and drifted away in poor surface visibility. As one analyses this section, however, one soon becomes aware that in many cases the incident would not have happened had the dive been planned better, or if the divers had followed simple rules.

Consider the divers without SMBs who were swept away by the tide after they had surfaced close to their boat. The glare of the evening sun prevented those in the boat seeing them. It later transpired that those in the boad had no idea which way the tide was expected to run, their radio did not work, and only one out of four flares attempted actually fired. In another case, divers without SMBs ignored advice and swam out to sea, where they were caught in a strong tidal stream. They surfaced 200 m from the boat, but were not seen and were only picked up after they had been carried through a tide-race and were spotted by a helicopter. On another dive, a boat cox dropped two divers off for a dive, then left for the beach with another pair. When he returned, the divers were nowhere to be seen, and were later found hanging on to some lobster-pot buoys after the Coastguard and a lifeboat had been alerted.

Another incident widely publicised in the press involved two divers who went on a drift dive without SMBs, leaving one of their wives and a 10-year old daughter in the boat. Neither knew how to start the outboard. The anchor failed to hold and the boat drifted from the site. After an extensive search the divers were found 7 hours later, 2 miles apart.

An equally unbelievable incident occurred when a charter skipper raised the alarm when two of the divers on a planned decompression dive failed to surface. Lifeboats and a helicopter were involved in the search. They were found safe and well, but the skipper later reported that the divers had been decompressing at 5 m, became bored, and decided to go off for a swim. They were carried off by the tide and were afraid of surfacing for fear of decompression sickness. I wish commonsense was more common!

Several of last year's incident reports contain critical comments by the Coastguard, and it is obvious that simple rules are not being obeyed. Thek use of SMBs in any sort of moving water or where the boat cover may have difficulty covering the site is essential. Those left in the boat must know the 'marks', and be able to get back on station if the boat drifts off-site. Accurate predictions of tidal streams must be acquired in advance, and the Coastguard must be informed of diving intentions. A report to him of your successful returns is also obligatory if you have informed him you are diving. Divers also need to be aware that surfacing close to the boat will not guarantee you will be seen as several divers this year will testify! It is important that boat coxwains keep a careful watch at all times.

Technique remains a short category in its own right, with 9 separate incidents classified under this heading. There still seems to be some evidence of divers becoming separated and deciding to carry on regardless, rather than surfacing. Presumably, they assume their buddy thinks the same! In an incident of this nature, the Coastguard was alerted when one of a pair of divers failed to surface shortly after the pair became separated during a 7 m dive. He eventually surfaced after 42 minutes, and later claimed that his buddy had told him that if they became separated not to bother surfacing as it was only 7 m deep!

The pure equipment incidents in 1987 have produced some rather bizarre events. There were two explosions when cylinders were being filled, one where the compressor high pressure union blew and the operator narrowly escaped injury. In the other, in an overseas location, the operator was badly injured when the cylinder itself exploded. Another unusual incident occurred when a diver suffered bruising when his buddy's adjustable buoyancy life jacket (ABLJ) cylinder exploded when being charged. It fractured near the junction of the valve and cylinder collar. It was only 3 months old. *In Australia an ALBJ is known as a buoyancy compensator)*

There have been two cases of structural failure with regulators. In one, a first stage of a year-old regulator sheared completely in half at 25 m. The divers completed a successful assisted ascent. A manufacturing flaw was diagnosed, although the manufacturer refused to accept this according to the report. In the other case, a diver rolled off the boat and found his air suply had failed. Much to his annoyance and discomfort, he found that he couldn't regain his posture in the water with air gushing from a fractured hose near the junction with the first stage. This had the effect of 'jet propelling' him under the water. He had to use an ABLJ to reach the surface in the correct position. A faulty regulator was found to be the cause.

The miscellaneous section of last year's chart remains quite small, with one or two unusual incidents. In one, a diver surfaced with severe stomach pains after a dive to 36 m for 14 minutes. A helicopter was called, but at the chamber he was diagnosed to have had a "lemonade bend", having drunk copious amounts of the liquid on the way to the dive site.

As mentioned above, 1987 has seen a significant rise in the number of reported decompression sickness cases, numbers having risen from 52 in 1986 to 69 last year.

Worrying trends include continued evidence of diving deeper than the recommended 50 m maximum, in some cases idiotically so. There has been an increase in the number of bends involving decompression computers, testimony to the numbers of divers now using them.

Continuing further on the deep diving trend, of the 20 incidents in the deep category (40 m plus), 14 occurred on dives below 50 m, and 6 took place after dives deeper than 60 m. The deepest depth recorded in last year's statistics for DCS was 70 m! The lure of deep wrecks, especially in the South West, accounts for 8 of these cases.

Perhaps the greatest concentration of lunacy occurred during an inter-branch charter during the summer, when a group of divers set out to attack a wreck in 54 m. They were diving with large twin-sets and decompressing at 15 m, 10 m and 5 m. Four of the divers were all treated at the same chamber for bends over a four-day period. One ran out of air during decompression, another made an emergency ascent when he got tangled in his SMB and then flooded his mask. Another developed symptoms after 15 minutes on the bottom at 54 m followed by 28 minutes of decompression. This was the second day with the same profile and only a month after treatment for a Type 1 bend after a 50 m dive, after which he was advised to lay off diving for a while!

And we wonder why divers get bad publicity!

The continued high number of bends cases after dives 'within the tables' highlights the fact that our use of a single-dive table for multiple dives has been somewhat optimistic.

Those who attended the 1986 Diving Officers Conference and heard Dr Tom Hennessey's presentation will remember his model of what happens to excess nitrogen over a series of dives within a relatively short time-slot. There is the so-called "gas phase" affecting surplus nitrogen, out of solution, which is not effectively redissolved once under the pressure of a second or subsequent dive. On the fourth dive in a series, it is likely that the gas phase lasts the whole dive. The advice which leads from this realisation is to avoid multiple ascents, however short, and whether or not the tables 'allow' such activities. This has implications for branch and/or instructor training when it may be necessary for a supervising instructor to make several ascents. This was borne out by one incident in 1987 when an instructor on a BS-AC Advanced Instructor event had a severe Type 2 bend after a normal dive to 36 m for 13 minutes. The previous day he had done about 10 ascents from 8 m supervising drills.

Finally, on decompression sickness, I must mention decompression computers and the lively debate which their increased use has aroused. The 11 reported incidents have shown one or two interesting trends. There seems to be a tendency to ignore basic physiology and depth recommendations, with 5 of the 11 cases occurring on dives below 50 m.

Some people obviously think that to strap a computer to their wrists is the passport to repeat diving pleasure, and that to do so gives them immunity from bends. You cannot ignore the basic physiology mentioned earlier, and you neeed to remember that the calculation and algorithms they are based on are not gauged to the individual diver.

I must also stress that a computer is not a shared piece of equipment! The diver who developed decompression sickness following a dive to 70 m was using a computer which had been used by other divers on dives to 12 m some 2 hours earlier. This was because, they said, "We wanted to dive on their penalties".

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The address of DIVER is 40 Grays Inn Road, London WC1X 8LR, United Kingdom.

The address of the British Sub-Aqua Club is 16 Upper Woburn Place, London WC1H 0QW, England.

ABSTRACTS OF INTEREST FROM THE 1987 JOINT CONFERENCE UNDERSEA AND HYPERBARIC MEDICAL SOCIETY ANNUAL SCIENTIFIC MEETING AND THE TWELFTH ANNUAL CONFERENCE ON CLINICAL APPLICATON OF HYPERBARIC OXYGEN

THERMOELECTRIC HEATING FOR MANNED UNDERSEA SYSTEMS. T.C. Schmidt and M. Vandervoort*. Lockheed Advanced Marine Systems. 3929 Calle Fortunada, San Diego, CA 92123.

The only USN field operational means of heating divers is via a hot water umbilical from the surface. The combat swimmer and divers operating from Seal Delivery Delivery Vehicles (SDVs) have inadequate heating. The situation is critical for SDVs - where the divers are inactive during transits of long duration. While there have been recent advances in diver suit insulation, dependence on passive insulation alone may be complicated by variations in water temperature and diver activity subsequent to transit. Also, closed circuit UBA show premature depletion of the CO_2 absorbent due to the effect of cold on hydroxide performance. Heat pumps are very energy efficient in the heating mode as the heat produced is equal to the heat pumped plus the heat equivalent of the power consumed. As thermoelectric (TE) heat pumps are solid state, they eliminate the refrigerant, compressor, condenser and evaporator common to conventional (vapor compression) heat pumps. Design concepts using TE heat pumping to provide UBA and respiratory gas heating for both the free swimmer and SDV user, and suit heating for the SDV user during transit have been developed. For open circuit UBA heat is pumped from the expired gas to the inspired gas. For closed circuit UBA heat is pumped from ambient seawater. For suit heating heat is pumped to a closed circuit hot water suit from another closed circuit water loop which passively extracts heat from a miscellaneous source such as the SDV motor housing. Empirical performance data for the various heat pumping modes over the forseen range of dependent variables has been completed. The development and test of more optimized prototypes is currently in progress. While present efforts are directed to special warfare applications this approach may be readily adapted to more conventional diving modes. Also, by reversing the current a heater becomes a cooler, for use in hot water diving applications.

LOSS OF CONSCIOUSNESS IN A DIVER AT 190 FEET OF SEAWATER (FSW). W.T. Norfleet, D.E. Warkander*, and C.E.G. Lundgren. Center for Research of Special Environments, Dept. Physiology, SUNY, Buffalo, NY 14214.

An ongoing series of experiments is investigating the physiologic responses of divers to a variety of inspiratory and expiratory breathing resistances. The subjects perform leg exercise at 60% $VO_{2\ max}$ while submersed during dives to 15 fsw and 190 fsw. After 25 minutes of exercise and exposure to a particular breathing resistance, additional "challenge" resistances are inserted into the breathing apparatus as exercise continues. Parameters including ventilatory muscle electromyogram, end-tidal PCO_2 ($etPCO_2$), transcutaneous PCO_2, and expired minute ventilation (V_E) are monitored.

One subject lost consciousness due to carbon dioxide intoxication/narcosis during an experiment at 190 fsw. The experiment proceeded as expected until shortly after application of the "challenge" resistance (disks with an aperature 0.35 inches in diameter) at 25 minutes elapsed time since initiation of exercise. During this particular dive the subject was exposed to minimal breathing resistances during this 25 minute period. HIs $etPCO_2$ had stabilized at 52 torr (a value typical of subjects performnig moderate exercise at 190 fsw without added external breathing resistance) with V_E = 46 1/min, and he reported mild dyspnea. At 27'00" elapsed time he again gave a hand signal denoting mild dyspnea, ($etPCO_2$ = 76 torr), but 20 seconds later he refused to stop exercise on verbal command and fought off efforts of tenders to extract him from the water. Immediately after removal from the water he lost consciousness for 70 seconds. Preliminary analysis of electromyogram data indicates no ventilatory muscle fatigue during this dive. This episode of respiratory failure appears to have arisen from a central, rather than peripheral, mechanism. Supported by the Naval Medical Research and Development Command, ONR #N0001486CO106.

HYPERBARIC RESEARCH IN HOBART
Preliminary Report 29 January 1988

Dr Peter McCartney writes

Dr P.McCartney, Director of Diving and Hyperbaric Medicine, Royal Hobart Hospital, and Dr J.Vial, Department of Medicine, University of Tasmania, are undertaking a joint study of free radicals.

Free radicals are molecules with an unpaired electron in their outer orbit and as a result of the strong tendency of unpaired electrons to interact with other electrons to form an electron pair they are usually highly reactive species.

One of the difficulties in studying the importance of free radicals in man has been the difficulty in measuring them. We have developed an electron spin resonance (ESR) method of measuring organic free radicals, in blood snap frozen in liquid nitrogen, which promises to overcome many of the previous difficulties. Electron spin resonance is a form of absorption spectroscopy in which radiation of microwave frequency induces changes in magnetic energy level of electrons with unpaired spins.

Hyperbaric oxygen therapy has been used to deliver high concentrations of oxygen to the tissues in the management of various conditions including gas gangrene, decompression sickness, carbon monoxide poisoning, gas embolism, refractory osteomyelitis, burns and poorly healing wounds.

Measurement of free radical levels generated and of the speed of breakdown of these highly ractive species is essential if therapy profiles for routine use are to be worked out on a more scientific basis.

Using Police Search and Rescue diving volunteers stressed with oxygen at varying tensions for a range of time spans, we have snap frozen blood samples in the chamber and subjected them to analysis. The data so far, combined with baseline levels, is indicating that breakdown of free radicals in the body is not as rapid as was thought.

These early results already point the way to the advantages of using lower pressures in certain conditions, to achieve the maximum therapeutic value.

SPUMS NOTICES

INCORPORATION OF SPUMS

The committee has been considering incorporation and has decided to go ahead, which involves every member voting on the issue. The Secretary will be writing to all members in the near future outlining the reasons for incorporation and the steps necessary.

DOCTORS WITH TRAINING IN DIVING MEDICINE

The current list is unsatisfactory as some of those on the list do not do diving medicals and some of the addresses are not that where the doctor concerned is to be found for a diving medical.

The Secretary will be making a new list which will include only those who arewilling to do diving medicals and the addresses at which their practice is conducted.If you wish to be included on this list please write to the Secretary of SPUMS (Address on page 2).

INSTRUCTIONS TO AUTHORS

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

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

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

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

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

REPRINTING OF ARTICLES

Permission to reprint original articles will be granted by the Editor, whose address appears on page 2, subject to the author's agreement, provided that an acknowledgement, giving the original date of publication in the *SPUMS Journal* , is printed with the article.

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

COURSES AND MEETINGS

ROYAL ADELAIDE HOSPITAL HYPERBARIC MEDICINE UNIT

Courses in Diving and Hyperbaric Medicine 1988

Basic Course in Diving Medicine

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

Venues a Royal Adelaide Hospital, Adelaide 12-16 September 1988

b New Zealand Underwater Association (NZUA) sponsored course, Auckland, New Zealand. 26-29 April 1988

Cost a $A 250.00 b $NZ 275.00

Advanced Course in Diving and Hyperbaric Medicine.

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

Venue Royal Adelaide Hospital, Adelaide. 19-23 September 1988

Cost $A 250.00

Further information and enrollment

For Further information or to enroll contact

For Royal Adelaide Hospital courses

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

NZUA spoonsored course

Dr A.F.N.Sutherland,
4 Dodson Avenue,
Milford,
Auckland 9,
New Zealand.

SPUMS ANNUAL SCIENTIFIC MEETING 1988

Mana Island, Fiji. 5th to 12th June 1988.

Guest Speakers (in alphabetical order will beDr William Runciman, Dr Robert Thomas, Dr John Williamson.

Members who wish to present a paper whould contact the conference organiser, Dr C.J.Acott, and inform him of the title of the paper, how long the presentation will take and what sort of projector will be needed, at

39 Oswald Street,
Rockhampton,
Queensland 4700,
Australia.

NEW ZEALAND CHAPTER OF SPUMS 1988 ANNUAL MEETING

For further details of this meeting, which will be held on 1st to 4th of April 1988 at Furneaux Lodge in the Marlborough Sounds, write to the convenor, Dr Mike Davis at

P.O.Box 35,
Tai Tapu,
New Zealand.

SPUMS JOURNAL BACK NUMBERS

Some copies of a few past issues are available at $2.00 each including postage.

The relevant issues are

1984 Vol. 14, No. 1. (2 copies)

This contains Professor Brian Hill's paper on "Decompression Physiology" presented at the 1983 Annual Scientific Meeting.

1984 Vol. 14, No. 2. (7 copies)

This contains papers presented at the SPUMS-RAN Meeting in August 1983 and at the ANZICS -SPUMS Meeting in Rockhampton in October 1983.

1984 Vol. 14, No. 3. (3 copies)

This contains further papers presented at the ANZICS-SPUMS Meeting in Rockhampton in October 1983.

1985 Vol. 15, No. 4. (10 copies)

This contains papers from the 1985 Annual Scientific Meeting in Bandos and from the New Zealand Chapter of SPUMS Meeting in November 1985, including an account of the formation of the New Zealand Chapter.

1986 Vol. 17, No. 2. (17 copies)

This contains papers from the 1986 Annual Scientific Meeting in Tahiti.

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