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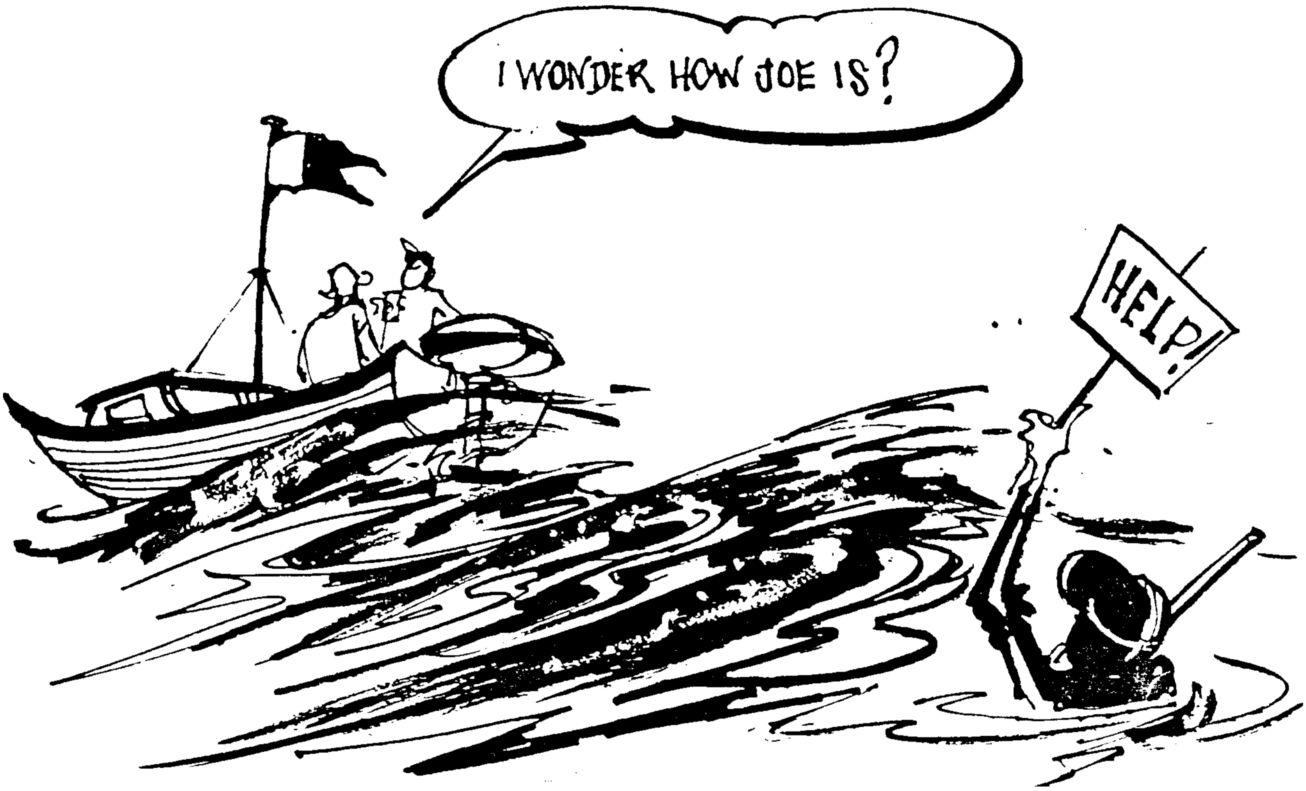

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OBJECTS OF THE SOCIETY

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

MEMBERSHIP

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

The subscription for Full Members is $A35.00 and for Associate Members is $A25.00. New Zealand members' subscriptions ($NZ50.00 and $NZ35.00 inclusive of GST) should be sent to Dr P Chapman-Smith, Secretary/Treasurer of the New Zealand Chapter of SPUMS, 67 Maunu Road, Whangerei.

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

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

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EDITORIAL

A happy and prosperous New Year with plenty of enjoyable safe diving to all our readers. You will have seen a cartoon in a familiar hand, that of the late Peter Harrigan, on the cover of this issue. It was among those commissioned for ideas that were not used in editorials and now seems appropriate to the topics of diver rescue and emergency treatment, the report of divers being rescued because someone heard their whistles being blown and the saga of the invention of the Safety Sausage. This latter shows how easily a planned dive and rescue can go wrong. However lessons were learnt from the near disaster and quite fortuitously a strip of plastic lying on the surface of the sea was found to be much more easily seen from the air than a diver beside a red buoyancy compensator. It is a worrying thought that a diver in his red buoyancy compensator was not visible from the air. The last trial showed how easily seen from both boat and air an inflated Safety Sausage was. Unlike a flare which has a limited time of visibility the Safety Sausage will still be there when the rescue team eventually look in the diver's direction.

The advertisement for the Safety Sausage to be found on the back cover is the first paid advertisement accepted by the SPUMS Journal. The Executive Committee has for some time considered that paid advertisements would be accepted in the Journal.

Dr Parkinson's paper on Malaria makes excellent reading and reminds us that avoiding mosquito bites by wearing clothes that cover the whole body after dark is part of our avoidance of malaria. His advice on prophylactic treatment will also be of interest to our members as the Annual Scientific Meeting will certainly be held again in a malarial area. It is sad to read of the recent spread of malaria back into areas of the Solomon Islands that had been malaria free in the recent past. Unfortunately this seems to be a world wide pattern of malaria control failure.

Wal Williams takes us through the problems of getting agreement on standards for sports diver training among competing commercial and personal interests. This year the West Australian government has had a task force working on regulating the training of divers and avoidance of decompression accidents, prompted by a large increase in the number of people requiring recompression treatment in the chamber at HMAS STIRLING. We will be publishing a paper about this excursion of government into the diving world in a future issue.

On the other side of the Tasman the New Zealand Underwater Association (NZUA), which is now affiliated with the Professional Association of Diving Instructors (PADI), has listened to the urgings of the New Zealand Chapter of SPUMS and now insists on a medical, albeit abbreviated compared to the recommendations previously published in this Journal, before the novice can start a diving course. We extend our heartiest congratulations to the New Zealanders for their actions and regret that the fragmented nature of the Australian diving instruction industry, with three organisations who do not see eye to eye, continues to prevent such a sensible procedure being adopted in Australia.

The malign influences of Murphy's Law are described in the papers by John McKee, Douglas Walker and Chris Lowry while a successful defeat of Mr Murphy appears in the paper by the late George Bond. Another note from the past is the paper by Dr Graham Blick, "late District Medical Officer at Broome, Western Australia", published in the British Medical Journal of 25 December 1909. We are indebted to Dr Tom Shields, this year's guest speaker at the Annual Scientific Meeting, for bring this paper to our notice. Dr Blick treated, without recompression facilities, many divers suffering from severe neurological decompression sickness. When they died he carried out post mortems and recorded important observations. As far as we know this is the first paper ever published about the diseases of Australian divers.

In our attempt to keep on whetting the appetites of our readers for more knowledge so that they can dive more safely by learning from others, we reprint an article about the West German hyperbaric research unit, also Diving Safety Memoranda from the North Sea and selected abstracts from the Undersea and Hyperbaric Medical Society (UHMS) meeting earlier this year. UHMS is the new name for the Undersea Medical Society (UMS) to represent more obviously that a large proportion of the members of UMS were engaged in hyperbaric medicine and had no connection with diving.

Finally we would draw your attention to the notices of courses in underwater and hyperbaric medicine to be held in Australia and New Zealand and of the meeting of the New Zealand Chapter in April and the Annual Scientific Meeting in June. We hope that as many of our readers as possible will attend to learn and to pass on their experiences and knowledge.

SPUMS NOTICES

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 150 mm 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: 1766-1770 [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*. Page numbers should be inclusive. Examples of the format for journals and books are given below.

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

2 Lippmann J, Bugg S. The diving emergency handbook. Melbourne: JL 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, eg. 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.

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NEW ZEALAND CHAPTER OF SPUMS 1988 ANNUAL MEETING

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

Dr Mike Davis
PO Box 35
TAI TAPU
New Zealand

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

The relevant issues are

1984 Vol 14, No 1 (10 copies)
This contains Professor Brian Hill's paper on "Decompression Physiology" presented at the 1983 Annual Scientific Meeting.

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1984 Vol 14, No 3 (8 copies)
This contains further papers presented at the ANZICS-SPUMS Meeting in Rockhampton in October 1983.

1985 Vol 15, No 4 (15 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 16, No 4 (13 copies)
This contains papers from the 19865 Annual Scientific Meeting in Tahiti.

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PROJECT STICKYBEAK

This project is an ongoing investigation seeking to document all types and severities of diving-related incidents. 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 organization to increase diving safety through better awareness of critical factors. Information may be sent (in confidence) to:

Dr D Walker
PO Box 120
NARRABEEN NSW 2101
Australia

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MALARIA

David Parkinson

The Solomon Islands is spread over a fairly wide area of sea. It is divided into Provinces, (Western Province and Ysabel Province) to the West and Makira and Temotu to the East. Most of the malaria in the Solomon Islands, in the east, is very low endemicity and in the west is also of very low endemicity. The places we have to worry about are the islands in the Central Group, Malaita, Guadalcanal and the Floridas. Where you are right now and where you intend to dive.

Malaria has a long history in the Solomon Islands. It goes back as far as Mendana and his group of men who came here in 1568. Many of these people died, mostly of intermittent fever which was later on thought likely to have been malaria. Mendana returned later to Santa Cruz where, once again, his men fell ill with the dreaded intermittent fever and many died. The descriptions closely resemble those of malaria. There is little record of malaria in our history books after that, possibly because the western world lost sight of the Solomon Islands and it was not until the 19th century, when the first missionaries, gold miners and entrepreneurs visited the Solomons that we began to hear again of the dreaded fevers. These people came to the Solomon Islands and tried to settle but found it was difficult, mainly because they became ill with the fever and many of them suffered for many weeks. Some of them became immune to the disease and stayed, others developed blackwater fever and died and this was about all we heard.

In the early 20th century, we had very little literature and it was not until 1913 when hospital statistics began to be collected that we began to learn a little of what was happening with the fevers in the Solomon Islands.

Between World Wars I and II, there were many admissions to hospital. By that time, there was a means to find out what the cause of the fevers and sickness was. There was a tremendous amount of malaria found in Guadalcanal and in Tulagi. There was not so much found in the West or in other Provinces. In Guadalcanal, in fact, most of the northern side was unpopulated or very lightly populated because people got malaria when they tried to settle and died. This was the indigenous population, as well as the expatriate population.

During World War II, the greatest causes of illness and morbidity were malaria and dysentery but malaria took first place and, in 1942, during the campaign on Guadalcanal, the number of malaria cases was 722 per thousand. In some cases there were up to 3,000 cases per 1,000 per month during some months of that particular year. In 1943, there was a slight improvement due to the use of stringent methods of malaria control which were introduced to the US, British and Australian Armies. This was the result of some very astute work at Cairns and on the Atherton Tablelands by the Land Headquarters Medical Research Unit of the Australian Army.

By 1944, the number of malaria casualties was reducing because of the intensive malaria control measures that were being undertaken on the north coast of Guadalcanal. However, in 1945, when all the hostilities had ceased and the northern pan of Guadalcanal was being used both as a rest and recreation area and as a source of fresh vegetables for the rest of the Pacific, the incidence of malaria could not be reduced below 20 per thousand.

After the second World War, many surveys were undertaken of the various medical problems in the British Solomon Islands Protectorate, as it was then known, including malaria which caused high morbidity and mortality amongst all age groups and, in particular, amongst children. A comparison of north Guadalcanal and similar areas in Papua New Guinea showed infant mortality rates of the order of 250 per thousand per year, mostly due to malaria or malaria related causes.

As a result, the Medical Department decided to establish a pilot project to find some means of controlling the disease, mostly here in Guadalcanal, on Savo Island and some other island groups. The methods that were used were based on the spraying of DDT or a residual insecticide inside every household in the Solomon Islands. This required a large manpower force organised along military lines which could carry around sufficient spray cans and spray the houses. It might seem an easy task but, in actual fact, it was very difficult and required caution in the amount of insecticide put on the walls of each house. However, it was done and when the pilot projects were concluded, the results were similar to those in Papua New Guinea.

Malaria prevalence rates came down from the order of 84% to around 10% in a matter of two years. The studies that I did with Dr Schofield and others in the Wam area in Papua New Guinea showed that infant mortality rates in the first five years of such programs came down from 250 per 1,000, to 80 per 1,000 per year and in the next five years to 40 per 1,000 per year.

The pilot projects were so successful that it was decided to try and conduct a country-wide program in the Solomon Islands. The people who undertook it, did so with a great deal of dedication and, within five years, the incidence of malaria was reduced to very low levels, particularly in the Western and Eastern Provinces but never down to such low levels across the central part of the country. Here it only reached the figures that we saw at the end of the second World War of 20 per 1,000 per year. Despite this it was decided during the mid-1970s to stop spraying in the East and West of the country. This was done at a time when the

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next long term cycle of malaria was due to begin. Unfortunately, the mass drug administration programs which were also conducted in the central groups of islands, were also stopped at that time. As a result, the cases of malaria started to increase rapidly. There were 3,000 cases in 1974 but the number of cases rose rapidly so that in 1983, only 9 years later, there were 84,000 cases.

What happened between 1974 and 1983? As I mentioned, the first thing that happened was that spraying was stopped in the West and East. This allowed the anopheles mosquito, which transmits malaria, to multiply in great numbers. In addition, there was increased economic development around that time. Population movement increased, particularly between the West of the country and the island of Guadalcanal and between the Florida Islands and Guadalcanal. These were the main areas affected with case numbers and case loads growing rapidly. In addition to this, chloroquine resistant strains of falciparum malaria were introduced from Papua New Guinea. This occurred in 1978 and, gradually spread across the country, from West to East. It was quite remarkable because in 1980 during i*n vitro* sensitivity tests in the field we found that there was no chloroquine resistant falciparum malaria in Guadalcanal, nor was there any in Malaita but quite a lot was found in the Western Province. We had to carry around a generator weighing about 175 kg and had to put it across a little canoe to take it from village to village hoping that someone would overturn the canoe so the Army would provide us with a new, lighter generator. We carried out these tests in the field and found there was quite a lot of chloroquine resistant falciparum malaria in the West, but none in the central group of islands of Malaita, Floridas and Guadalcanal in 1980. As there was an epidemic of malaria at that time, by 1981 there was plenty of chloroquine resistant falciparum malaria throughout the central group of islands. So, within one year, there was a complete change in the pattern of sensitive and resistant strains and the parasite species ratio.

When malaria parasite species were first looked at in the Solomon Islands there was a predominance of Pl*asmodium vivax*, which does not kill but makes people very sick. By the time chloroquine resistant falciparum malaria had appeared, the species ratio had been inverted and there was a predominance of *Plasmodium falciparum* which exists today.

Dr William Osler was probably the first person to elucidate the principles of malaria eradication around 1906. These were (a) to protect people from bites by infected mosquitoes, (b) to reduce the number of mosquitoes, and (c) to radically treat patients. This is exactly what we are doing today but with slightly different technical means of doing it.

When we refer to drug resistant malaria, this does not mean an absolute degree to resistance. The common parasite which is resistant to the drugs we use in malaria treatment is *Plasmodium falciparum*.. Unfortunately, it is the killer parasite and quite a nasty parasite; it creeps up insidiously and it makes people very sick, frequently causing death or severely debilitating them. So severely that in areas where you have a predominance of chronic malaria, most people have a haemoglobin level of about 70%, therefore an oxygen carrying capacity of around 70% and all the repercussions of that.

Here in the Solomon Islands at the moment, about 50% of falciparum malaria is resistant to chloroquine, this being the most commonly used drug in treatment of malaria. About 50% is sensitive so that is not a bad level. Of the 50% of resistant strains, 95% are resistant at the R1 level or at the level of least resistance. About 2% or about 3% are at R3 level but we rarely see these cases. They are fairly easy to treat once you get them.

How do you recognise chloroquine resistant falciparum malaria? When a person first falls ill with malaria, they are treated with chloroquine for 3 days. After treatment, the patient recovers both clinically and parasitologically. In fact, the parasites clear completely from the blood. If the parasite is sensitive, there will be no further recurrence at all and no relapse because falciparum malaria does not have a secondary tissue phase. Once it is treated and it has gone, it has gone. However, with the chloroquine resistant strains there are a few parasites which remain in the bloodstream at sub-patent level, so they cannot be recognised by looking at the blood, they are just there. The malaria recrudesces from between 7 days and a month after the first treatment and the patient will come in again complaining of the usual prodromal symptoms of malaise, flu-like illness, joint pains, etc., which will progress on to a rigor and which will eventually become synchronised and will re-occur about every 48 hours. At that stage, having treated the case, knowing that the patient has come back with another rigor, another attack of malaria between 7 and 28 days after the first, you suspect that he probably has an R1 type of chloroquine resistant falciparum malaria. If it is the R2 type, there is a slightly different picture. Initially, after the treatment with chloroquine, the patient responds fairly well but, the parasitemia only comes down to about a quarter of the original level and then begins to climb again and the patient's symptoms return. With R3 type, there is either no improvement or the patient just gets progressively worse.

How does one treat it? The treatment of chloroquine resistant falciparum malaria is fairly simple. First of all, with the R1 resistant strains, the response to chloroquine is still very good, so on the third day when the parasitemia has gone down to a very low level, again usually sub-patent, you give Fansidar, a combination of pyrimethamine and sulphadoxine in a single dose and that is sufficient to mop up the remaining parasites. Why do we give it on the third

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day? Pyrimethamine and sulphadoxine are plasmodistatic drugs as opposed to the plasmodicidal drugs like chloroquine, quinine and amodiaquine. So, first of all, we have knocked down the parasites to a very low level by using plasmodicidal drugs and we only have a very few parasites remaining. These can then be mopped up, so to speak, by the slow acting Fansidar which also remains in the blood for some period of time having a half-life of approximately one week. This is the simple treatment of uncomplicated chloroquine resistant falciparum malaria.

If the person has an R2 or R3 resistant strain, then one would use quinine in the first instance. Quinine is a very old and well tried drug. It is very rapidly absorbed and it is plasmodicidal in its action and reduces the parasitemia very quickly, so that within 24 hours the parasites come down from the order of say, 100,000 per cu mm to about 1,000 per cu mm, then further down so that by the third day most of them have disappeared and are ready to be mopped up by the Fansidar. Quinine alone could be used, but if used alone, it would take 7 days of treatment. I do not know whether any of you have taken quinine but, after the third day, when you feel as though a railway train is rushing around in your head and there are bells ringing all over the place, you are having hallucinations and sweating like blazes and thinking it is worse than the malaria attack you have just had you do not feel like taking any more quinine. Therefore, quinine therapy should be supervised to ensure the drug is taken and dosage reduced where necessary to relieve these untoward side effects of the drug.

So much for the treatment of the uncomplicated case. The complicated cases are much more difficult to treat and would require a separate talk.

Malaria chemoprophylaxis. What should one do when going to an area where there is malaria? The first thing is to find out whether there is any chloroquine resistant falciparum malaria and find out which drugs are effective in prophylaxis. The second thing to do on arrival in the area is to remember hat the anopheles mosquitoes have a predilection for biting at night. They bite around the ankles mostly and if one is covered around the ankles they tend to try and bit further up but not so frequently. They also tend to stay around the rural areas and not so much in the urban areas so one will not find too many around the Mendana Hotel. If you stray into the bush at night, you might find some anopheles mosquitoes biting. The female anopheles is the one that bites because she is the only one that sucks blood. The male does not suck blood at all, so it is only the female that transmits malaria.

How do you protect yourself?. You should wear long trousers and socks and long sleeves. If you do not do that, I suggest that you use a repellent. These are the first principles of protecting yourself from mosquito bites. You should also sleep in screened quarters at night or under a net and if you do that, in most cases, you will be lucky enough not to be bitten by an infective mosquito. In addition to that, in areas where malaria is highly prevalent and where it is transmitted constantly throughout the year, it is wise to take some sort of chemoprophylaxis. Some people do not but they are tempting fate and I have treated too many of them and brought them back from death's doorstep to know that they should be taking chemoprophylaxis.

What does one take? Here in the Solomon Islands the parasite is still very sensitive to the very simple antimalarial proguanil, which is the least toxic of all the antimalarials and does not cause many side effects and certainly does not cause any nasty ones. Pyrimethamine cannot be used because there are pyrimethamine resistant strains which are highly resistant. Chloroquine, despite the fact there are chloroquine resistant parasites here, can still be used and it is very effective. Amodiaquine can also be used and belongs to the same chemical group as chloroquine, the 4-aminoquinolines, and is just as effective. Third line drugs will be discussed later. Proguanil has to be taken daily. For people who cannot remember to take daily tablets, it is pointless giving proguanil because it is excreted very rapidly and the blood levels would fall too rapidly to ensure protection. Chloroquine is taken weekly. Fansidar, a third line drug, is to be used only in treatment of chloroquine resistant strains in combination with chloroquine or quinine since it is plasmodistatic and, because of its mode of action, resistance develops very rapidly. As it is our only line of treatment for the drug resistant cases at the moment, we like to keep it in reserve for that purpose.

Dr David Parkinson's address is World Health Organisation, PO Box 22, Honiara, Solomon Islands.

CEREBRAL ARTERIAL GAS EMBOLISM OR CARBON MONOXIDE POISONING A CASE REPORT

John McKee

This is a case report about a 32 year-old diver, a Victorian who visits the south coast of New South Wales periodically for sports diving activities. He has had 7 years experience on hookah and on scuba equipment. Last year he was having another sporting dive off the far south coast of New South Wales.

On the day of his "accident" we have no idea of the profile of his first dive. We believe it was probably not more than 30 or 40 feet as he was diving on hookah equipment. We know the second dive profile and that was also using hookah, a dive to 20 feet for approximately 5 minutes when he was struggling with and trying to loosen an anchor which was caught on the bottom. He succeeded in doing this and was then observed to ascend rapidly. On reaching the surface complained of feeling nauseated. He was helped aboard the boat, his nausea was then worse but he attributed this to sea sickness. Within a further 2 or 3 minutes he collapsed on the dive boat. The description we have from his buddies was that he soon went unconscious. He was unable to speak. He was unable to open his eyes and one buddy described him as going rigid in the back. The buddies said that he was "unconscious" for perhaps 90 minutes. When he was brought to shore he was subsequently transferred by air ambulance to the Prince Henry Hospital Hyperbaric Unit in Sydney. I expected that he would have been transferred to Morwell as he came from Bairnsdale. He arrived in Sydney within approximately 4 hours of the diving accident, not pressurised, and when admitted to the hyperbaric unit he was fully conscious, it was noted that he was not speaking correctly and he used incorrect words. His mental processes seemed to be somewhat slow, his blood pressure was 180/120 initially but after resting for 20 minutes this fell to 150/80. A chest x-ray was done and this revealed no abnormality. He was immediately put into the hyperbaric chamber on oxygen.

In the meantime a full blood count and electrolytes were normal. The most interesting thing in the first blood test, which became available while he was still in the chamber, was the fact that his carboxyhaemoglobin was 20%. He was treated on the usual tables and by the following day his carboxyhaemoglobin had returned to normal. His CT scan showed a diffuse mild cerebral oedema but no other abnormality and an EEG showed some mild abnormalities on the left side with hyperventilation.

His treatment involved after the hyperbaric treatment, 2 days in bed and he was then mobilized. On the fourth day, after being examined by a neurologist, he was permitted to leave hospital.

I think it is worthwhile pointing out that carbon monoxide is toxic, it is odourless and it is tasteless. The greatest problem with it is its affinity to combine with haemoglobin, 200 times greater affinity than oxygen, to form carboxyhaemoglobin. Carboxyhaemoglobin displaces oxygen and hence if sufficient combination occurs hypoxia will result. The hypoxia produces symptoms. Probably some symptoms occur as a result of a direct toxic effect on the cell.

The interesting thing in the treatment of this patient was the fact that he, perhaps accidentally, received the correct treatment by having hyperbaric oxygen. The amount of oxygen in solution was increased so that the supply of oxygen to the cells and tissues was increased and the haemoglobin system was more or less bypassed. At the same time of course the oxygen encouraged the more rapid diffusion of carbon monoxide. As you know the correct treatment for most cases for carbon monoxide poisoning is hyperbaric oxygen.

In summary then, this was a sports diver who had two dives, one and somehow or other his hookah intake was contaminated with carbon monoxide from the compressor. Presumably he had some symptoms at the end of the first dive and they became much more pronounced on the second dive. I would have thought that if he had a carboxyhaemoglobin of 20% at least four to six hours after emerging from the sea, the level at the time when he came to the deck may well have been 50%. At 14%, divers may have headache, dizziness and some breathlessness on exertion. At 30% they usually become confused and supposedly at 60% they become unconscious. This patient maintains, during the 90 minutes that his buddies thought he was unconscious, that he was not unconscious but he admitted there was no way he could open his eyes and there was no way he could speak.

So the suspected cerebral arterial gas embolism due to pulmonary barotrauma after struggling with the anchor and a rapid ascent turned out to be a case of carbon monoxide poisoning.

Dr J McKee's address is PO Box 265, Bega NSW 2550, Australia.

CLAM MARICULTURE

David Davies

Introduction

For thousands of years, the seven species of Tridacnid bivalves or giant clam, prevalent in the Pacific, have played an important role in the diet, folklore and mythology of the Pacific Islanders. In some areas a traditional form of farming of the clams has occurred on the fringing reefs but, despite this, over harvesting has resulted in depletion of stocks and even in local extinction. During recent decades, massive commercial exploitation, mainly for the Asian market, has resulted in wide spread depletion of natural stocks in many areas and total extinction of the species in other areas.

Tridacnid harvesting for the Asian market is extremely wasteful as the fishermen have been taking only the adductor muscle. The shell, mantle and entrails are discarded despite the fact that all the flesh, apart from the kidney is quite edible. The Chinese tend to prefer the meat in the dried form whereas the Japanese prefer to use the raw form for sushi and sashimi.

Until stringent regulations were introduced and enforced by both the Australian and Taiwanese Governments, both

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the harvesting and importation into Taiwan was done illegally and consideration of the 1985 figures shows the reason. On the wharf in Taiwan a clam fisherman could command US$22.00 per kg, for frozen clam adductor muscle. Sun dried to about 30 percent of its live weight, this meat was being sold for US$120.00 a kg. It has been estimated that there is a market in the ASEAN region for about 3-4,000 tonnes of tridacnid meat per year.

Rates of meat production by young giant clams are similar to those produced by European Mussel Farms. However, because the clams can be raised without the high management costs, tridacnid mariculture is potentially more attractive than traditional ocean-based protein production system.

In order therefore to overcome this exploitation and devastation of the natural resources, programs have commenced in several centres throughout the Pacific Basin to try and breed the species back to some semblance of normal numbers.

The habitat of the giant clam is largely limited to the sunlit shallow waters of the coral reefs of the largely unpolluted Indo-Pacific islands. For many years it was considered not feasible to artificially grow these animals because of the limitations imposed by low concentrations of phytoplankton and essential inorganic nutrients. Trench and others in 1981 showed that a dinoflagellate living in enormous numbers in the blood sinuses of the siphon and mantle tissues supplied not only the major nutritional needs of the clams but were also responsible for the large size and the rapid rate of growth of the clams. Thus, for the reasons that the clams are sedentary, have very few predators, have a high growth rate, a high market value and much of their feeding is photosynthetic they become excellent candidates for domestic production.

Yamaguchi pointed out numerous similarities between tridacnids and trees and suggested that giant clams should be managed like intensive forestry.

Currently, research and development programs are underway in Palau, Fiji, Papua New Guinea, the Philippines, the Solomon Islands and Australia. The Australian centres are based on Orpheus Reef, run by Professor Lucas of the James Cook University, and a small commercial venture on Fitzroy Island, near Cairns. Figures from the Micronesian Mariculture centre on Palau, suggests that intensive farming of giant clams will produce as much, if not more meat than a comparable area of mussels.

Commercial production

Commercial production of large numbers of giant clams occurs in three separate phases, each of which has its own requirements.

The Hatchery

This is the land based section of the organisation. It needs to be sheltered, close to clean water, unpolluted by man or fresh water, and close to a fairly shallow reef suitable for planting out the seed clams. Usually the hatchery is set up with large tanks through which filtered seawater is pumped.

The broodstock clams are harvested from a nearby reef. Because the Great Barrier Reef is a Marine Park and the giant clams are protected species, it requires months of negotiation and a special licence to do this. Harvesting the mature clams too is quite a difficult manoeuvre as they are usually embedded in the reef and they are very heavy, requiring either several men or a mechanical lifting device such as a craypot hauler. These clams are then placed in the spawning tanks where they are covered with about 50 cms of filtered seawater.

Clam spawning takes place usually in the second and last quarters of the lunar month and occurs throughout the year. Prediction of spawning is made more accurate by needle biopsy of the gonad through the mantle tissue as not all clams spawn every month. As soon as spawning occurs, the tanks are flushed with filtered seawater, until all macroscopic evidence of semen disappears. About four hours later egg release commences and fertilisation takes place immediately with the residual sperm remaining in the mantle cavities of the brood stock. On completion of this phase the brood stock are replaced on the reef. The water level is raised to about one metre and the tanks are then left undisturbed for about seven days.

In the tank there is usually an algal bloom at about day 3 which coincides with the commencement of larval feeding. Metamorphosis of the larvae then occurs on day 5 and the resultant baby clams settle out onto the floor and sides of the tank. Once settlement occurs the tanks are gently flushed with filtered fresh seawater for about 8 hours per day. Despite this filtration, many varieties of other sea life find their way into the tanks. Most of these intruders need to be culled to prevent predation of the vulnerable young clams. However some other species such as the trochus are useful to keep the tanks clean of excess algae.

At about 5-6 months of age the young clams are scraped off the bottom and sides of the tanks and are transferred to special plastic trays, the bases of which are covered with basalt gravel. The clams at this time are about 12-17 mm in length so that about 1000 fit into each tray. The basalt gravel in the tray allows the byssal threads of the clams to fix but still enables them to be thinned without disturbing the clams or breaking the byssal threads. Over the next 4-5 months the clams grow to 30-40 mm in shell length at which stage they can be transferred to the waters of the lagoon.

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It is essential that all the materials used in the construction of the tanks and trays are inert. Early work resulted in losses of total populations of young clams until it was discovered that the clams were being poisoned by the chemicals leaching out of the plastic of the tanks.

The Nursery

In the sheltered, fairly shallow waters of the coral lagoon the young clams are maintained in trays on basalt chips until, over a period of 15 - 18 months, they grow to 100-120 mm in shell length. To reduce attack by predatory snails, crabs, octopus and fish, the trays are placed on concrete bricks about 30 cms above the sea floor and a polyethylene mesh lid is placed over the trays. As the clams grow, the trays become over-crowded so that, at regular intervals, the trays need to be lifted to the surface and the clams separated and thinned. This requires the services of a diver but as the water is shallow, decompression sickness is not a problem but gas embolism may be. Our experience is that most of the diving at this stage can be breathhold, thus overcoming all these worries.

There was initially concern that overgrowth of algae and weed on the mesh covers of the trays would exclude the sunlight thereby reducing the rate of growth of the clams but it has been found that this weed is a good source of food supply for parrotfish, surgeonfish and the like which tend to keep the weed growth under control. The screens are also cleaned when the clams are decanted into other trays so that the potential problem has not, in fact, been realised.

It has also been found that the trays with their protective cover act as an artificial reef and many little fish find refuge inside and under the trays. These fish, too, help to keep the trays and screens clear of excessive weed growth.

Planting Out

The nursery stage is deemed complete when the clams reach about 120 mm in shell length, usually at the age of about two years. They are then removed from the nursery trays and planted directly onto the reef. In their natural habitat clam densities vary between 10-100 clams per hectare. Obviously such sparsity is not compatible with efficient management. Since most of their nutrition comes from the photosynthetic activities of the zooxanthellae, densities much greater than this can be easily tolerated by the reef as the clams are ecologically innocuous. By the time the clams reach 120 mm in length they have very few predators and are easily able to fend for themselves. They are left on the reef for a further 2-3 years during which time they grow to the marketable size of 200-500 mm crown-rump length. At this stage the survival rate is about 90 percent.

Marketing

Clam meat

The Asian market currently takes about 3000 metric tonnes of clam adductor muscle meat each year. This is required both as fresh frozen meat and as sun dried meat.

Clam shells

Shells are a popular collectors item and small ones, 100-150 mm in length, retail for about $2-3.00 in the souvenir shops in Queensland. However larger shells up to 500 mm in length, can bring up to $100.00 each. Heslinga reported that in 1984 Taiwanese brokers were offering US$600.00 a tonne for 250 mm shells in quantities over 100 tonnes. These shells are used for crafted serving dishes, bowls, lamps and so on and, at this price, are more valuable than the meat itself.

Seed clams

There is a growing demand throughout the Pacific and Caribbean for seed clams in the 15-100 mm size range. These are used for stock enhancement, repopulation of denuded areas and experimental introductions by appropriate governments.

Aquarium specimens

In the US alone, the aquarium industry generates over US$1 billion annually and offers a potentially lucrative market. In Washington small specimens are fetching US$20.00 each and in Europe these same animals may bring up to US$50.00 each.

Whole live clams

Throughout the Pacific, small clams are usually eaten raw and have a clean, crisp, taste and texture. The rest of the clam meat is popular as subsistence food and all can be eaten except for the small kidney. This meat does tend to taste rather strongly of algae. The soft tissues can be readily used for soup or can be dried, chopped and used as high protein stock feed for pigs, marron, crayfish, prawns and barramundi.

Summary

Artificial culture of the giant clam along the lines of intensive forestry is now a commercially viable enterprise. There have been many problems in the past with the post larval stages of production but with greater understanding of the physiology and development of the clams and control of predation by other marine species, the way is now open for successful Australian production of this previously threatened species.

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DIVER RESCUE, DECOMPRESSION SICKNESS AND ITS IN WATER TREATMENT USING OXYGEN

John Knight

To rescue a diver you first have to find him. It is difficult to see divers in the water from a small boat. It is difficult for divers to see each other in the water, because of water movement and waves coming between them. The New Zealanders have had problems in the past with lost divers (see page 163) and they have produced a very effective aid in the form of an inflatable plastic tube called the Safety Sausage.[1](Figure 1) The Safety Sausage rolls up into a little bundle that fits easily in the pocket of a buoyancy compensator. When needed it is unrolled. The open end is put over the diver's regulator. One hand holds it tight round the regulator hose while the other presses the purge button. Suddenly there is a 2.4 m (8 foot) sausage of plastic, 10 cm (4 inches) in diameter, standing up out of the water clearly marking the diver's position. It is very much easier to see something sticking up out of the water than to see something on the water surface. It is quite easy to spot a mast against the horizon when one is looking for a boat. It is just as easy to spot a Safety Sausage against the horizon when looking for a diver. The Safety Sausage is wider than most small boats' masts, although not so high.

It is important that the Safety Sausage be held tightly round the regulator hose otherwise most of the air finds it easier to escape underwater rather than go up the tubing. It is a device that will sell for around $10.00 in Australian dive shops, so is a lot cheaper than a flare and unlike a flare can be used many times.

Having rescued the diver in an emergency, one has to treat any problems. One problem that is better avoided than treated is decompression sickness.

How to avoid decompression sickness (DCS)

It is usually recommended that one should always do no-stop dives. The next recommendation is always stay well within the decompression tables. What this means varies from speaker to speaker. It is important, in fact essential, when using tables that one knows the maximum depth reached. This means using a recently calibrated depth gauge. Depth gauges have been shown on many surveys to be inaccurate. There are two forms of inaccuracy. The safe one is where the gauge reads deep, because the diver thinks he or she is deeper than he is. The unsafe one is when the gauge reads shallow. This is a very unsafe form of inaccuracy as the diver thinks he is shallower than he or she actually is and dives deeper than the planned dive. There are some gauges that are inaccurate over part of their range only, so it is essential that one knows the inaccuracies of one's gauge, which means regular testing.

The next necessity with tables is to know the bottom time which requires a waterproof watch, or one of the many devices that automatically turn themselves on when a certain pressure is reached, and turn themselves off when they return to that pressure. These give a total dive time rather than a bottom time, defined as the period from the leaving the surface to starting the ascent, which is needed to work out most tables.

One should never ascend faster than 18 metres (60 feet) a minute and preferably much slower. It is quite clear that many cases of decompression sickness in Australia, and I suspect in other parts of the world, are associated with rapid ascents. I believe the correct ascent rate should be no faster than 10 metres a minute and preferably slower. One should always do a stop at 5 metres, or thereabouts, on every dive, so that there is time to let the lungs filter out any bubbles that have formed on the way from the bottom to 5 metres.

If one must do a decompression dive, one should decompress for the next deeper depth and the next longer time. A shot rope should be used because there is no other way that one can maintain depth accurately. Remember that currents and tides will swing the diver away from the vertical, so that the marked position on the shot rope will no longer be at that depth. One should always have extra air on the shot rope in case the decompressing diver runs out of air. After diving one should not fly or cross mountains for at least 12 hours and it is a lot better and safer to make it 24 hours.

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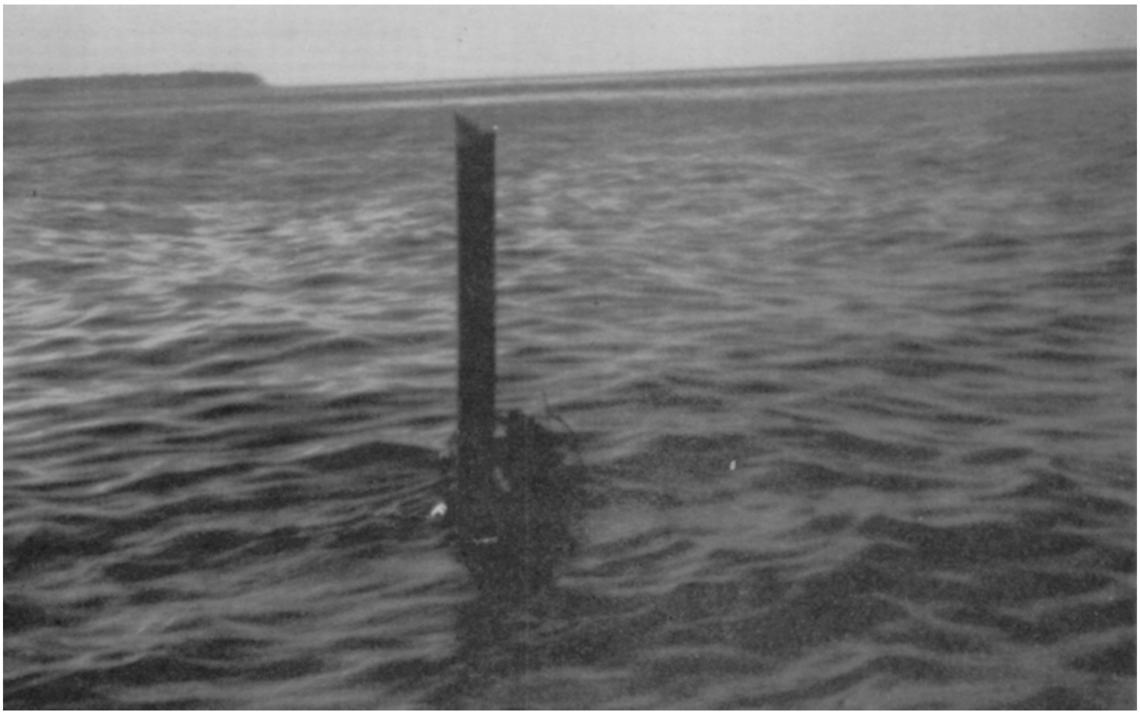

Figure 1 Diver and Safety Sausage at sea.

READ THIS BEFORE USING THE TABLES

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

ASCENT RATE 10m A MINUTE.

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

USE THE TOTAL TIME UNDERWATER (BOTTOM TIME + ASCENT TIME + SAFETY STOP TIME) TO FIND THE REPETITIVE GROUP AT THE END OF THE DIVE.

TABLE 4

MODIFIED AIR DECOMPRESSION TABLE*

Depth m	Depth feet	Bottom Time minutes	Decompression Stops minutes at 10 feet	Repetitive group
18	60	70	7	K
		80	12	L
21	70	60	13	K
		70	19	L
24	80	50	15	K
		60	22	L
27	90	40	12	J
		50	23	L
30	100	30	8	I
		40	20	K
33	110	25	8	H
		30	12	J
36	120	20	7	H
		25	11	I
39	130	15	6	F
		20	10	H
42	140	15	7	G
		20	11	I
45	150	5	5	C
		10	6	E

* FOR THOSE WHO ACCIDENTALLY EXCEED THE NO-DECOMPRESSION LIMITS

TO CALCULATE THE REPETITIVE GROUP AFTER A REPETITIVE DIVE.

3rd DIVES BELOW 9m(30 feet) ARE NOT RECOMMENDED.
A REPETITIVE DIVE IS ANY DIVE WITHIN 12 HOURS OF THE LAST DIVE.

1. Subtract the actual bottom time of the repetitive dive from the bottom time available in table 3 to get an answer in minutes.
2. Subtract this time difference from the Bassett Bottom Time limits in table 1. The answer is the equivalent bottom time of the repetitive dive.
3. Add the ascent time and the safety stop time to the answer in 2. This is the equivalent total time underwater of the repetitive dive.
4. Use this time to enter table 1 to find the repetitive group at the end of the dive.

A 2B PENCIL WRITES WELL ON THIS PLASTIC AND IS EASILY RUBBED OUT.

	EXAMPLE	2nd dive	3rd dive*
Repetitive Group before the dive.	B		
Proposed depth of dive	24 m		
Bottom time available	22 min	min	min
- Actual bottom time	20 min	min	min
= Difference	2 min	min	min
Bassett Bottom Time limit	30 min	min	min
- Difference	2 min	min	min
= Equivalent Bottom Time	28 min	min	min
+ Ascent time	3 min	min	min
+ Safety stop time	5 min	+ 5 min	+ 5 min
= Equivalent total time underwater	36 min	min	min
Repetitive group at the end of the dive	I		

The RESIDUAL NITROGEN TIME can be found by subtracting the MAXIMUM TIME AVAILABLE FOR A REPETITIVE DIVE (Table 3) from the BASSETT BOTTOM TIME LIMITS (column 3 of table 1).

Figure 3. Bassett Tables (Back)

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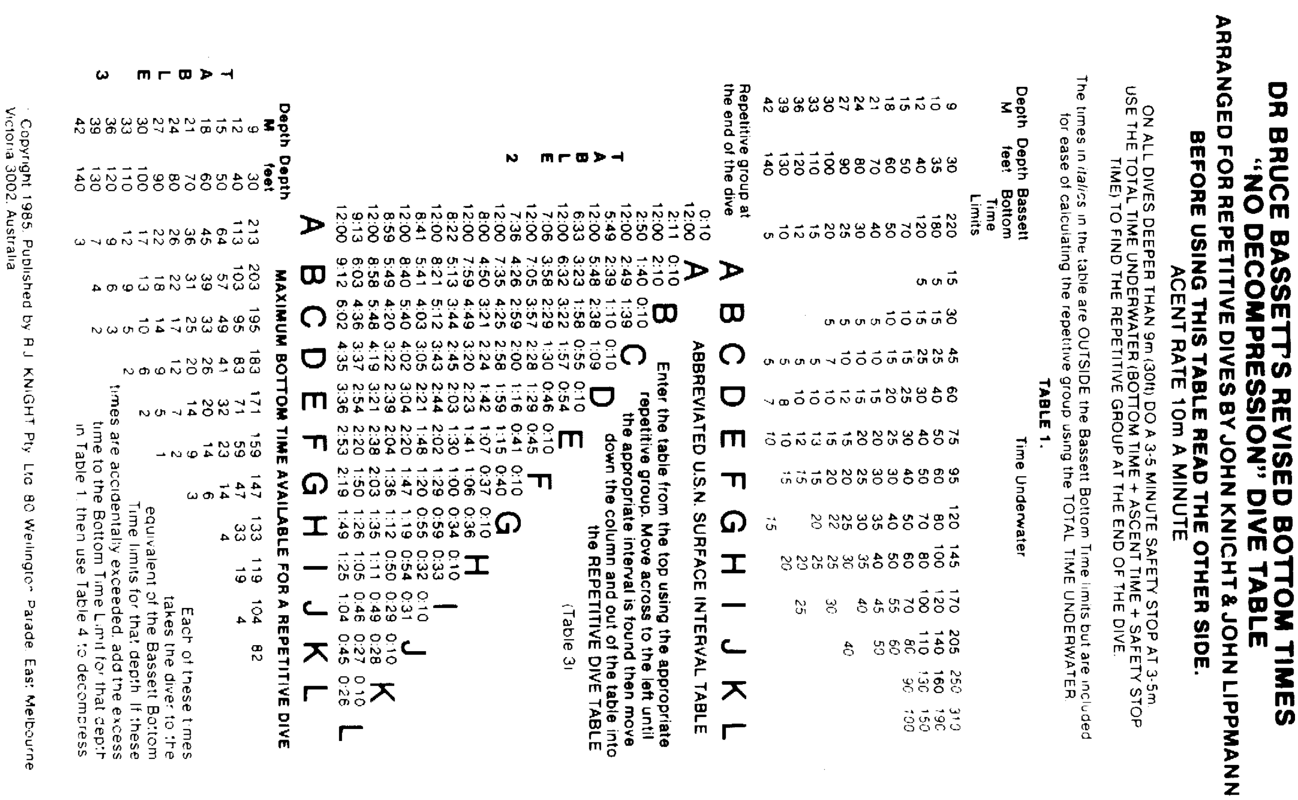
Staying "within the tables", to make them safer, requires thought and memory, both of which are affected under water. It is easier to use as safe a set of decompression tables as one can find. At the moment it is my opinion that the safest tables that are readily available in Australia are the Bassett Tables that John Lippman and I have published.(Figures 2 and 3)[2] They have a number of safety factors built in. No-decompression times are shorter because a lesser supersaturation ratio has been used in the mathematics. There is a safety stop at 3 to 5 metres for 3 to 5 minutes on all dives below 9 metres. We have amended the ascent rate from 18 m (60 ft) a minute to 10 metres a minute. So there are three safety factors for the first dive. For the second dive one uses the total time under water for calculating the repetitive group. Then using the United States Navy (USN) surface interval table, to find the USN Residual Nitrogen time. Taking this time away from the Bassett Limits gives the table for the second dive which only shows the time available for that second dive. This builds in two more safety factors.

To use the tables one selects from column 1 or 2 in Table 1 the depth one intends to dive to, and from column 3 the no-stop time available for the first dive. At the end of the dive one runs a finger across the table to find a number equal to or greater than the total time spent in the water. Running the finger down that column will find the repetitive group letter at the end of the dive. Run the finger vertically down to find the same letter in Table 2, now the finger travels across to the left to find the surface interval. When the surface interval is found run the finger down to the letters at the bottom of that table to find the new repetitive group. Continue down into Table 3 which shows the time available for each depth in that repetitive group so that the second dive does not exceed the Bassett no-decompression Limits.

The table has the advantage of being very easy to read under water, because of the yellow highlighting of alternate lines and columns, so that if one does drift deeper than one intended one can recalculate the dive profile immediately. Besides being safer than the United States Navy Tables, the table is extremely easy to use as it only requires the diver to be able to read and move his finger horizontally and vertically. It is an unfortunate fact that many divers are unable to work out for themselves the time available for their second dive. Some have great difficulty even working out the time available for the first dive. If one drifts lower than one intended and finds one has exceeded the no-stop limits in Table 1 of the Bassett Tables turn the card over



DR BRUCE BASSETT'S REVISED BOTTOM TIMES
"NO DECOMPRESSION" DIVE TABLE
ARRANGED FOR REPETITIVE DIVES BY JOHN KNIGHT & JOHN LIPPMANN
BEFORE USING THIS TABLE READ THE OTHER SIDE.
ACENT RATE 10m A MINUTE

ON ALL DIVES DEEPER THAN 9m (30ft) DO A 3-5 MINUTE SAFETY STOP AT 3-5m. USE THE TOTAL TIME UNDERWATER (BOTTOM TIME + ASCENT TIME + SAFETY STOP TIME) TO FIND THE REPETITIVE GROUP AT THE END OF THE DIVE.

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

TABLE 1.

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

TABLE 2

ABBREVIATED U.S.N. SURFACE INTERVAL TABLE

Enter the table from the top using the appropriate repetitive group. Move across to the left until the appropriate interval is found then move down the column and out of the table into the REPETITIVE DIVE TABLE (Table 3)

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

TABLE 3

MAXIMUM BOTTOM TIME AVAILABLE FOR A REPETITIVE DIVE

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

Each of these times takes the diver to the equivalent of the Bassett Bottom Time limits for that depth. If these times are accidentally exceeded, add the excess time to the Bottom Time Limit for that depth in Table 1, then use Table 4 to decompress.

Figure 2. Bassett Tables (Front). The tables are printed in waterproof ink on plastic and are varnished for extra protection. They fold easily to fit a buoyancy compensator pocket. Yellow highlighting makes rows and columns easy to follow.

and there is a short decompression table for those who have drifted lower than they intended (Figure 3). There is also the way to use the tables and a method of calculating one's repetitive group at the end of the second dive. So that if one wishes to do a third dive, which I do not recommend, it is possible to work out the equivalent bottom time of the second dive. This allows one to enter Table 1 (Figure 2) and, using the equivalent total time underwater, find the repetitive group at the end of the second dive then one can use the surface interval table and Table 3 to get the time available for a third dive.

How to recognise DCS

Most people who develop decompression sickness get their symptoms fairly soon after emerging from the water. The figures vary, but it is a fairly standard statement that 80 per cent come on within one hour and 50 per cent within 30 minutes.

The symptoms of decompression sickness are extremely wide ranging and include malaise, weakness, exhaustion, skin itching and skin rash, nausea, vomiting and abdominal pain, numbness, tingling and giddiness, joint and limb pains, disturbances of nerve function and difficulty with breathing (the chokes). Disturbances of nerve function can cover anything from patches of anaesthesia or analgesia to frank paralysis.

Two things that most of the text books do not yet include is that the personality of the diver is often affected by decompression sickness and that many divers have great difficulty in accepting that they might have decompression sickness. It is essential that a diver's buddy, who notices that the diver's personality has changed after a dive, takes steps to get the diver to a recompression chamber as soon as possible.

It is becoming more and more obvious that limb bends and skin bends are often accompanied by central nervous system changes. That means that there are bubbles in the central nervous system. CNS changes due to DCS are often vague and subjective, but reverse dramatically with recompression. Divers have to be encouraged to believe that any problem occurring after a dive are due to that dive until proven otherwise.

It is usually said that the presenting symptoms of decompression sickness are mostly pain only. Rivera published a series of 935 cases from the US Navy in 1963.[3] Presentation was with pain only in 82.7%; other 10.3%; cerebral, including inner ear, 6.4%; spinal 0.2%; and cardiorespiratory 0.4%. That was USN diving with very carefully controlled divers (Table 1). Twelve years later, Erde and Edmonds,[4] who treated sports divers presenting for treatment in Hawaii and Sydney, had very different figures. Pain only was 33%; other was 15%; cerebral, including inner ear, was 33%; spinal was 13%; both spinal and cerebral 5%; and cardiorespiratory 1%. These divers were doing deep dives and many of them made very rapid ascents (Table 2). So it does seem that the way the diver dives will influence the way he is affected.

Table 1

PRESENTING SYMPTOMS OF DECOMPRESSION SICKNESS, US NAVY

From Rivera (1963) 935 cases

Cerebral (including inner ear)	6.4%
Spinal	0.2%
Cardiorespiratory	0.4%
Pain only	82.7%
Other	10.3%

Table 2

PRESENTING SYMPTOMS OF DECOMPRESSION SICKNESS, SPORTS DIVERS

From Erde and Edmonds 1975. 100 cases

Cerebral (including inner ear)	33.0%
Cerebral with Spinal	5.0%
Spinal only	13.0%
Cardiorespiratory	1.0%
Pain only	33.0%

Emergency treatment

Divers do not come to the surface wearing a little label saying "I have decompression sickness". They come to the surface feeling terrible or are unconscious, or develop symptoms after they get out of the water. A flow chart (Figure 4)[5] starts, "Do not panic". This is because accidents are rare occurrences to the average diver, and the average diver is not going to practice his diving first aid very often and when one is faced with frightening and unfamiliar circumstances it is very easy to run round in circles, metaphorically, doing very little.

The first question one has to ask oneself when dealing with a diver who has been involved in an accident in the water, is "Is he injured and bleeding to death". If he is bleeding briskly, squirting blood, the first thing to do is to stop that bleeding. Because no matter what other resuscitation you do, that man or woman can die from blood loss if a major artery is bleeding. Once massive bleeding is under control the next question the first aider has to ask is, "Is the patient conscious or unconscious?" and this is rapidly answered by speaking to the victim. If there is no reply one has to

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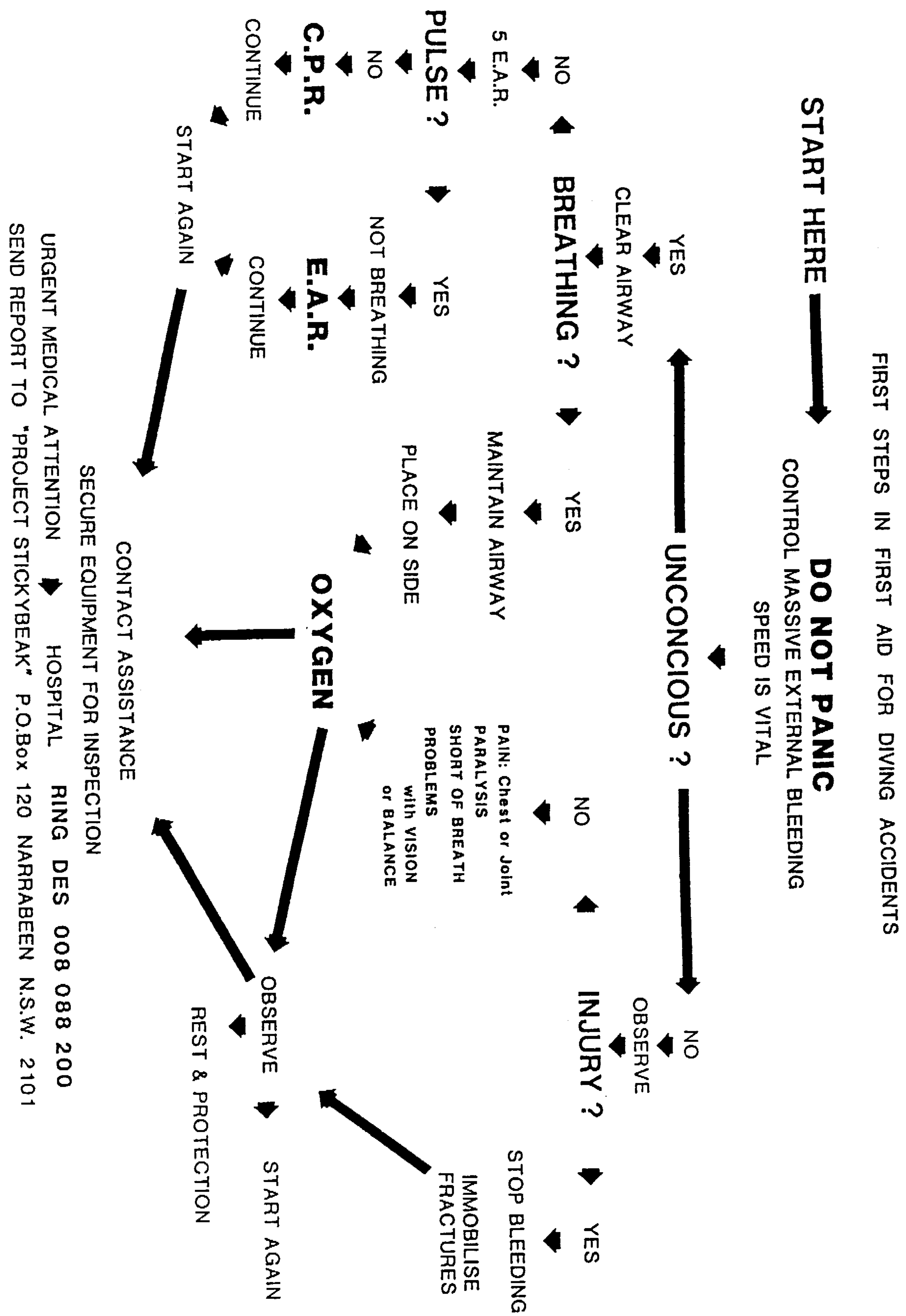

Figure 4 Diver rescue flow chart

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assume that he or she is unconscious. The next question is, “Is he or she breathing?”. If he or she is, the next thing to do is to roll him or her on their side in the coma position and observe how he or she does. If he or she is not breathing, it is necessary to give expired air resuscitation (EAR) and the current recommendation in Australia is to start with 5 quick breaths, then feel for a pulse. If there is a pulse, carry on with EAR. If there is no pulse there one has to start CPR. Either is quite a performance to carry out in a crowded diving boat. While giving EAR it is possible to give oxygen enrichment. The rescuer takes a breath from his own regulator attached to a Bendeez adaptor 6 screwed into an oxygen cylinder, between each puff into the patient. In this way a high oxygen concentration can be given for the patient.

A conscious patient has to be assessed for injury and if there is none one has to observe to see whether he or she develops symptoms that might be due to decompression sickness or air embolism, such as pain, giddiness, difficulty with breathing, paresis or paralysis and unconsciousness. If the patient has an injury it has to be dealt with and the patient observed.

All unconscious patients should be given oxygen as soon as possible. All patients having EAR or CPR should have oxygen. Once the patient is breathing on his or her own he or she should have 100% oxygen. With a diver it is fairly easy to give 100% oxygen by putting a regulator on a Bendeez and putting the regulator in the diver’s mouth. There are problems with this if the diver’s mouth will not open, but usually it will.

If somebody develops decompression sickness symptoms, they must go on oxygen to try and slow down progression of the symptoms while they are on the way to a recompression facility. The aim of giving oxygen for a decompression diving accident is to exclude nitrogen from that person’s lungs. If one can exclude further nitrogen from that person’s lungs it vastly increases the outward gradient of any nitrogen the diver has absorbed. Oxygen is most easily given in Australia by having a ‘D’ or larger size cylinder of oxygen with the diving party and a Bendeez adaptor which allows the diver’s own regulator, which he is certain to have with him, to be attached to the Bendeez and so the diver gets oxygen through his own regulator. This method works with divers because divers have been taught to breath through their mouths. It does not work with people who are not divers, as they do not like breathing through their mouths. For them one must use a bag and mask set up, which is a little bit more complicated because one needs an oxygen regulator, a flow meter, 2 m of tubing, a mask, a bag and an expiratory valve, and the whole lot costs quite a lot of money. Table 3 shows the CIG Medishield Part Numbers and December 1987 prices. The bag and mask has the snag that unless it is put on by an anaesthetist, an intensive care nurse, or mobile intensive care ambulance officer, the mask is unlikely to achieve a complete seal, and if the patient is bearded it is almost inevitable that it will not get a complete seal except at the price of extreme pressure on the person’s face. If there is any leak between the mask and the patient’s face he or she will not receive 100% oxygen. In the effort to avoid giving the patient more nitrogen, I prefer to use the Bendeez.

Table 3

CIG-MEDISHIELD EQUIPMENT NEEDED FOR GIVING 100 % OXYGEN BY MASK

Description	Part number	Price $A
Oxygen Regulator (to fit a large oxygen cylinder)		
	518800	139.40
Flowmeter	TM 105	82.40
Tubing (2m)	YR 62 per metre	.60
Expiratory valve	DF 655	163.20
4 litre bag	OBM 372764	11.90
Male connector (to connect bag to mask)		
	OBM 1353552	32.05
Resuscitation face mask (adult)		
	515743	23.60
Clausen head harness	OBM 301061	17.15

All divers should have a copy of the Diving Emergency Handbook, by John Lippman and Stan Bugg. A new revised edition[7] has just recently been produced. On its back page is a flow chart similar to the one in Figure 4, which includes the Diver Emergency Service (DES) number.

The Diver Emergency Service, is contacted by dialling 008 088 200. A telephone rings in the Intensive Care Unit of the Royal Adelaide Hospital. It is answered immediately and the diver is put onto the duty Hyperbaric Consultant who may be in any part of Australia. It is a highly sophisticated system of switching telephone calls around the country. The Australian Underwater Federation (AUF) publishes a plastic card which is headed “Diving Emergency Service”, giving the phone number. This plastic card is available in dive shops or from the AUF. On one side it has the telephone number, on the other it has the list of what to do. The routine is to telephone the DES number (008 088 200), state that it is a diving emergency, provide details of the incident, depth, time, location and symptoms, wait for advice and directions, act on the advice and directions, and follow up by informing “Project Stickybeak” by writing to PO Box 120, NARRABEEN NSW 2101. All information is treated as confidential and all identifying details are removed before any information is made public. Dr Douglas Walker is interested in gathering details of all diving accidents and accidents that have been avoided not only in fatal or nearly fatal ones.

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From overseas, one can contact DES by dialling ISD 61 8 223 28 555.

The treatment of DCS

The treatment of DCS is recompression, oxygen and fluids, preferably very soon after the onset of symptom, as this gives the best chance of recovery. This treatment is best given in a recompression chamber (RCC) equipped with intensive care facilities, which means a hospital hyperbaric unit. However, this is not always possible and there may be long delays reaching a RCC from remote areas.

Underwater oxygen therapy

Oxygen in the water treatment, hyperbaric treatment, was designed for remote locations, places where there was a long delay before the patient could hope to get to a recompression chamber. The typical scenario, when this equipment was designed by Carl Edmonds[8] in the late 1960s and early 1970s, was that people would develop DCS in the relatively less remote parts of the Pacific and even if they immediately got through to the RAN School of Underwater Medicine, it would be over 24 hours before they could possibly be retrieved. There were delays involved getting a Hercules airborne and flown to wherever the patient was, and it had to arrive in daylight because usually the island did not have landing lights on its airstrip. Then it often had to then wait overnight and take off the next morning. Sometimes it took two days or more to get a patient to Sydney. Remember that the sooner a person is recompressed, the better chance he or she has of a useful clinical result.

What are the advantages of hyperbaric oxygen in water? There are none if one is close to a recompression chamber. The diver must be a long time from a recompression chamber before in water oxygen has an advantage. By long time, I mean that it will take more than 6 hours to reach the chamber. I think that if I had a paraplegia I would bring that time down to one hour. It is a warm water, tropical island, treatment. It is a treatment for out of the way places, with long delays in reaching a recompression chamber. Although Carl Edmonds has tried it in the Antarctic, I consider that in southern Australian waters, without extra heating, one would convert a decompression sickness patient into a patient suffering from a combination of decompression sickness and hypothermia. Its major advantage is that no nitrogen is added to the body during treatment. The bubbles are approximately halved in volume, whatever shape of size they are. With round bubbles the diameter is reduced by approximately 20%. The diameter of a long bubble in a blood vessel will not be reduced at all, but the length will be reduced, so reducing the frictional resistance and increasing the chances of the bubble moving on. There is a large nitrogen pressure gradient out of the bubble. There is increased oxygenation of the tissues that are being perfused. Also there is increased oxygenation of the tissues that are not being perfused because oxygen will diffuse much further because of the high pressure gradient.

There is said to be no risk of oxygen toxicity. The only case reported of oxygen toxicity using this system[9] was some years ago and it is disputed by some people.[10] There is no risk of decompression sickness for the attendants. Finally, wet suits are still effective insulation at 9m.

What does one need to give the treatment in a remote part of the world with warm water? Emergency decompression in water using oxygen requires a full face mask. The chances of a person having an oxygen convulsion under water are low resting at 9m but it is always possible. A person who has not got a full face mask on when he has a fit is almost certainly going to drown. So a full face mask should be used. If the patient vomits under water, he or she vomits into the mask. It is a relatively simple matter to clear the vomit from the mask. A finger is put under the chin and the mask lifted up a little bit and the vomit will trickle out into the water. The patient needs a wet suit including a hood. He or she needs a shot rope to hang onto. A rope is needed to support the patient so that the patient cannot drop. Preferably this should end in a seat for the patient because sitting in a rope soon becomes very uncomfortable. The depth must be limited to 9m and that is achieved by putting a mark on the rope 9m from the patient and keeping the mark at the surface. The patient must be over weighted, and it is a good idea to put a weight on each ankle so that his or her legs do not float up. An attendant is needed in the water to watch the patient. A communications system is needed. The simplest communication system is that the patient talks into the full face mask. This is easily understood by the attendant. The attendant must have some sort of slate to write on so that he can write messages for the patient to read. When information has to be taken to the surface the simplest way is for the attendant to signal the surface for another attendant to be sent down. When he or she arrives, the first attendant goes up to the surface and gives the message to the supervisor.

The equipment SPUMS has is a Scuba Pro Visionnaire full face mask (Figure 5) and the hose comes off the top of the mask. It has to be led down the patient's back and put under the weight belt so that if the patient does convulse it is not going to be dislodged by the patient thrashing about. With the Visionnaire full face mask the glass acts as an inhalation diaphragm. The inboard end of the equipment is preferably a 'G' size cylinder of oxygen which will last for a full treatment, and an oxygen regulator which has to be adjusted to as near 100 psi as possible. Anaesthetic regulators are set to 60 psi and can seldom be adjusted above 80 psi. The oxygen hose must be clearly marked in feet or metres so as to control the ascent. There has to be a tender for the

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Figure 5. Diver in Visionnaire full facemask ready for in water oxygen recompression.

oxygen hose, to keep an eye on the patient. There has to be a minimum of a spare tender. Someone has to keep records of times and depths. So there has to be a minimum team of 4. Then all that is needed is 9 metres depth of water. This can quite often be found alongside a jetty, and if not, one has to take the patient out to sea.

The patient is put on oxygen. The face mask must be fitted tightly to the head, because if it is not tight water gets in and that is uncomfortable and may be dangerous. The attendant is kitted up breathing air, the patient is lowered to 9 m with the attendant alongside him. The patient stays at 9 m for 30-90 minutes depending on the progress of his decompression sickness. If it was a pain only bend and it is completely cured by 30 minutes, the patient may start the ascent. If the patient has neurological decompression sickness and is completely cured by 30 minutes, he should be kept at 9 m for at least another 30 minutes. The ascent rate is either 1 metre every 12 minutes or, what is fractionally slower, 1 foot every 4 minutes. These rates give ascent times of nearly 2 hours, so it is a short oxygen treatment.

If the oxygen runs out the patient is brought straight to the surface because the whole object of the exercise is to exclude further nitrogen loading. The patient must not be given air while under water. Once the treatment is completed the patient is given oxygen by mask for alternate hours for the next 12 hours.

Hyperbaric oxygen in the water is an emergency treatment for use in warm water in places where a chamber is more than 6 hours away. I have no intention of promoting it as anything other than a second best treatment compared with chamber treatment. However, it is far better for the patient to be treated promptly than to have long delay. I am unaware of any cases who have been made worse by this treatment. There are sufficient people who do not approve of in-water oxygen recompression to make it fairly certain that should anyone have been made worse the word would get out.

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RECREATIONAL DIVING STANDARDS IN AUSTRALIA A MOVE TOWARDS STANDARDISATION

WA Williams

The development of the underwater breathing apparatus opened up the underwater world to the masses. It suddenly took what had been the domain of the professional hard-hat diver and gave it at minimal cost to a large number of people.

I am sure there are people here today who can remember those intrepid adventurers of the late 40's and early 50' s who made their own masks from inner tube rubber and plate glass, and clad in bathers and an old jumper for warmth and armed with a five foot long home-made speargun, entered the waters around our coastline.

When the first scuba gear appeared on the market, these spearos changed from breath-hold to compressed air divers and our sport was born. At that stage, little was known of the effects of breathing compressed air and inevitably accidents occurred. Them was no formal training as such and the need for adequately trained instructors became apparent. One of the first national bodies to get themselves organised and create some form of progressive training standard, and standards of the day in most British Commonwealth Countries, including Australia, was the British Sub-Aqua Club.

In Australia, the Australian Underwater Federation emerged as the body which represented the sport of skindiving and the growing offshoot of scuba-diving. At that time, the various clubs around Australia joined together to create the Federation which controlled the skindiving competitions and set the sporting rules and standards. The AUF produced a set of diving standards, initially based on the BSAC standards, but modified to suit the unique needs of the Australian diver. Our long, sparsely populated coastline dictated that our divers needed to be self-sufficient in areas such as accident management, boat diving, dive planning, etc. Thus our standards placed greater emphasis on some aspects of training than the BSAC, but we still retained the club orientated system of scuba instruction.

These standards have been modified over the years based on experience, reports on common accidents as revealed by Project Stickybeak and on the changes in equipment. Overall however, these standards have produced safe competent divers capable of diving with a buddy to depths of 20-30 metres.

In the UK, it is relatively easy for the BSAC clubs to maintain an even standard of club instruction as visiting examiners from other clubs located in nearby cities ensure standards are kept. In Australia however, the large distances between cities and thus clubs, proved impossible to fund such visiting examiners and inconsistent standards of divers resulted. We therefore had the standard, which by that time had been accepted by the World Underwater Federation (CMAS), but not real way of ensuring that it was maintained at an even level around Australia.

By the early 1970's, the number of people being attracted to scuba diving reached a level where specialised diving instruction on a commercial basis became economically viable. Shops specialising in the sale of scuba equipment emerged, and the owners set up their own instructor course based on the owner's knowledge and what was known at the time.

There were sufficient of these owners and instructors who had trained through the AUF to create an Australia-wide instructor body. Thus, the Federation of Australian Underwater Instructors (FAUI) was born and an agreement which suited both organisations at the time was signed. FAUI agreed to use the AUF scuba diving standards if the AUF agreed to stop club instruction. Hence we obtained professional diving instruction and were better able to maintain a standard, issue international diving certification, and ensure safe diving in Australia.

Like all monopolies, we became a little complacent, and in the late 1970's the two American instructor organisations, Professional Association of Diving Instructors (PADI) and National Association of Diving Instructors (NAUI) entered the field and began to make inroads into the diving scene.

Both of these instructor bodies have the backing of their parent organisation and have standards based on an entirely different philosophy. Whereas the BSAC originated AUF/FAUI standards tended to be conservative and attempt to fully train a diver in all aspects before granting him/her a certificate to dive, the American courses were based on progressive teaching using individual course packages, that is, one could become a scuba diver without being taught rescues or even have dived in the sea. The courses were designed in America to suit American conditions and were well presented, easy to sell and generally less expensive than the home-grown courses.

Thus the AUF/FAUI partnership began to feel the strain as the conservative safety-first AUF resisted change while the FAUI shop owner felt the need to become competitive with PADI and NAUI.

In the early 1980's, the Australian Coaching Council approached the AUF to produce a set of diving standards which would be recognised under the National Coaching Accreditation Scheme (NCAS). Naturally we used as a basis our standards which had been designed around the need of Australian divers. As FAUI instructors taught to

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these standards, all were able to become a National Accredited Coach and other instructors who were able to demonstrate that they had similar qualifications were also accepted.

However, our methods of teaching and examination differed from those of both PADI and NAUI, and neither organisation were able to change or amend their system to accomplish certification to the NCAS. As schools and other government institutions began to refuse any instructor who had not an NCAS qualification, a long series of political arguments commenced which unfortunately is still going on.

In 1985, FAUI, feeling the need for independence, broke away from the AUF, but its standards are still such that their instructors can become registered under the NCAS should FAUI choose to apply for this. NAUI in the meantime had gained a level of independence from their parent organisation and had reached an agreement with the AUF to teach an additional package at their instructor qualification courses and thereby also gain NCAS certification. We had thus gained standardisation to some extent, although PADI, by now the largest of the instructor bodies, were still not eligible.

In 1984, the Standards Association of Australia released a draft standard for the working diver. This standard, called “Training and Certification of Divers” was supposedly for professional working divers only, in fact it included a disclaimer that it was not meant for recreational divers. The draft was in four parts and was based around a similar standard in force in the UK for the teaching of North Sea Divers. The parts were: 1. Air Divers, 2. Restricted Commercial Air Divers, 3. Commercial Air Diving with Surface Compression Facilities; and 4. Bell Diving. However, the first part, ie. for air divers, appeared to contain glaring discrepancies between what level of competency was sought and the actual subjects to be taught. By its very title, the AUF became alarmed that we would be getting a pseudo new set of standards on which some uninformed coroner would base a finding, regardless of the disclaimer in the standard.

Accordingly, we presented the SAA with an 18 page series of comments on the inadequacy of the standard and proposed, as a counter, that the NCAS standards be used as a start point on which to base Part 1. After all, the professional diving student needs to be taught to scuba dive first of all just like any other diver. As a result of our submission, and many others from equally concerned organisations, the SAA produced Parts 2, 3, and 4 of the SAA Standard AS2815 and kept Part 1 for further consideration.

I was then involved in negotiations with the SAA which finally resulted in the SAA Committee forming a separate sub-committee to investigate the feasibility of producing Part 1 as a standard for recreational and professional air divers, ie. the first section of the standard will adequately train air divers while the second will continue with the training to produce a professional air diver who can then progress through Parts 2, 3, and 4 to finally become a lock out diver.

The initial meeting of this sub-committee was in Townsville on 18-19 June 1986 and in those two days almost accomplished what we have been trying to achieve for 10 years.

All concerned bodies sat down, and using the AUF Philosophy Paper which had been produced to show the reasons for our standards, we were able to almost reach a consensus. Naturally, there were disagreements, but in many cases after discussion, we were able to reach an agreed standard or test which although different to what we were used to, had the same long term effect.

During this meeting, and of interest to this audience, Dr Ian Millar, representing the Australian Medical Association, (no SPUMS representative was on this sub-committee by the way) had a very instructive discussion with the sub-committee on the requirements of the medical examination for the standards.

In Sydney on 12 and 13 February 1987, the sub-committee met again and reviewed our original findings. There still were some disagreements and we agreed at that stage to disagree but to present our findings to the parent committee for approval to send out for public scrutiny. Ian Millar by then had produced his draft medical tests and a very lively discussion took place, mainly based around trying to find a fool-proof way of getting the medical result to the diving instructor quickly without breaking doctor/ patient confidentiality.

I have just been informed that the sub-committee will be presenting its findings to the parent committee in Melbourne on 1 July 1987. I expect that the draft should be circulated for comment by the end of the year. Areas which are in disagreement are:

- The distance specified for the snorkel swim while wearing scuba and if a diver should demonstrate his fitness during the swim by being neutrally buoyant or be allowed to use his buoyancy vest.
- The minimum total bottom time required by the trainee prior to certification. The current suggestion is 140 minutes although the AUF would like 4 hours and others would wish this to be reduced to as low as 80 minutes including assessment time. (If anyone has any information on the period of learning a new skill until it becomes second nature, I would be pleased to be informed of it).

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- The instructor/student ratio is another problem.
- The standard of the scuba rescue test.

I would urge you, as the people who will be involved in the medical tests and the unfortunate results if we make mistakes with these standards, to examine the standards when they appear with a critical eye to the safety of the student.

Once circulated for public comment, the sub-committee will need to re-convene to examine the results and make the necessary adjustments. The second draft will then be re-circulated for public opinion by which time hopefully, a full consensus will be reached and the standard produced.

Let me state now that in many of these tests the standards of the four organisations are at a much higher level and in other cases equal. Each instructor organisation intends to continue to teach to their own standards. The Australian Standard will merely state the minimum levels which can be taught. Once the standards are released, it will be up to state legislation to legalise its use.

Perhaps then, we will have achieved our goal of a set of safe standards for the Australian Scuba Diver.

Wal Williams is Chairman of the Technical Committee of the Australian Underwater Federation. His address is 46 O'Rourke Street, WEETANGERA ACT 2614.

MINUTES OF THE EXECUTIVE COMMITTEE MEETING

HELD ON MONDAY 2 MARCH 1987

AT THE HOTEL HILTON INTERNATIONAL, SYDNEY

PRESENT

Dr C Acott, Dr C Lourey, Dr D Davies, Dr G Barry, Dr D Walker, Dr A Sutherland, Dr J Knight, Dr P McCartney, Dr L Greenbaum (Executive Secretary of the Undersea and Hyperbaric Medical Society), Dr M Fraundorfer.

1. MINUTES OF LAST MEETING:

   The minutes of the two previous meetings were circulated and confirmed.

2. BUSINESS ARISING:

2.1 Dr Shields has not yet been in contact with the Society. Dr Lourey will undertake to contact him and possibly arrange additional speaking dates around Australia.

2.2 Rockdive. A successful meeting was held in Rockhampton with over 80 delegates. Arrangements for a similar meeting to be held in other states have not come to fruition. The President will investigate some possibilities.

3. NEW BUSINESS

3.1 Annual General Meeting 1988. This being the Centenary year, the Committee agreed that the meeting should be held in Australia. The President will study options available along the Queensland Coast.

3.2 List of Doctors trained in Underwater Medicine.

3.2.1 It was noted that no New Zealanders were on the list. This is because none of the eligible doctors has contacted the Secretary.

3.2.2 The New Zealand Chapter of SPUMS is compiling its own list of doctors with appropriate training.

3.2.3 Applications for listing have been made by doctors who have completed the WA Course. The course was discussed. Dr Tim Anderson, Officer in Charge of the School of Underwater Medicine, has been approached and the Committee agreed, on his advice, that the WA Course was equivalent to the Basic Course run by the RAN School of Underwater Medicine.

3.3 Bulk Billing for Diving Medicals. This was again discussed at length. It was reiterated that such examinations cannot be claimed from Medicare.

3.4 Journal Equipment. Dr Knight requested that the Society purchase some ancillary equipment for his Macintosh Computer so that all the layout and type setting of the Journal could be done more efficiently. On the last Journal he spent over 23 hours cutting and pasting. The Committee agreed that the equipment should be purchased.

3.5 Diving Medical Courses. It was brought to the Committee's notice that courses in "Diving Medicine" are being run by people with no qualifications or recognised training in Diving Medicine. The Committee felt that such courses should not be supported.

NEXT MEETING:

To be held in conjunction with the AGM in Honiara, June 1987.

THE MINUTES OF THE ANNUAL GENERAL MEETING HELD ON SUNDAY 7 JUNE 1987

AT THE HOTEL MENDANA, HONIARA

PRESENT All members attending the Scientific Conference.

APOLOGIES Dr A Slark, Dr J Williamson, Dr C Lourey, Dr P McCartney, Dr D Gorman, Dr A Sutherland, Dr D Walker, Dr M Page, Dr A Bridger

1. MINUTES OF LAST MEETING

These had been previously published. Acceptance moved: Dr J Knight; Seconded: Dr Logan. Carried.

2. BUSINESS ARISING

Nil.

3. REPORTS

3.1 Reports were presented by the President, Secretary, Treasurer and Deputy Editor.

3.2 Discussion was held over the financial independence of the New Zealand Chapter and its accountability to the general body of the members. A motion was put, "that a certified financial statement from the NZ Chapter be published each year as soon as possible after presentation by the NZ Treasurer". Moved: Dr Davies; Seconded: Dr Knight. Carried.

3.3 The costs of attendance at Executive meetings was discussed and a motion put, "that an honorarium be available for the Executive so that no one is out of pocket for attendance at a Committee Meeting". Moved: Dr Leslie; Seconded: Dr Logan. Carried.

3.4 The possibility of holding Executive Meetings by telephone linkups was discussed. This will be investigated by the Secretary.

3.5 All reports were received. Moved: Dr M Davis; Seconded: Dr G Davis. Carried.

4. NEW EXECUTIVE COMMITTEE

President	Dr A Slark
Immediate Past President	Dr C Acott
Secretary	Dr D Davies
Treasurer	Dr G Barry
Editor	Dr D Walker
Deputy Editor	Dr J Knight
Committee Members	Dr D Gorman
	Dr C Lourey
	Dr P McCartney

As Dr Slark was unable to be present, Dr Acott remained in the Chair. Dr Davies thanked Dr Acott for his help and work on behalf of the Society.

5. DIPLOMA

The Chairman announced the award of the Diploma of Diving and Hyperbaric Medicine to Dr T Dillon who has satisfied the requirements of the Executive Committee.

6. AUDITOR

Dr Barry discussed the problems of a full audit of the books each year. Instead, a detailed inspection of the accounts will be made by a certified Accountant. A motion was put, "that Mr David Porter be appointed for this task". Moved: Dr Barry; Seconded: Dr Knight. Carried.

7. GENERAL BUSINESS

7.1 Dr J Lloyd suggested that the Society computer could be connected to the Viatel network and be used to promote the Society and perhaps receive applications, etc. The Secretary will investigate feasibility and costs of this.

7.2 Dr McKee suggested there was disquiet about the proposed venue for the next Annual Scientific Meeting. A long discussion followed. A motion was put, "that the Executive reconsider the venue and make the appropriate decisions over the next two weeks". Moved: Dr Logan; Seconded: Dr Westlake. Carried.

7.3 Dr Chesterfield-Evans expressed dismay about the appearance of the lobbying letters during the election. The Secretary replied that the problem had been discussed by the Executive and appropriate recommendations made to prevent such occurrence in the future.

7.4 Dr G Olsen considered the travel arrangements unsatisfactory especially for NZ numbers. Suggested that in future alternative arrangements be sought and explained as required.

7.5 Dr M Davis moved a vote of thanks to the Convenors of the Conference for its success.

7.6 Moved: Dr R Leitch; Seconded: Dr Westlake that Russell Kitt enumerate problems encountered during the Dive Program.

Russell Kitt said that the diving program was most successful because of the warm water, the smooth seas, and the need for few weights with thin wet suits so reducing changes in buoyancy. The major problem was with equipment not being serviced before the conference. There was also some confusion as to which tables should be used.

The Secretary added that all boats should carry correct safety equipment such as life jackets and flares.

8. CLOSED:

There being no further business the meeting was closed at 18.30.

THE KIWI APPROACH TO DIVING MEDICALS

Diving Medicals Mandatory in New Zealand

The New Zealand Underwater Association (NZUA) has accepted the representations of the New Zealand Chapter of SPUMS that a diving medical is mandatory before starting the practical aspects of a diving course.

During the negotiations the diving medical form, which is reproduced as pages 160 and 161, has been simplified from that published in the SPUMS Journal in 1986.[1] A number of investigations which are considered essential by Australian Standard 2299, such as chest x-rays, pulmonary function tests, and audiograms have been made optional in order to reduce costs and to achieve acceptance by the NZUA of a mandatory medical examination.

REFERENCE

1. Adair A and Sutherland A. Diving Medicals. *SPUMS J* 1986; 16(1): 19-20.

IMPERIAL AND METRIC MEASURES RELEVANT TO DIVING

WEIGHT (MASS):

1 pound	0.454 kg
2.205 pound	1 kg

LEAD WEIGHTS

2 lb	0.9 kg
3 lb	1.4 kg
6 lb	2.7 kg

* kg/cm^2 and bar are not approved SI units, but are often found on imported pressure gauges.

VOLUME:

CYLINDER

72 cu ft	2000 litres
80 cu ft	2250 litres
88 cu ft	2500 litres

PRESSURE:

CYLINDER FILLING PRESSURES

2250 psi	16 MPa 16000 kPa 160 kg/cm^2* 160 bar*
2400 psi	17 MPa 17000 kPa 170 kg/cm^2* 170 bar*
3000 psi	21 MPa 21000 kPa 210 kg/cm^2*

INTERMEDIATE LINE PRESSURE

100 psi	0.7 MPa 700 kPa 7 bar*

CYLINDER RESERVE PRESSURE

500 psi	3.5 MPa 3500 kPa 35 bar*

ATMOSPHERIC PRESSURE

1 atmosphere 14.7 psi 33 fsw	0.1 MPa 100 kPa 1 atmosphere 1 bar* 10 msw

LENGTH:

DEPTH

1 foot	30.5 cm
33 feet	10 metres
1 fathom	1.83 metres

DISTANCE

1 yard	915 cm
100 yards	91.5 metres
1 mile	1.61 km
1 nautical mile	1.85 km
0.62 mile	1 km

DIVERS MEDICAL CERTIFICATE

FULL NAME ....

ADDRESS ....

....

DATE ..../........../..........

This is to certify that the abovementioned has been fully examined by me this day.

1) He/She has been found to be fit for diving

Advice to Instructor (where relevant)

....

....

....

....

....

2) He/She is permanently unfit for diving.

He/She should undergo a routine medical review in ...... years.

Signed ....

Medical Practitioner
(print) ....

Address ....

Phone No. ....

Tear along dotted line — Post/send to Diving Instructor

NZUA COMMERCIAL LIMITED

NZUA PADI

P O Box 875 Auckland Ph 895-456

Cnr Shaw and Collins Sts,
Morningside,
AUCKLAND.

DIVERS MEDICAL EXAMINATION (SPORT DIVING)

(Revised 1987 in conjunction with the South Pacific Underwater Medical Society, N.Z.)

SECTION A: (Diving candidate to complete prior to medical examination).

Full name: ______________________

Address: ______________________

____

______________________ Phone: __________

Date of birth ____ day month year ____ age ____ occupation

PREVIOUS DIVING EXPERIENCE: ______________________

____

HISTORY:

	(✓) NO	YES	NOTES
1. Have you ever suffered from:			
a. any heart complaint			
b. chest pain			
c. shortness of breath			
d. asthma			
e. any other lung condition			
f. nose or sinus disease			
g. ruptured ear drum or ear surgery			
h. dizziness fainting or blackouts			
i. fits or epilepsy			
j. concussion or head injury			
k. diabetes			
l. any other illness or disability			
m. any other operations or injury			
2. Do you smoke?			no. per day
3. Are you on any medication?			
4. Any known allergies?			
5. Have you ever failed a medical exam?			

NOTES: I hereby certify that the above information is correct, and authorise release of the attached certificate to my diving Instructor. Where appropriate, further medical information may be released to the New Zealand Underwater Association Medical Adviser.

______________________ signed (Candidate)

Date ____ day month year

SECTION B: (Medical Practitioner to complete)

EXAMINATION Date ____________
day month year

Height ______ cm Weight ______ kg B.P. __/__ mmHg PEFR ______ L/m

	normal (✓)	or describe abnormalities
1. Cardiovascular		
2. Respiritory system		
3. Effort tolerance		
4. External, middle, inner ear		
5. Eustachian tube patency		
6. Mouth and teeth		
7. Abdomen		
8. Nervous system		
9. Locomoter system		
10. Idenification marks		

Further notes: ______________________________

____

THE FOLLOWING INVESTIGATIONS MAY BE INDICATED IN SOME CANDIDATES:

	Date	Result
1. Chest X-ray	__/__/__	______
2. Pulmonary function	__/__/__	______
3. ECG	__/__/__	______
4. Excerise ECG	__/__/__	______
5. Audiogram	__/__/__	______
6. Urinalysis	__/__/__	______
7. Other	__/__/__	______

Instructions to Medical Practitioner:
Complete the medical certificate, detach and hand to candidate. Record certification details below, and retain sections A and B for your records.

RECORD OF CERTIFICATE ISSUED:

circle FIT

UNFIT*

Re examine in ____yrs

Advice to Instructor:

____

____

____

______________________ signed

DIVING MEDICAL — Guide to Medical Examiner

1) Diving frequently involves heavy sustained effort, often without opportunity to rest. The diving gear is heavy awkward to lift and carry on land or boat. Special attention should therefore be paid to the cardiovascular and respiratory systems.

2) All air containing spaces must equalise pressure readily. Special attention should be paid to equalising middle ear pressure (Valsalva manoeuvre), and obstructive lung disease (eg history of asthma).

3) Even momentary impairment of consciousness under water may result in death (eg epilepsy).

4) The following are contraindications to diving:
   a. Epilepsy
   b. Insulin treated Diabetes
   c. Asthma
   d. History of spontaneous pneumothorax
   e. Ischaemic heart disease
   f. Pregnancy

5) Other medical conditions which may require special consideration are: Previous middle ear or lung surgery, hypertension, impaired lung function, severe migraine, severe motion sickness, psychological disorders, physical handicaps, visual or hearing impairment, obesity, heavy smoking, drug or alcohol use, and advancing age.

6) Some medical conditions (eg recent chest or ear infection, Trauma etc) may render an applicant *temporarily* unfit to dive, and will require reassessment at some later date.

Should there be any doubt as to the suitability of a diving applicant please contact the NZUA to be directed to further medical advice.

NZUA, P.O. Box 875, AUCKLAND. Ph: (09) 895-457.
or 895-456

A detailed guide for the medical examination of divers may be obtained from the NZUA.

SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY STATEMENT OF RECEIPTS AND PAYMENTS FOR THE YEARS ENDING 30TH APRIL, 1985, 1986 AND 1987

	1987	1986	1985
OPENING BALANCE			
Standard Chartered Finance Ltd.	1,000	1,000	
United Permanent	7,659		
National Australia Bank	80	4,607	
Cash on hand	60		
Other deposits		5,763	8,427
	8,799	**11,370**	**8,427**
INCOME			
Subscriptions	22,945	18,992	13,887
Interest	1,680	1,057	
	24,625	**20,009**	**13,887**
TOTAL	**33,424**	**31,419**	**22,314**
EXPENDITURE			
Secretarial	2,696	3,564	1,873
Stationery	240	864	30
Journal	6,481	5,808	4,793
Postage	2,465	3,156	1,738
Travel	4,415	7,504	2,274
Equipment (computer and 0_2 kit)see note	7,451		
Miscellaneous	576	1,724	236
Bank charges	268		
Returned cheques	42		
TOTAL	**24,634**	**22,620**	**10,944**
CLOSING BALANCES			
Standard Chartered Finance Ltd	1,000	1,000	1,000
United Permanent	7,361	7,361	
National Australia Bank	403	80	
Cash on hand	26	60	
Other deposits			5,763
TOTAL	**8,790**	**8,799**	**11,370**
	$ 33,424	**$ 31,419**	**$ 22,314**

NOTE: Equipment is written off as purchased.

I have conducted various tests and checks as I believe are necessary considering the size and nature of the Society and having so examined the books and records of The South Pacific Underwater Medicine Society for the years ended 30 April 1986 and 1987 report that the accompanying Statements of Receipts and Payments have been properly drawn up from the records of the Society and give a true and fair view of the financial activities for the years ended on those dates.

David S Porter, FCA
Chartered Accountant

13 May 1987
NEWPORT BEACH 2106

(Registered under the Public Accountants Act 1946, as amended).

ORIGINAL PAPERS

THE DEVELOPMENT OF THE SAFETY SAUSAGE

Bob Begg

THE BEGINNING

MARINE SEARCH AND RESCUE EXERCISE SUNDAY 22 July 1984

This exercise was organised by the Marine Search and Rescue Advisory Committee with the object of involving the Navy's new Patrol boat "Moa" in a full scale Search and Rescue (SAR) Exercise.

I was involved firstly as training co-ordinator for the committee and secondly as one of the missing divers. I decided to be directly involved rather than an observer so that I could follow through the exercise and try out the system.

The plan was for two divers to be reported missing. They were to be found by an air search and dropped a liferaft then picked up by the Moa. As an extra part of the exercise one of the divers would have bends symptoms and would be transferred to hospital by helicopter and ambulance.

As it turned out, all went according to plan except that we really did get lost and it took two hours longer than it should have to find us.

We set out from Papanui Inlet on the seaward side of the Otago Peninsula about 0830 in fine calm conditions with a slight swell. We were in an Avon inflatable with a boatman, radio operator and two divers - myself and Colin Sutcliffe. We had two dives, one bounce dive to 80' then another 5 minute dive to 100'. On surfacing after the second dive we were about 50 m from the inflatable and they started letting off flares. The time was 9 am and conditions were still dead calm.

We gradually drifted away from the inflatable and after half-hour we could no longer see them although they could see us. At about this time 6 to 8 Dusky Dolphins arrived and swam around us for 15 minutes or so. At this stage we were unconcerned although we were starting to wonder why the plane had not arrived.

Between 1000 and 1030 we noticed the plane searching in an area well away from where we were. At this stage the inflatable moved away from our position as we did not want to make it too easy to find us!

At about the same time the wind came up, quickly increasing to around 15 knots from the South West. The plane was still searching the wrong area and we realised that we really were lost and were going to be very hard to find. By now we were about 15 km offshore and about 5 km north of where we entered the water.

The difference in our equipment were now starting to become important. I was still quite comfortable in my US Divers inflatable suit and cold water hood, new Moray gloves and Neptune Octi boots without zips. Colin was wearing a new Aquapro Topline 7 mm suit with cold water hood, Mitchell leather-palm gloves (not waterproof) and Mitchell hard sole boots with zips. His hands and feet were extremely cold and he was becoming cold all over. I was using a USD Proline compensator which I was able to take off and use as a raft. Colin was using a yoke type compensator which did not allow him to keep his head clear of the water, as I could. We took Colin's tank off and attached it to the jacket compensator. The water temperature was 11°C.

By about 1100 we could see the plane and a helicopter looking for us and we also saw the Moa had arrived although it was miles away from us. We decided to start swimming We realised it was pretty futile but it was something positive to do. By now we were almost due East of Taiaroa Head which is at the northern tip of the Otago Peninsula. The dolphins still swam around us occasionally but by now they had lost their appeal.

Over the next 30 minutes both the plane and the helicopter flew over us at least once each. As we saw one of them approaching we would put Colin's yellow tank on top of the jacket compensator and I would wave the yellow catch bag I had. It seemed unbelievable that they could fly over us and not see us. It was also extremely frustrating.

Colin was by now fairly concerned although I was reasonably confident that they would find us pretty soon. The biggest problem was the weather. It was blowing quite hard and low cloud was starting to form over the land.

However at about 1135 we saw the plane flying directly towards us. He circled around us and then we noticed a fishing boat about 30 m away. It turned out it was the fisherman who had found us and called in the plane. We did not even realise that he was in the area. The liferaft was dropped to us and very soon the Moa was also in the area. As we now had the helicopter and the plane flying above us and the Moa and a couple of fishing boats standing by - we no longer felt lonely.

We were taken on board the Moa and examined. It was decided that Colin had mild hypothermia but I was alright and decided that the exercise should proceed. George Lay was roped in as the "Bent" diver and we were flown to shore by scoop net under the helicopter and taken to hospital by ambulance.

We had drifted from about 3 km east of Papanui Inlet in a Northerly direction to a point about 5 km east of Taiaroa Head, a distance of about 8 km in two and a half hours, giving a drift rate of about 2 knots.

Lessons

1. Most important, divers are much harder to see from the air than one would expect. Both pilots and their observers were very experienced and said later that they could see seals, dolphins and bits of seaweed but could not see us. We were more visible than many divers with the yellow catch-bag and tank and jacket compensator floating on the surface.

2. Choice of suit and accessories is most important for extended periods in 11 degree water. While Colin had a very good suit his hands and feet were very cold fairly soon after entering the water. By the time we got out his hands and feet were blue and he was very cold. I was still quite comfortable and feel I could have stayed in the water for a much longer period.

3. All divers should review their safety procedures when there is any risk of becoming separated from their boat or the shore.

Suggestions

A. When the support boat is not anchored a weighted line and buoy should be placed at the point where the divers enter the water. This gives a reference point and is most important if a search is needed.

B. If possible the divers should either tow a float or carry a handspear or similar object and a flag or catchbag to signal the boat.

C. In high risk conditions a dye marker or waterproof smoke flare could be carried.

D. Some item of gear should be dayglow orange.

E. A chemical lightstick should be standard equipment on evening or night dives and can easily be carried at all times.

THE NEXT STEP

MARINE SAREX 19 MAY 1985

The object of the exercise was to test two hand held flares (supplied by Terry Corbett), one dye marker (supplied by Bob Begg) and another dye marker. One other object, a strip of orange tape, was also tried.

The exercise was carried out approximately 600 metres offshore from Tairoa Head, between 1000 and 1300. Weather conditions at the time were perfect, with no wind and clear skies. The tide had a northerly drift of approximately 2 knots. Underwater visibility was 3 to 4 m.

There was a swell of about a one metre .For safety reasons the divers held onto an anchor line and buoy to stop them drifting.

Paul Young and George Lay were the divers conducting the tests. Before the arrival of the plane, the orange tape was unrolled and tied to the anchor line.

When the plane arrived, the first dye marker was activated and appeared to be very poor. The plane turned and a pinpoint (light) flare was let off. Paul commented that he had trouble unscrewing the cap and that when the flare went off it let out a lot of noise. Also had the flare not been immersed to cool it down, severe bums would have resulted.

He waited approximately 45 seconds and then activated a smoke flare, which failed to fire. It should be pointed out that this flare had hairline cracks in the cap, and was not expected to fire. The plane then turned and the second pinpoint flare was set off, with no problems. Then the second smoke flare was let off. Both flares had been carried by Terry Corbett for some time and had been logged for each dive on duration and depth. Sealant had been used on one flare and this was found to be unacceptable to the divers. One of the caps that had been sealed had to be put into a vice to be opened! It appears that a sealant it not necessary as the O ring fitted should do the job, however further tests by Pains Wessex will confirm this. The expected life of these flares under diving conditions may not be 3 years as stated on the flare, as this time is for storing flares under optimum conditions. Flares are an essential survival aid of the diver. Trouble was encountered when trying to trigger the flares. One of the flares with sealant was very difficult to activate, and the trigger mechanism had to be dug out with a watch strap. Presumably if one was lost, by the time it took for someone to search in the general area, hands would be too cold to activate the trigger mechanism.

The second dye marker was then put into action and it worked reasonably well, but a lot of effort in agitating the package was needed to make it effective.

The first dye marker package was dropped while opening the second package, and sank very quickly. The colour of the dye blended well with the milky green colour of the water, and was not suitable for the conditions.

The whistle supplied on the Fenzy worked well and did not require much effort to operate.

Pilot's Comments

Don Macintosh was the pilot on this occasion. Because of the local Albatross Colony, a 1,500 foot lower limit had been imposed by the authorities.

The streamer tape laid out by the divers was very visible and seemed to be a very beneficial piece of equipment.

The light flares were easily seen, but smoke in this sort of weather was best seen.

Both buoyancy compensators were bright red. George had his compensator off and floating beside him, while Paul wore his in the usual manner. The compensator floating next to the divers was far easier to see from the air than the one worn. In fact although Paul's compensator was bright red, it did not show up from the air. Faces showed up well when the divers were looking at the plane, and an extra set of eyes in the plane would have been helpful.

The dye was not effective in the conditions. It was only visible flying towards the sun, and no good flying away from the sun. Although the dye was not useful in these conditions, it could well prove excellent on other occasions. Ground to air radio was absolutely useless and for the entire exercise Don was transmitting blind.

Land Base Comments

The divers were barely visible to the naked eye from the base when they were 600 metres off-shore. The base was approximately 150 feet above sea level. Whistles were heard and it was commented that these could be a handy piece of equipment for all divers to carry. However the whistles used on this exercise have now been superseded and a new whistle will soon be released. It was suggested that in a search the motor on the boat could be switched off now and then on the off chance that a whistle is being used, however, because of possible engine malfunction in rough weather the dangers of cutting the motor must be remembered.

The ground to air radios were hopeless. Two were taken and neither would transmit, however one received. Some serious thought should be put to finding a better radio. CB radio in the boat and on land was found to be invaluable. Giving bearings to land base via CB radio was good for fixing positions.

Boat Observer's Comments

When 200 metres from the divers Paul wearing his compensator, rather than George with his beside him, was more easily seen with the naked eye. Both were clearly visible when viewed through binoculars. At 400 to 600 metres using binoculars, shapes were found before colours registered. After colours were visible blue flippers stood out very well.

Both light flares were very good and burnt for approximately 20 seconds each. The orange smoke was excellent, and it was thought to burn for approximately 29 seconds, however a cloud hung above the divers for quite some time and was still discernible for some ten minutes afterwards.

The orange tape did not stand out from the boat.

When the second dye marker was activated, it was visible on the swell from a distance of 300 to 400 metres, but it was thought that if one did not know where to look it would not be seen.

The whistles was heard from the boat at a distance with the motors off.

Lessons

Flares are an essential survival aid of the diver.

The orange tape lying on the surface of the water was found to be an excellent additional piece of equipment and showed up very well from the air. This tape is used to show where buried electrical cables are, and if thought worthwhile further tests would have to be made with different colours to find the most suitable.

Although the dye markers were not satisfactory on this exercise, they should not be written off. The dye could be very effective in blue water.

The biggest trouble of this exercise was the performance of the radios.

THE FINAL STEP

SAREX 26 May 1985

Held to test inflatable plastic tubes for visibility from boats and aircraft. 2 plastic tubes, 1 orange and 1 dark red, each approximately 3 m long were tried.

At 1430 the weather was fine, calm, with high cloud covert. The sea was calm with 1.5 to 2 m swell. Two divers were put in the water on an anchored line with the tubes. The boats moved off until divers were only just visible when on the top of swells, about 200 m. Then the tubes were inflated. The tubes were found to be easily inflated and easily held vertical by holding the end down beside the diver at arms length underwater. The tubes were immediately visible when vertical and were often seen when the divers were invisible. The vertical tubes were easily seen from all angles although they were more difficult to spot when looking directly into the sun. They were still visible with the naked eye from half mile away, and were easily visible through binoculars at this distance. Even if the tube is holed it will still float and be of use in an air search.

The tubes were left flat on the water while the plane flew over. The pilot commented that the tubes were easily visible from 2,000 feet and that the divers were easily found. The divers appeared as dots at the end of the tubes. The divers would have been very hard to find otherwise.

As the conditions were calm more tests need to be done in windy and rough conditions.

Lessons

Inflated plastic tubes standing vertically in the water are easily seen regardless of colour. Red tubes lying on the water are easily seen from the air. These tubes would be a worthwhile piece of equipment for every diver. They are cheap, easy to make and easily carried.. They are simple, have no valves, are easily blown up using a regulator or by mouth. They are very visible from a boat, so preventing divers getting lost, and from the air. However some care is needed in storage.

CONCLUSION

These tubes are now available as Safety Sausages from TL Begg and Sons Ltd, PO Box 5216, Dunedin, New Zealand. The Australian distributor is Diving Security (a branch of RJ Knight Pty Ltd), PO Box 6298, Melbourne VIC 3004.

Bob Begg's address is TL Begg and Sons Ltd.

TWO POWERLESS CHAMBERS CASE REPORTS

Douglas Walker

These two cases, taken from very widely separated sources, illustrate that arrival at a recompression chamber is not necessarily the end of the accident phase for the victim, and that chamber operation is not immune from the effects of Murphy's Law.

Case 1

While a naval diver was making a working dive to change a vessel's propeller he was crushed when it unexpectedly, and for some unknown reason, slid forwards. His tender quickly recognised that he was in trouble and the stand-by diver was sent down. He managed to pull the propeller off the victim, who was now unconscious. The victim started to sink as soon as he was freed. He was quickly hauled to the surface by his lines by the topside crew and brought into the dive boat. He was unconscious, fitting, and had suffered physical injuries so he presented them with a very urgent, serious, and difficult management problem. He was transported to a naval hospital and the staff of the recompression chamber were alerted.

His condition was deteriorating rapidly so it was decided to recompress him in the chamber despite it being unready for use because of maintenance work. The moisture separators were out of the compressed air system so it was not possible to refill the high pressure air bank by the usual means. However, the air bank had been topped up to 3,000 psi (43,050 scf) and was holding the equivalent of 1 at IATA, so it was possible to commence treatment. From here on problems plagued the operation.

An operation call for assistance brought divers from several ships. This was not an unmixed blessing as they had never practiced together for such an emergency situation. There was a malfunction of an O-ring in the high pressure valves which made it impossible to ventilate the chamber. While this was being replaced two surface supply umbilicals were rigged from a dive boat to the gauge stop in the chamber's control panel to supply low pressure air to the chamber. This proved adequate. As a precaution the local fire brigade was asked to lend their high pressure compressor, used for filling their emergency air breathing apparatus cylinders. This compressor was attached to the chamber's emergency air supply.

The treatment also was not routine, the scenario being as follows. The victim was recompressed to 50 msw (165 fsw), to where he showed a limited response. As he had not obtained a complete response by 30 minutes it was decided, by the master diver and two medical officers, to bring him to 18 msw (60 fsw) and place him on 100% oxygen. This decision was based on the uncertainty concerning the extent of his internal injuries. Two minutes after commencing on this treatment he began to improve. The treatment table was extended by three additional 25 minute periods at 18 msw (60 fsw) as he continued to show progress. Upon arrival at 9 msw (30 fsw) the patient was asymptomatic except for chest pain on inspiration.

After completing the chamber treatment the patient was transported to hospital for a complete medical examination. The chest x-ray revealed the presence of a right haemopneumothorax, mediastinal emphysema, which extended into the fight upper quadrant of the abdomen, and a pneumopericardium, so he was transferred to the care of a cardio-thoracic surgeon at another hospital. Four days after the accident a further x-ray examination revealed multiple fractured ribs and a fractured sternum. The degree of recovery he achieved from these injuries is unknown.

Case 2

The patient, a 56 year old diver, was being treated for a spinal bend when a power failure occurred. As a result the chamber operators were unable to prevent a build-up of carbon dioxide in the chamber. Through the police they contacted the diving team at a naval establishment and were supplied with a two-ton generator complete with crane. This source of emergency electrical power took 4 hours to arrive and in the meantime the diver had been given an emergency resuscitation set. Mains electricity was restored 1 hour later.

The diver had been on mixed gas treatment for 72 hours before the power failure. There would normally have been sufficient reserve facilities available in the unit to cope with a power failure, but on this occasion a second diver was receiving treatment in their other chamber. The unit is now seeking to raise sufficient money to obtain a carbon dioxide "scrubbing" system for the chamber to take care of such an eventuality should it ever occur again.

The diver had apparently been following an accepted Table while he made a no-stop dive but suffered a spinal bend and been flown by helicopter to the treatment centre. Following the recompression treatment he was transferred to a hospital near his home. He has been advised he should never dive again.

Discussion

These cases illustrate the fact that there is far more involved in having a recompression chamber unit for local use than the chamber itself and a staff of willing volunteers. Those who are to be responsible for treatments must not only be trained but be sufficiently experienced to be flexible in their response to the problems peculiar to each patient, and to unexpected external factors such as are reported here. They must be a team with a clear basic management protocol to ensure that the patient has correct evaluation before recompression is commenced. In Case 1 the incident depth is unknown, nor how far he sank before being recovered, but the depths can be assumed not to be great or there would have been a recompression chamber (RCC) at the dive site. The use of recompression down to 50 msw (165 fsw) gauge a trial of 100% oxygen at 18 msw (60 fsw) gauge made the case management more difficult than necessary. However recompression to 50 msw for suspected air embolism is still recommended by many authorities. Both the patient and those treatment him were very fortunate that his pneumothorax did not produce serious clinical symptoms during the ascent phase in the chamber.

In Case 2, the fact that the patient was on a mixed gas therapy implies that the staff of this recompression unit was experienced in the management of serious and complicated cases. Yet despite this it seems that their "disaster plan" was quite inadequate to cover total power failure when both their chambers were in use. There was too great a trust that a power cut would never occur while their facilities were fully extended. They had forgotten Murphy's Law! They would have benefited from remembering how "Papa Topside" anticipated just such a problem and devised a simple answer. Wartime submariners would have told them to scatter sodasorb on the chamber floor.

In the post-war years of rapid developments in diving one of the notable characters who entered the United States Navy (USN) Medical Corps, after an active and unusual stint in general practice, was Dr George Bond. He realised that some problem might result in a "bell" (personnel transfer capsule or PTC) remaining an unexpectedly long period underwater without adequate ventilation. This situation would lead to a dangerous build up of carbon dioxide, so he considered what would be the simplest remedy. He proposed, and successfully chamber tested, a simple no-moving-parts carbon dioxide scrubber. This consisted of one or two pairs of pantyhose filled with sodasorb. Lateral thinkers consider the objective (exposure of sodasorb to the carbon dioxide loaded air) rather than concentrating on modification of the mechanical method which is giving trouble. Dr Bond's paper was reprinted in the SPUMS Journal 1979, April-Sept, p 41-45 and is reprinted in this issue for the benefit of our newer members and as a tribute to the memory of an intelligent and humane Diving Doctor.

These cases are presented because there is a tendency on the part of both divers and civil authorities to under-appreciate the problems which may arise in association with the management of a safe and efficient recompression facility. The sources of these case histories are thanked for making them available for use in this paper. In the interests of confidentiality the sources are not stated here.

Dr Douglas Walker's address is 1423 Pittwater Road, NARRABEEN NSW 2101, Australia.

ASTHMA AND DIVING A CASE REPORT

CJ Lowry
Diving Medical Centre, Sydney

The patient, aged 33 years, had been a qualified diver for six years. He was a known asthmatic and had been observed to use Ventolin aerosol frequently in the preceding week. He had no hospital admissions for asthma.

The dive was off Boat Harbour, near Kernell, on Sunday, 11 May 1986. His buddy was a female friend, of recent acquaintance and who had just completed her C Card certification. At no stage did they descend more than 30 feet in depth, and they were underwater for approximately 20-30 minutes prior to the patient signalling that he would ascend and get his bearings. He proceeded to do this, leaving the female diver on the sea bed. He then returned to her, in a state of some apprehension. He signalled that they should surface, and then he proceeded to do so at a considerable rate, faster than she thought safe. Nevertheless she continued with him because he seemed to be in distress, and arrived on the surface soon after him. He was thrashing around with his hands, started swimming overarm and had taken his regulator out of his mouth. She attempted to ditch his weight belt (he was not wearing a BC) but failed because he fought her off. She then tried to pull him towards shore. She spoke to him but he did not reply. His face was white and he looked terrible. He then appeared to lose consciousness and went quite limp.

She continued towards the coast line, which unfortunately was a very rocky area with waves beating on it. With her own buoyancy vest inflated, she managed to hang on to him until she got him to the rocky sea shore. The waves kept pushing her onto the rocks, and then drawing them both off. She feels that he probably aspirated some sea water during this time, and they both sustained many lacerations from the rocks. Several times she attempted to give mouth-to-mouth ventilation. At times he appeared quite stiff but it is not clear whether he actually convulsed.

After approximately ten minutes they were rescued by a group of on-lookers, and taken to the road. The patient remained unconscious, and finally the ambulance and Westpac helicopter arrived concurrently, but it was decided to transfer him to HMAS Penguin by helicopter for recompression therapy.

Mouth-to-mouth respiration and external cardiac massage were carried out once he had reached the roadway, and during transport IV Haemaccel and oxygen were administered. It was also continued until he was taken to HMAS Penguin, where further assessment took place prior to recompression. He was noted to be comatose, unresponsive but breathing spontaneously. It was decided to compress him to 18 metres on 100% oxygen.

There was great difficulty in maintaining adequate air entry, and at 18 metres the arterial oxygen only reached about 70 torr. It remained around 50 torr during subsequent ascent. The arterial carbon dioxide levels were usually above 100 throughout. The pH was below 7.01.

The patient was gradually brought back to the surface, with only a little worsening of the arterial oxygen levels, over a period of five hours. At that stage he was on a respirator, with an endotracheal tube inserted and with positive end expiratory pressure (PEEP), of an indefinite amount (chamber conditions made this difficult to assess).

On surfacing he was transferred to Royal North Shore Hospital Intensive Care Unit, where ventilation with 100% oxygen was continued. A radial arterial line and a Swan Ganz pulmonary artery catheter were inserted.

On 100% O_2 (12 x 700 ml a minute) with 10 cm PEEP, the blood gases were:

	Arterial	Mixed Venous
PO_2	72 torr	35 tort
PCO_2	49 tort	58 torr
pH	7.30	7.21
Base excess	-3.3	-4.8

He was noted to have been mildly hypothermic, with 35.4° C and hypotensive with a systolic blood pressure of 80. Aramine boluses and a dopamine infusion were initiated to ensure the blood pressure remained above 95. He had a tachycardia of 130-160. A space blanket was used to retain heat.

On examination there was widespread inspiratory and expiratory rhonchi. Nebulised Ventolin together and an aminophylline infusion were commenced and PEEP was increased.

The chest x-rays showed gross pulmonary oedema, which was consistent with his widespread inspiratory and expiratory rhonchi. There was no pneumothorax or evidence of mediastinal emphysema.

The next day (day 2), there was some improvement in respiratory and cardiovascular function, with maintained urinary output. His arterial gases: on a FiO_2 of 70% were

PO_2 = 144 torr, PCO_2 = 50 torr, pH = 7.33, Base excess = +6.3

Several episodes of generalised fitting with myoclonic jerks were noted and thought to be post-hypoxic.

He was then gradually weaned from 70% FiO_2 and 17.5 cm of water continuous positive airway pressure (CPAP) to 50% FiO_2 and 10 cm of water PEEP. Arterial gases then were:

PO_2 = 83 torr, PCO_2 = 40 torr, pH = 7.43, Base excess = +3.2

EEG showed flow waves consistent with hypoxia and the CAT scan was normal. He had developed a temperature of 38° C. He was weaned from the dopamine infusion.

Ventolin, aminophylline and hydrocortisone were continued, as were the other supportive measures.

On days 3 and 4 he was still unresponsive to painful stimuli, and there were several episodes of generalised fitting and frequent myoclonic jerks.

On day 5 he was neurologically lighter, the myoclonic jerks were infrequent and arterial blood gases on FiO_2 50% with CPAP were:

PO_2 = 93 torr, PCO_2 = 45 torr, pH = 7.46

A tracheostomy was performed.

On days 7 and 8 the patient responded to simple commands, looking around. Over the next few weeks he had several setbacks with bowel obstruction, septicaemia, required further respiratory support but continued to improve neurologically so that at 5 weeks he was orientated in time and space, with global cognitive problems associated with moderate frontal (behavioural) problems. There was a residual dysarrthria, a left hemiparesis, and ataxic gait and myoclonic jerks. The speech therapist stated that there was no expressive dysphasia, but jerky stuttering type speech appeared to be related to myoclonic jerks. The EEG irregularities with mixed theta and delta components of low voltage. There was not specific localisation and no myoclonic activity on the EMG.

He was then transferred to the Head Injuries Unit at Lidcombe State Hospital. He claims that he will continue diving together with motor bike riding. He said there was no previous history of head injury. He had been home on weekend leave and had apparently got drunk with his mates. His social activities also included flirting with other patients.

A psychometric performance was carried out and the following report was made:

Due to the pronounced myoclonus, it is not possible to administer the full test battery. Of the tests that were administered, his motor difficulties produced slowed responses which were reflected in the results for the Digits symbol and Bourden-Wiersma tests, both speed and tensions tests, the overall results were lower than our normal range. His performance in the Bourden-Wiersma tests, however, was extremely accurate showing that his attention abilities are certainly intact.

The results for the CFF test are on the lower end of our normal range. This result is difficult to interpret as he was extremely variable, again most probably due to his myoclonus. The variability was much greater for his right eye and right hand.

The short-term memory was within normal limits as was his ability to learn new material. These results suggest his problems stem mainly from the motor regions.

Further information obtained later indicated that the patient had had a medical from his own General Practitioner and had completed a diving course in 1980. He used Ventolin before every dive and indeed had a pocket built into his wetsuit to hold the aerosol.

DIAGNOSES:

(1) Asthma
(2) Cerebral arterial gas embolism
(3) Near-drowning

Dr CJ Lowry's address is 133 Raglan Street, MOSMAN NSW 2088, Australia.

PAPERS OF INTEREST FROM OTHER JOURNALS

EMERGENCY SCRUBBING

Dr George Bond

Since we had the one-time occasion to surface the PTC (personnel transfer capsule) with its human cargo as an emergency we have had deep concern about the reliability of the CO_2 scrubber system of the capsule. Looking ahead to the ever-present possibility that a loaded PTC might have to survive as long as eight hours without ventilation, we cast about for a passive system of CO_2 scrubbing quite independent of electrical power. Clearly a system of random scattering of sodasorb within such a habitat was untenable. Likewise individual closed-circuit breathing units seemed inadvisable. But how about simply filling a few ladies' nylon pantyhose with the absorbent and hanging them in the chamber? The idea had appeal despite its naively so we launched the project, using two pairs of pantyhose, one black and the other red, filled with a total of 8.6 kilos of the sodasorb.

For the actual experiment we "locked" four volunteers (one female) in the inner lock of the Draeger chamber, which has a 3000 litre volume, supplied them with an oxygen monitor and a batch of Draeger CO_2 sniffer tubes, and left it up to the pantyhose array to do its bit. In order to provide for metabolic oxygen requirements I maintained a constant flow of 2.5 litres per minute of oxygen, which perfectly kept their atmosphere at 21% oxygen throughout the procedure. Both the carbon dioxide and oxygen levels were determined inside the chamber at 15 minute intervals and recorded outside, while I maintained more or less constant visual and voice contact with our subjects.

As you might guess, Morgan Wells and I were a bit edgy at first since the CO_2 levels in this situation could be expected to rise at a rate of 0.82% every fifteen minutes, which gives little leeway. Still, we had plenty of safeguards so we started the show on time.

Both Morgan and I were a little stunned when the first 15 minutes' reading came out a fat 1.5% and rose quickly thereafter to 2.25%. Still, we had some faith in the system and stuck to our guns. Sure enough, as the chamber humidity commenced to rise, the galloping slope simmered down, and after almost three hours stayed steady between 2.75% and 3.0%. By this time we were already designing the MK II Pantyhose Scrubber, one capable of 75% efficiency, so we called the game and released our volunteers, who were none the worse for their experience. Tomorrow the MK II will be made up, sealed in plastic bags, and duly installed in the PTC.

Improvised, and at-the-scene, experimental work is fascinating. I find it instils a sense of confidence in the aquanauts as well.

(EDITOR: Regrettably, Dr Bond died in 1983)

This paper was reprinted from the Institute of Diving Newsletter of APRIL 1977 in the April to September 1977 issue of the SPUMS Journal, pages 41 and 45. It is reprinted as a comment on the two incidents reported on page 166.

NOTES ON DIVER'S PARALYSIS

Graham Blick, MD Durh, MRCS, LRCP Lond.
(Late District Medical Officer, Broome, Western Australia)

From 1900 to 1908 I have had medical charge of probably the largest pearling centre in the world, including in its population upwards of 400 professional divers who are daily engaged gathering pearl shell at depths varying from 7 to 20 fathoms. I have myself seen a diver bring up shell from a depth of 25 fathoms (150 ft), but this was an exceptional feat. This means that these men are working under pressure, roughly, from 20 to 50 lb per square inch above normal, the shifts varying in length inversely as the depth of working. In the lesser depth a diver will remain down one, two, or more hours, in the greater generally under half an hour. The ordinary rubber diving dress with metal helmet is the apparatus used, air being supplied by three barrelled pumps worked by hand wheels. The divers are of various nationality - whites, Japanese, Filipinos, Malays, etc, the majority being Japanese, the whites being the least numerous. They work from small schooners of 10 to 14 tons, and range over many hundred of miles off one of the most forlorn and desolate coasts in the world. Consequently, when an accident happens they may be several days' sail from port, and so have not the advantages of their colleagues the "caisson" workers, with their decompressing and recompressing chambers and immediate medical attention. Hence, many severe and often fatal cases of diver's paralysis occur.

For eight years I have impressed on these men and their employers the fact that they can with very little extra time and trouble obtain all the safety conferred by the decompressing chamber by a slow and gradual return to the surface, and when this course has been followed few, if any, cases of paralysis have occurred.

Since 1900, not counting the slighter cases characterised by the men themselves as "rheumatics", I have had upwards of 200 cases of diver' s palsy; 60 of the patients were dead before a doctor could be reached and I made *post mortem examinations.* Among the 140 odd who reached me alive I have had to deal with all degrees of paralysis, from slight paralysis of legs and inability to pass urine (always present) up to total paraplegia and loss of sensation. Clinically, the salient features of the paralysis are its bilateral distribution and the constant loss of the power of micturition. The legs are attacked before the arms and recover later. Sensory nerves seem to suffer much less than motor, but I am bound to add that many cases had to be examined through an interpreter, and it is difficult in any case to get correct replies on such a matter from coolies. Out of these 140 cases 11 died, 8 from septicaemia consequent on sloughing and cystitis, and from supervening meningitis. The rest, after a longer or shorter time, recovered, most of them completely, about 10 per cent, being permanently affected with slight paresis, generally of the anterior muscles of the legs.

I have had patients who have been twice, thrice, or even oftener paralysed, and who have more or less completely recovered. I have never seen extensive secondary degeneration of the cord follow, though one would expect this from the lesions found in the cord *post mortem.*

The treatment after the establishment of paralysis is that of all organic nervous disease - one can only wait on Nature's efforts, though in this disease Nature is kinder than usual. General hygiene, massage, and electricity, all are useful to some extent, and, of course, any complications which arise must be treated. I have been often astonished at the way apparently hopeless paraplegics have recovered in the course of many months.

The most troublesome cases were those complicated by cystitis and deep sloughing. The former complication is very frequently set up by imperfectly cleaned catheters used by the diver's friends, often for several days, while making for port. The paralysis of micturition is so well known among the men themselves that no diver would consider his outfit complete without a soft catheter. The sloughing is also the result in many cases of the treatment applied as first aid by the patient' s friends, and is especially common among the Japanese, whose unbounded faith in very hot baths too often leads to parboiling and damage to the enervated tissues, forming the starting point of frightful sloughing, which often defies all efforts of nursing to restrain. I have seen the sacrum, portions of the ilium, and the capsule of hip-joint absolutely denuded, and several of the deaths in my cases resulted from this condition. A few very bad cases, however, made wonderful recoveries. One case, a Filipino diver, was admitted to hospital with total paraplegia and sloughing over the buttocks, which extended till the right hip-joint, most of the sacrum, and the posterior portion of the crest of the ilium could plainly be seen; yet after more than twelve months in hospital and several plastic operations he made a fair recovery, and was able to return to the Philippines.

Owing to the distance from port at which these boats work, I have never been able to see a case in the earliest period of attack. The general history is that the diver has worked longer and deeper than usual, and then has hurried to the surface. He has felt quite well below, and gets aboard as usual. Often he has had the dress removed and even sat down to his meal before symptoms appear. Then he suddenly drops, sometimes "as if shot", or he may remark he is not feeling well, and the symptoms come on more gradually. He may or may not lose consciousness. Some rapidly fatal cases have occurred without initial loss of consciousness, and it is practically never lost in slight attacks. Death may occur within an hour or not until after a day or two.

Clinical experience directs attention to the spinal cord in this disease, and my sixty autopsies have amply corroborated the inference that here is to be found the greatest mischief. I have never found the classical "bubble of nitrogen" in the hearts of my cases; indeed, I honestly confess I doubt my ability to recognise a bubble of nitrogen. I have, however, often fancied that during the rapid putrefaction of these bodies there has been a larger evolvement of gases and greater distension of the tissues than is the case with other bodies after equally sudden death. I have only once found an infarct in the lungs, and only twice clots in the heart, and then to no great extent; and in these cases beri-beri, with its often insidious onset and clotting in the heart, has always to be remembered. Beri-beri used to be the greatest scourge known to the pearling fleets, but segregation and sanitation have greatly diminished its ravages. Almost invariably the heart, lungs, and large veins are engorged with dark liquid blood. So marked is this that on one occasion a medical man present at one autopsy frankly told me he would, from the thoracic examination alone, have been quite content to certify asphyxia; yet, on exposing the spinal cord, the characteristic "teased" appearance and minute haemorrhages were present, together with free blood, in the rural canal.

In my experience the following appearances are typical of diver's paralysis on *post-mortem e*xamination of a rapidly fatal case. The thoracic viscera and large veins of the neck are engorged with dark liquid blood. There is nothing noteworthy in the abdomen. There is more or less venous engorgement in the meninges of the brain, markedly increasing towards the base, especially round the medulla. Section of the brain is generally negative; sometimes the blood points seem rather larger than usual. I have only once found a haemorrhage in the brain; it was about the size of a horse-bean, and situated in the left internal capsule, and was accompanied by another haemorrhage practically severing the spinal cord opposite the body of the fifth cervical vertebra. The most characteristic signs are found on exposing the spinal cord. The rural cavity contains blood or bloodstained fluid, the meninges of the cord are congested with blood, and the congestion appears to be most intense in the cervical region, say the portion corresponding to bodies of the fourth to the sixth cervical vertebrae. This portion of the cord appears to me to be the diver's calx Achillis. It is here that the characteristic "teasing" is most apparent. I call it teasing for want of a better word to explain the appearance in the section of cord; it looks as if one had stippled the face of the section with a fine knife or needle, a semi-disintegrated appearance. With this condition is nearly always associated haemorrhage of greater or less extent, also most marked in the above portion of the cord; indeed I have never found an effusion of any size except in this part; here they may range in size from mere points of blood to, as I have seen in nine cases, large haemorrhages practically cutting the cord in two, and forming clots filling the meningeal tube for over 1 1/2 in. I had neither time nor appliances for microscopic pathology, which in such a hot climate would need exceptional apparatus, and, I may add, exceptional skill, to obtain good results. In this respect, however, I hope my omission will soon be rectified by more competent pathologists, for I have reason to believe steps are being taken to get a specimen cord for examination.

When I first met with this disease I was greatly handicapped by the want of literature on the subject - in fact, all I had was comprised in one page of Osler's Medicine. Consequently I was presented with a pathological problem which I had to unravel as best I could, and was often sorely puzzled. For instance, I noticed that though the divers started work about March there were practically no cases of paralysis before September, and from thence to the end of the working season, about the end of November, cases came in almost daily. All sorts of theories are current among the men themselves accounting for this well-known fact - for example, working further out in deeper water, that the water itself "gets heavier" at this end of the season, etc.

The mystery was elucidated by the discovery in one autopsy of signs of scurvy. There was the simple explanation of the prevalence of the disease among men who live for months on small boats, eating salted and tinned foods, and also of its infrequent occurrence till the blood vessels have been somewhat weakened, as we know happens in scurvy. Acting on this knowledge I preached an anti-scurvy crusade, and noted that in fleets where my advice was taken and extra vegetables and other antiscorbutic precautions used there was a very considerable reduction in the number of cases of paralysis.

The points which have particularly impressed me in dealing with diver's paralysis are:

(a) Signs of asphyxia are nearly always present; it would appear from this that in the rapidly fatal cases death is usually due to affection of the breathing centres.

(b) In roughly 2 per cent of the cases in which death was not immediate meningitis set in about a week after paralysis. In this respect, however, considering the damage done to the central nervous mechanism, the only wonder is that it is not a more frequent occurrence.

(c) The question arises as to the cause of the congestion found in the meninges on pos*t-mortem* examination of fatal cases. Is it due to over-expansion of vessels by gases suddenly released from pressure, or is it simply part and parcel of the condition of asphyxia? From concomitant appearances in the thorax, it would appear that the latter is the true explanation, yet when one considers the blood or blood-stained cerebro spinal fluid, one is forced to think of the former as being equally applicable. Probably both factors are often present.

(d) The paralysis of the bladder and loss of the power of micturition are constant, and occur in cases so slight that it is practically the only symptom calling for attention. I have had patients walk up to hospital for catheterisation. Why this centre should be attacked so early and constantly is a problem I have failed to solve, more especially as the lumbar enlargement of the cord does not show nearly so much damage as higher up.

(e) The apparent point of selection for the most striking lesions of this disease is in the cervical portion of the spinal cord. The part of the cord where all the large haemorrhages were found without exception could be covered by three cervical vertebrae. Even in the cases in which apparently the disintegration of the nervous substance was the chief lesion, and no large blood effusions occurred, this portion of the cord showed the curious teased appearance more plainly than any other. Why such is the case is a problem for anatomists and physiologists. I can only make two modest suggestions: First, the comparatively large size and great mobility of the spinal canal at this point. Secondly, and this is a mere bow drawn at a venture, this portion of the cord is movable in the metal helmet of the diver, the rest being covered by the rubber dress closely pressed to the body by the water pressure. Theoretically, there should be nothing to choose from the pressure point of view. Is there anything in the movement? It must be remembered that a diver's dress at a great depth precludes bending the back beyond a very slight degree.

Reprinted from the British Medicine Journal, 1909, Vol. 2 (25 December), pages 1796-1798, by kind permission of the Editor.

The guest speaker at the 1987 SPUMS Scientific Meeting, Dr Tom Shields, drew the attention of the meeting to this paper. We have reprinted what is probably the first paper ever published about the diseases of divers in Australian waters.

GUSI

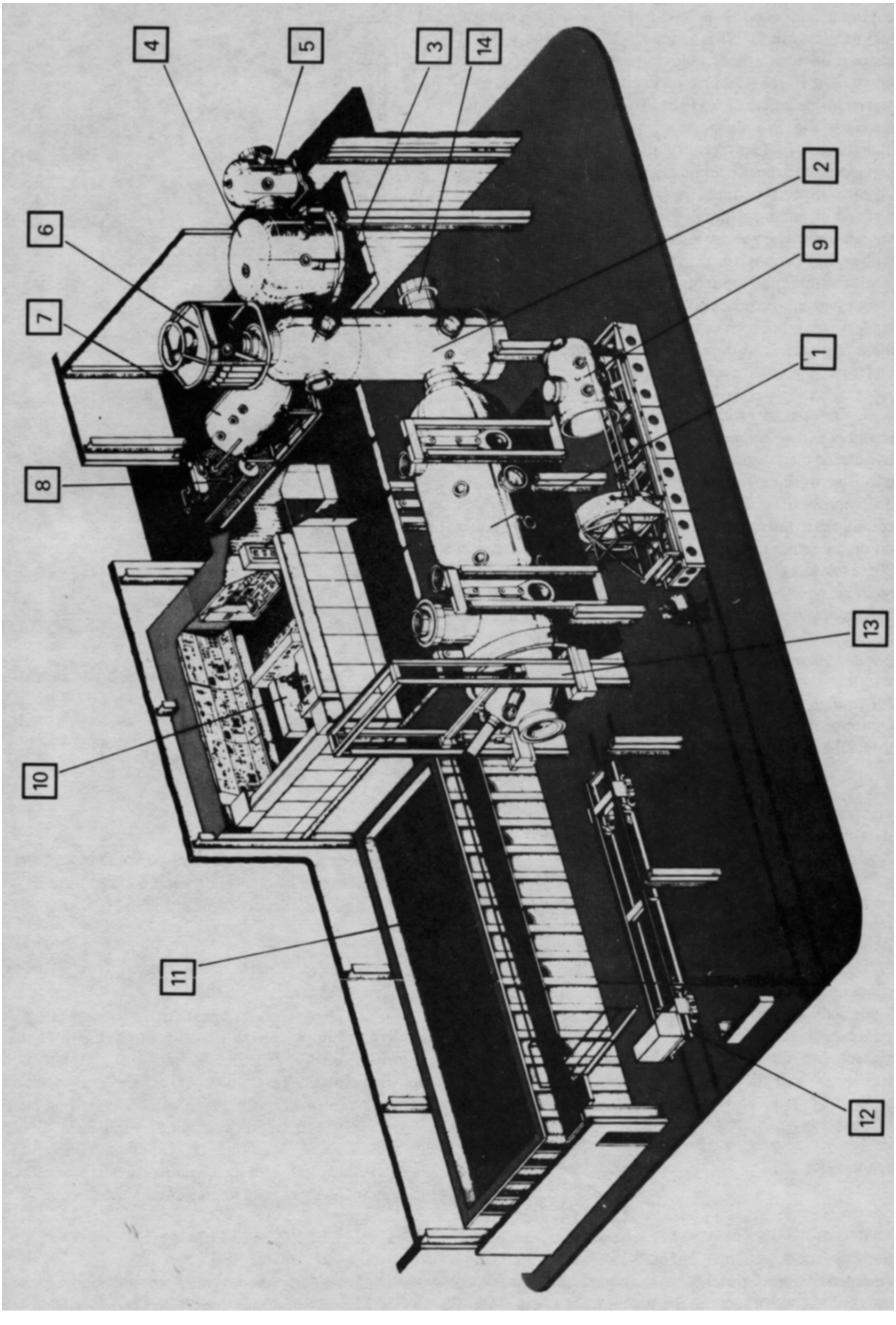
GKSS-UNDERWATER-SIMULATOR

In spite of its high technical potential, the industry of marine engineering in the Federal Republic of Germany finds it difficult to gain a foothold in the worldwide offshore market for lack of basic scientific elements as well as proven techniques, references, design principles and experienced personnel, and in particular of the necessary facilities for practical testing and verification. Taking the international standard of underwater technique, there is a technological gap in the Federal Republic ranging from the repair practice to future production processes. The research and development objectives within the scope of the major research effort of "Underwater Technique" by GKSS are to foster and promote many industries. They are aimed at finding technical solutions of underwater work and contributing by the provision of new technologies to the safe and efficient performance of underwater work of the required quality. Essential research activities are the development and testing of inspection, maintenance and repair practices. They include the necessary diving technique, equipment engineering, underwater testing, safety of the underwater work and training of underwater specialists as well as labour protection.

The major research effort of "Underwater Technique" was started by GKSS for more than ten years with the operation of the underwater lab "Helgoland" and the relevant deep diving equipment.

Underwater jobs in the offshore region involve considerable costs and risks, they are subject to changing weather and wave conditions. By means of a simulator it is possible to conduct tests under reproducible conditions and relatively low costs. Technical tests and developments are easier to make with a realistic approach to the present requirements and future perspectives in the offshore region in an appropriate underwater simulator. Such an installation was designed in co-operation with industry, the universities and based on the conceptions of GKSS. The GKSS underwater- simulator GUSI is one of the most sophisticated installations in the world and permits manned diving tests down to a simulated water depth of 600 m and unmanned tests down to 2000 m of simulated water depths. The installation is used to perform underwater jobs and operations under closely controlled safety precautions varying pressure, temperature current, salt content, visibility

FIGURE 1 Schematic drawing of the GKSS Underwater Simulator. 1. Main horizontal working and test chamber (600-1,000 m). 2. Working chamber (600 m). 3. Transfer chamber (600 m). 4. Medical treatment chamber. 5. Entrance lock and medical preparation chamber. 6. Personnel transfer chamber. 7. Living chamber. 8. Life support system for living chamber. 9. Unmanned high pressure test chamber (1,200 m). 10. Main control room. 11. Working pool. 12. Wagon for test rig. 13. Door lifting device. 14. Material lock. (see opposite page)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and contaminants. To simulate the working and environmental conditions found in offshore maintenance and repair work GUSI is equipped with a large wet test chamber, which is designed for a maximum operating pressure of 100 bars and has an internal diameter of 3.50 m and an inside length of 12.70 m. To open the chamber a lid covering the full diameter of the chamber is moved hydraulically. This permits also complete underwater service crafts to be accommodated and tested in the wet test chamber. Special partition walls (buffalos) were fitted to the wet test chamber so that in the individual sections of the chamber both wet and dry tests can be conducted. Openings with sealing flanges permit the introduction of pipelines and steel structures and the application of appropriate torsional stresses to the components to simulate the wave action. Underwater work such as welding, cutting or conserving of these structures can thus be tested in a wet test chamber under realistic load assumptions and site conditions.

A vertical central chamber connects the wet test chamber with the other pressure chambers where the divers live during their resting periods up to several weeks. It is not until the working cycle is completed that the divers are decompressed, ie. are slowly adapted under clearly defined conditions to the normal atmospheric pressure. Depending on diving depth and period of stay such a decompression phase can last several days or weeks. A safety feature is the medical chamber of treatment of injured divers. In an emergency the divers can be evacuated from the building to a safe place in a mobile rescue chamber with an independent gas and pressure supply system. An additional work basin with a water depth of 6 m and a size of 15 x 5 m is available for testing working procedures and methods under flow conditions. All test chambers can be operated at arctic and tropical water temperatures.

For the control of the chamber atmosphere, the gas composition, pressure and the test runs a modern electronic data processing system is used which makes for a fast evaluation of all test parameters.

Exploration and production of offshore hydrocarbon reserves will be extended to ever greater water depths. Already now platforms are operated at a depth of more than 300 m. As the depth increases new technologies are substituted for conventional techniques. Thus extended operations of divers in large water depths or manned underwater crafts are replaced by automatically controlled systems and equipment carriers. Progress in the underwater technique will depend on the capability to supply technically sound and well- tested as well as safe and inexpensive developments in time.

GAS SYSTEM

The gas system consists of a gas storage with a volume of 36,000 cbm in gas bottle batteries at the moment, the gas being supplied either direct to the rapid and emergency control panel of the individual chambers or via the central control room to the pressure chambers. At the compressor station there is always a set of two compressors for the filling of helium or air, for the transport of oxygen and the optional transfer of mixed gases or contaminated gases.

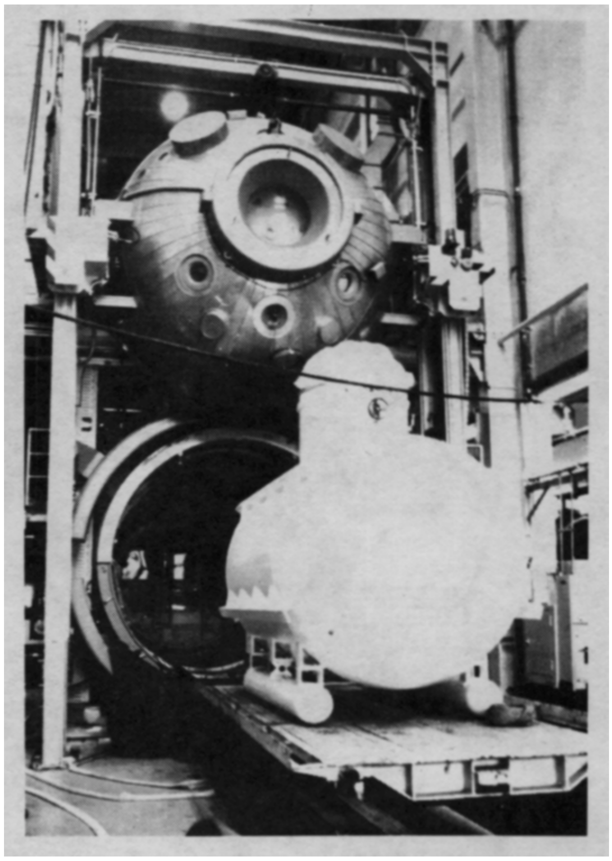

Figure 2 GUSI has a wet chamber which has an internal diameter of 3.5 m and an inside length of 12.7 m. This permits testing of complete underwater service craft or underwater facilities used in the offshore area. The lifting frame for the end door can be clearly seen.

HELIUM RECOVERY

GUSI requires for one dive to a water depth of 300 m just for filling the pressure chambers 6000 cbm of helium. In an offshore dive of 30 days at a depth of 300 m involving six divers working two hours each daily the total consumption would be 38,000 cbm of helium if no helium recovery and purification systems were available. In order to reduce these operating costs helium recovery and purification systems for the chamber gas and the breathing gas of the divers are used in underwater operations.

GAS ANALYZING SYSTEM

No devices for analyzing the breathing gases of divers operating in greater depths have been available so far which permit determination of harmful substances in the gas mixture with sufficient accuracy. The limits set for GUSI, for example, in a relaxed state were 5 ppm carbon dioxide and 20 ppb (1:50 million) nitrous oxides. Such a high accuracy is only possible by the constant calibration of the analyzers using specially composed calibration gases (reference gases), particular emphasis being placed on the long term stability of the measurements over several weeks. The calibration of 20 gas analyzers with a total of 83 measuring ranges is done cyclically by means of a process computer system. The data are shown on the display ready processed as required by the operator.

LIFE SUPPORT SYSTEM

The purpose of the life support system is to control the environment parameters of the breathing gas in the living and working chambers within the permissible limits for the divers. Since GUSI is operated at compression rates of up to 2.5 bars/min. and special breathing gases (trimex, helium-oxygen mixture) are used, the life support systems were designed for appropriate gas densities with due allowances for compression heat and expansion cold. They will allow divers to stay even at depths of 600m.

Owing to the high heat conductivity of helium and its pressure increasing heat capacity for life support system must control the temperature and humidity within very close limits. Variations may very quickly lead to an undesirable undercooling or overheating of the diver. The range within which the temperature of GUSI may be set is 26 degrees Celsius to 32 degrees Celsius at an accuracy of +0.5 degrees Celsius. This is achieved by an electric resistance heater with pressure resistant encapsulation in the gas stream which in addition to the heating of the chamber gas and pressure vessels permits to compensation of radiation losses of the pressure vessels at low environmental temperatures.

The chamber climate is also determined by the relative humidity which can be set here between 40% and 70% at an accuracy of +4%. Control is achieved by cooling the chamber gas below the dew-point temperature and then heating it again. With provision for setting the circulation volume of the chamber gas between 80 cbm/h and 450 cbm/ h optimum ventilation far beyond the requirement of Det Norske Veritas (36 cbm/h for 6 persons) is ensured. CO_2 flavour and odour traces are removed from the breathing gas through breathing lime and activated carbon filters. The ventilation is arranged in such away that the atmosphere is rather homogeneous in the chambers regarding temperature, humidity and CO_2 content.

WELDING GAS ABSORBER

One of the most important tasks of GUSI is the simulation of conditions in an underwater welding chamber to test welding methods and welding equipment. The welding gases produced hereby contain both solid particles and a variety of harmful vapours which are a health hazard to the divers and must be eliminated. Based on a development sponsored by the Federal Ministry for Research and Technology, Dragerwerk AG built a welding gas absorber system which permits by means of an externally located closed system purification of the atmosphere in the working chamber. There is also the welding heat produced to be removed. With a suction efficiency of 80% achieved at the welding point the chamber atmosphere is free from hazardous impurities.

PROCESS COMPUTER SYSTEM

Complex simulators require for a safe and effective operation extensive data processing. For GUSI and EDP system was installed for the following functions to be performed:

1. to show the present environmental parameters in the chambers;
2. to sound the alarm if the limits of the parameters are exceeded;
3. to record the data for subsequent evaluation.

A special function of the EDP system is to inform the chamber operator about predetermined and immediate actions to be performed. It also undertakes the automatic calibration of the gas analyzers ensuring long-term stability of the measuring system within the life of the sensors. Defective sensors and other faults in the gas analyzing system are detected by the computer system and shown on the display.

SAFETY FACILITIES AND SYSTEMS RELIABILITY

Since there are neither national nor international regulations or safety standards for the construction of diving simulators, safety concepts were designed and implemented in close co-operation with acceptance and classification institutions and also with diving experts of international reputation. Germanic Lloyd prepared an extensive safety expertise for the simulator.

For the whole system extensive error analyses were made to determine the effects of the failure of a single component on the safety of the divers. It is to be expected that this technology will also be used in deep diving systems and medical high-pressure chambers.

UNDERWATER WELDING AND METALLURGICAL TESTS

The importance of the Offshore Technology is growing rapidly by the development of oil- and gas fields for guaranteeing a constant energy supply. Therefore, the efforts are concentrating on greater water depth. Today the main working depths are at 250 m but within the next few yeas depths of 450 m will be reached in the North Sea

Regions. To work in these depths not only well tested reliable diving techniques combined with relating apparatus are missing, but also operational techniques (such as welding, and NDT, Systems). The GKSS Research Center tries to cover the necessary R&D work and to provide a well developed and reliably tested diving technique, machinery, testing equipment, welding, and cutting technique which is essential for the diving and exploring industry.

The operational technique, for safety aspects, and the training of underwater experts are also included in the program. Welding and cutting are the main subjects looked upon. The program is set up in such a way, that the solution of problems of immediate interest are as well developed on short notice as long term R&D projects on systematical investigations on welding, and cutting, systems are carried out. These investigations include basic research work and the development of procedures of mechanical welding systems up to fully automatic devices.

Today it can be stated that in foreseeable time the diver welder will only operate in shallow water depths, welding and curing procedures in greater water depths will be carried out in the long run by semi, or fully automatic apparatus. As rules and regulations even for shallow water welding operations are not existing in Germany, the GKSS activities concentrate in the elaboration of such industrial supporting material together with industry and the German Welding Society. In detail the welding activities concentrate mainly on the systematic elaboration of basic welding data, material properties, influence of shielding gas and chamber atmosphere, development of welding fumes gases in the welding process, influence of pressure on the ore and the weld pool, solution of problems which root gap and misalignment etc. and their correlating influences.

Several power sources for the different welding procedures, such as TIG-(GTAW), MIG/MAG (GMAW) welding are available and can be used for manual and mechanized welding systems. For the investigation and comparison of the operational performance of the power sources tyristorised and transistorised machines are available. Mechanized welding is carried out by a modified industrial equipment or by orbital heads all adjusted to hyperbaric conditions.

Besides the routine mechanical technological investigations, the metallurgical research activities concentrate more on the metal-alloy reactions of the base metal and the consumables in, eg. combination with the shielding gas or the chamber atmosphere. The knowledge about these details shall improve the materials behaviour or underwater welded steel products.

Different investigations have been carried out down to a simulated water depth of 300 m on C-Cn and C-Mn-Ni filler rods and a pipeline steel in GMA Welding process. Argon-Oxygen gases were used as shielding gas with different Oxygen contents. It was possible to create welded joints without any reasonable failures in the weld, when using a shielding gas of Are +5% O_2, all parameters were kept constant except the voltage, which had to be adjusted between 28 V at 1 bar to 36 V at 30 bar. No influence of the pressure on the hardness as well as on the stress/strain behaviour could be observed. Only the charpy-V-notch tests showed a slight influence of the pressure. Tests in fracture mechanics have been carried out. No remarkable influence of the pressure on the characteristic CTOD-value under maximum load could be detected. Detailed chemical analysis of the microstructure of the weld have been carried out and resulted an influence of the pressure on the Oxygen contents in the weld-metal. Microstructure and toughness have been negatively influenced.

Reduced oxygen contents of the shielding gas produces lower oxygen contents in the weld material, but the toughness did not improve remarkably. It was found, that the shielding gases with low oxygen contents are obstructive to the microscopical change of grain structure normally induced by the following layes. Therefore it seems necessary not only to optimise the shielding gas but also to modify the structure of the welding joint. A lower oxygen content in the shielding gas changes the chemical analysis of the welded metal. All investigations are carried out in close collaboration between the GKSS Research Center, universities and industry. The results will enter into the research activities on, eg. automatic orbital welding as well as into the research activities on manual welding during the saturation dives.

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WHISTLIN' IN THE KEYS

Eugene and Diana Cope began to dive off the Keys town of Marathon last April at 5.15 pm. They told their 15 year-old son Kevin, who was to wait in their private boat, that they would return about 6.15 pm.

When they became overdue from their dive, Kevin tried, but couldn't start the boat, so he radioed that his parents were missing.

A search involving the Coast Guard and private boats got quickly underway, but soon darkness fell and the chances for locating the two divers before morning were very slim.

At 10.45 pm, a local resident heard the faint sound of whistles blowing and carefully followed the noise. He found the two missing divers a mile and a half from where they had started their dive.

Diana Cope later recounted that they had surfaced about 1000 yards from their boat, but were unable to reach it because of strong currents.

The Copes owe their rescue to whistles they carried on their buoyancy compensators. Years ago nearly all BC's came with whistles, but today only Scubapro, Dacor and Tabam include whistles as standard equipment. Most other manufacturers don't include them simply to keep down the price of the basic BC.

Dime stores and dive shops sell whistles for a buck or two. Every diver ought to have one, especially those who dive privately, at night or anywhere a current might appear.

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The address of UNDER CURRENT is PO Box 1658, Sausalito, California, 94965, USA.

DIVING SAFETY MEMORANDA

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

August 1986

DIVING SAFETY MEMORANDUM NO. 6/ 1986

GUIDANCE ON PRE-DIVE BELL CHECKS

Diving Safety Memorandum No. 4/1985 gave guidance on the length of time of bell runs. Paragraph 4 states:-

"Divers should not be required to man the bell in readiness for diving until all other preparations which may delay the launching of the bell, have been completed. Immediately divers have manned the bell and completed the necessary safety checks, a pressure seal should be made thus effectively starting the bell run."

It has come to my notice that some diving companies are conducting pre-dive safety checks for the next dive during the ascent phase of the previous bell run, in order to reduce change around time.

Diving companies are reminded that it is the responsibility of the diving supervisor to ensure that pre-dive checks have been performed by a competent person within the 6 hours before the diving operation commences.

In this context the competent person is taken to be the appointed diving supervisor who "must ensure that the more immediate pre-dive examination of diving plant and equipment has been carried out by a person who has the necessary knowledge and experience." (see HSE Guidance Note 89). The "person" would normally be the divers about to undertake the dive for the checks inside the bell and not the divers from the previous bell run. Other competent persons/divers can perform the checks on the outside of the bell. If the start of a dive is delayed by more than 6 hours, the pre-dive safety checks must be performed again.

This legal requirement only covers those checks relating to safety and does not include any checks which may be made on non-vital equipment, tools etc. associated with work tasks.

In the context of Diving Bells a pre-dive safety check list should cover the requirements listed under SI399 1981 Regulation 12(1)(g) and Schedule 6 - see booklet HS(R)8 "A Guide to the Diving Operations at Work Regulations 1981 ".

An appendix illustrating a minimum pre-dive check list is attached to this Memorandum.

APPENDIX TO DSM NO. 6/1986

NOTE: This list is for illustration only and is neither exhaustive nor sequential.

PRE-DIVE SAFETY CHECK LIST

Inside the diving bell (to be carried out by divers commencing the dive).

1. Check mixed gas complement content and refill if required.
2. Connect and test diving helmets.
3. Check bail out bottles and refill if required.
4. Check divers safety harness and belt arrangement.
5. Examine medical kit and replenish if required.
6. Soda sorb checks and replacement.
7. Check emergency lighting and scrubbing facilities.
8. Check O_2 cylinder content and refill if required.
9. Inspect survival gear.
10. Test communications - surface to bell, surface to diver, surface to bellman.
11. Test emergency communications.
12. Check gas analysis equipment, O_2 and CO_2
13. Test B.I.B.S.
14. Check divers recovery lifting device.
15. Check knives.
16. Check emergency tool kit and wire cutters.
17. Spare door seals.

18. Check position of all valves.
19. Check for good working order the diver emergency recovery winch.

Outside the diving bell (to be carried out by other members of the diving team appointed by the diving supervisor).

1. Visual check of ballast and of ballast release.
2. Visual check of main lift wire and emergency lift sockets.
3. Strobe light.
4. Emergency relocation device.
5. Check for leaks on valves, gauges, gas cylinders, doors etc.
6. Check position of all valves.
7. Visual check of umbilical securing devices.
8. Check bellman's communications, if the bellman's umbilical is kept outside of bell.
9. General visual check of bell for damage.
10. Where applicable, check emergency release systems for status, wear.

April 1987

DIVING SAFETY MEMORANDUM NO. 3/1987

NORWEGIAN PETROLEUM DIRECTORATE SAFETY NOTICE NO. 5/1987

The following diving safety notice has been issued by the Norwegian Petroleum Directorate and the recommendations are supported by the Diving Inspectorate of the Department of Energy.

"The 30th March 1987 a diver perished while diving on the Norwegian continental shelf. The diver was on his way from the bell to the worksite at 110m depth. When it became clear that the diver was having difficulties, the standby diver left the bell and found the diver laying on the bottom, unconscious without the helmet on.

"NPD cannot at the present time draw definite conclusions as to the exact sequence of events leading to the accident.

"Since the perished was found without the diving helmet on, NPD will direct attention to the locking mechanism which locks the helmet to the neckseal. The importance of well maintained and functional main locking mechanisms and locking systems is hereby emphasised.

NPD recommends that all helmets and the locking arrangements to the neckseals immediately are to be examined thoroughly to detect possible defects/weaknesses. It is further recommended that evaluations are made with a view to possible modifications which can improve safety."

May 1987

DIVING SAFETY MEMORANDUM NO. 5/1987

COMEX-PRO HYPERBARIC FIRE EXTINGUISHER PART NO. 611-000

The Diving Inspectorate have been advised of certain modifications which have been implemented by the manufacturers to prevent the possibility of overpressurisation of the LP container as follows:-

(a) A synthetic emulsifier under Part No. 611-099 is now available as a direct replacement for the original protein emulsifier Part No. 610-999. As this is a direct replacement no modification is necessary in order to use the existing units.

(b) On all new units supplied from 15 October 1986, the following modifications have been made:-

(i) a non-return valve has been fitted in the LP supply line to the LP container gas inlet.

(ii) a bursting disc (rated 20 bar) has been fitted in the LP container cap.

A conversion kit has been made to enable existing units to be brought up to the new specification.

Both the above modifications have been accepted by Det Norske Veritas.

Further information may be obtained from Mr P Hogben, UWI Ltd, Unit 2, Logman Centre, Greenbank Crescent, East Tullos, Aberdeen AB1 4BG.

The Norwegian Petroleum Directorate's Safety No. 4/87 dated 24 March 1987 also refers.

R Giles
Chief Inspector of Diving

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

DIVE PROFILE SELECTIVELY INFLUENCES THE RELATIVE FREQUENCY OF DECOMPRESSION SICKNESS MANIFESTATIONS. CE Lehner, DJ Hei*, M Palta*, TM Ives* and EH Lanphier. Department of Preventative Medicine and The Biotron, University of Wisconsin, Madison, Wisconsin 53706.

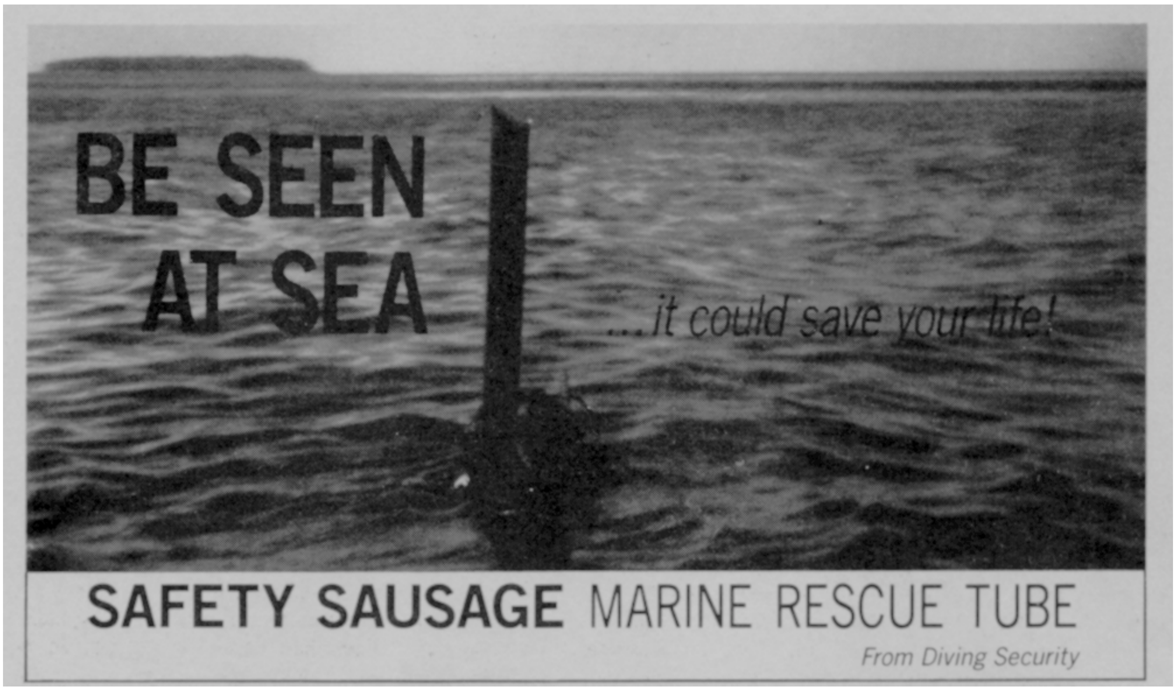
Decompression responses of 11 large sheep after simulated no-stop decompression dives indicate that dive profile selectively influences the relative frequency of limb bends and CNS-DCS. Sheep were exposed to compressed air for 1/2, 1 and 4 hours and decompressed (1.8 ATM/min) to ambient pressure to provoke decompression sickness (DCS) signs. In the ongoing study, twelve of 123 animal-dives have provoked DCS signs for an almost 10% DCS incidence. Limb bends and CNS-DCS (all spinal cord) responses were separately fit by maximum likelihood with logistic regression on log pressure and log duration of the simulated dives. We evaluated the dive pressure estimated to provoke a 5% incidence each of limb bends and spinal cord DCS for each dive duration. Estimated pressure required in 1/2-h hyperbaric exposures to provoke a 5% incidence of limb bends (4.6 ATA) was greater than for CNS-DCS (4.2 ATA). This relationship was reversed in 4-h exposures with CNS-DCS (2.8 ATA) versus limb bends (2.2 ATA) each again at 5% predicted incidence. These findings indicate that spinal cord injury occurs in "fast" tissues with a more rapid inert gas wash in than in the "slow" tissues of limb bends. These results confirm our previous findings which suggested that deep, no-stop "bounce" dives carry a higher risk of spinal cord injury than shallow dives with the same risk of DCS. (Supported by the University of Wisconsin Sea Grant Program).

EVIDENCE FOR CORONARY ARTERY AIR EMBOLISM ASSOCIATED WITH CEREBRAL AIR EMBOLISM IN DIVING ACCIDENTS. RM Smith* and TS Neuman. UCSD School of Medicine, La Jolla, CA, 92103.

Coronary artery air embolism has been described frequently as a complication of cardiopulmonary bypass but only rarely with diving accidents. Over a 4 year period from 1982 to 1986, 14 patients with cerebral air embolism following a diving accident were seen in the Emergency Department of UCSD Medical Center. 13 incidents were associated with an uncontrolled ascent from depth (6-120 fsw, mean = 61) and one with a rapid ascent from 260 fsw with a missed decompression stop. In all cases there was onset of central nervous dysfunction within 5 minutes of arrival at the surface, typically immediately on surfacing. There was elevation of serum levels of creatine phosphokinase (CPK) in 10 of 14 patients (382-98840 IU/L; median = 1570); in 5 of these the level of MB isozyme was elevated (4-12%; 39-11860 IU/L, mean = 2780 IU/L). Closed chest cardiac massage was performed in the one case with the highest level of CPK elevation but the level of CPK prior to chest compression was also elevated at 1965 IU/L; chest compression was not performed in any of the other cases. In no case was there elevation of BB isozyme. ECGs were available prior to recompression therapy in only one case; this showed loss of anterior forces and diffuse T-wave abnormalities which resolved following treatment on a modified Navy Table VIa. In another case, post-treatment ECG demonstrated only non-specific abnormalities and technesium pyrophosphate scan was negative, but 2-D cardiac ultrasound showed evidence of focal hypokinesis in the inferior left ventricle. These studies suggest that myocardial eschemia as a result of coronary artery air embolism may be a more common sequelae of gas embolism with diving accidents than has previously been thought.

NEW PERFORMANCE GOALS RECOMMENDED FOR UMBILICAL SUPPLIED OPEN CIRCUIT UBA BASED UPON NEDU TEST RESULTS
Christopher J Tarmey Lieutenant Commander, Royal Navy.

In 1981, The Navy Experimental Diving Unit Panama City, Florida published standardized procedures for the unmanned testing of underwater breathing apparatus (UBA). These procedures have been adopted by the navies of Britain and Canada and are widely used by civilian test facilities. At the same time, NEDU established performance goals against which the UBA being tested would be considered for potential Navy use. The aim was to provide goals for work of breathing and breathing resistance that would ensure that a diver's performance would not be limited by the performance of his breathing apparatus. Ideally of course, zero external work of breathing, perhaps even with some assisted breathing, would have met this aim. However that would not have been practical. Furthermore some types of UBA are inherently worse breathers than others but are non-the-less needed for a particular mission. Accordingly the various types of UBA were grouped in categories and performance goals were established for each category taking into account the state of technology at that time. The intention was to redefine the category performance goals as advances in technology were made. In September 1986, NEDU conducted unmanned testing of eight umbilical supplied demand UBAs to identify which would best meet the Navy's requirements for saturation diving to 1000 FSW. Those tested included rigs widely used by military and commercial divers. Of all these only two were able to meet the performance goals to 1000 FSW. The others fell far short. Failure to meet the performance goal was invariably due to the adverse effect of umbilical pressure drop on regulator performance. The current performance goal is for work of breathing not to exceed 1.8J/ L at 62.5 RMV, (representing a moderately heavy diver work rate), to the maximum operating depth. One of these UBA was the first umbilical supplied demand regulator ever tested at NEDU that was capable of higher work rates than 62.5 RMV and exceeded the performance of many free flow helmets at depth. For the first time we are now able to consider performance goals at 75 to 90 RMV (Heavy and Extreme work rates). Accordingly NEDU has recommended new more stringent performance goals for umbilical supplied UBA. Testing procedures, performance goals and detailed results of the testing will be presented together with a description of the Ultraflow 500 mechanism that has made new performance goals possible.



The Safety Sausage will soon be available in Australian dive shops. The recommended retail price is $10.00. You can help make them available by showing this advertisement to your favourite dive shop and asking them to stock the Safety Sausage.

All enquiries to Diving Security, PO Box 6298, MELBOURNE VIC 3004. Diving Security, is a branch of RJ Knight Pty Ltd.

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Further information and enrolment

For further information or to enrol contact
Royal Adelaide Hospital courses:
Dr DF Gorman
Director Hyperbaric Medical Unit
Royal Adelaide Hospital
North Terrace
ADELAIDE SA 5000
Telephone (08) 224 5116.

NZUA sponsored course
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New Zealand.

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

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

Dr Acott's address is
39 Oswald Street
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