New Zealand deaths associated with scuba diving, from the period from 1961 to 1973 were reported in a paper in the New Zealand Medical Journal by an Auckland pathology registrar. He examined the inquest details of the 21 cases over this twelve year period. The number of cases per year was roughly the same, which to my mind indicates an improvement since scuba diving has become much more popular in recent years. Nine cases ran out of air. Only in two was aspiration poorly but not adequately described. Often histology was not done. There is a strong indication that the causes of death are changing possibly due to better standards of diver education.

Dr Martin Sher

I have heard before of aspiration being the cause of deaths. I wonder whether it should be part of diving courses to learn bow to cope with vomiting. If you feel like vomiting you should take your regulator out, as vomiting into the regulator and then breathing it back in may be the cause of aspiration. Talking to divers, many of them are not aware that they should take out their regulators, their only though is to get out of the water as soon as they can. How to cope with vomiting underwater should be pushed by the instructors and made known in diving courses.

SALVAGE DIVING

Ian Lockley
Salvage Pacific Ltd.
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Salvage diving is a fairly broad subject. I will confine my talk to the area that we work in. Our base is in Fiji and we branch out into New Guinea, Australia and occasionally to New Zealand. To the east, we go as far as the group of islands south of Hawaii. Most of the diving we do is in warm water. This certainly makes diving a lot more pleasant and enjoyable. Most of it is also in clear water, so we are normally able to see what we are doing. However, we do run into jobs occasionally that go back to my early training days, which were in the Brisbane river. Once you were 1cm under the surface, it was dark and everything was done by the Braille method. We developed several techniques while we were diving like this. One was to use the stainless steel mesh glove used commonly in abattoirs, to enable us to have the tactile sense that is so necessary to perform useful work when you cannot see. As the various senses go, sight, touch, sound, naturally the diver becomes less efficient. It is amazing the number of little things that have developed in the industry, particularly over the last ten or fifteen years, that have enabled us to achieve more and more in a given time.

One of the problems which we run into in this part of the world is that it gets deep very quickly. We have restricted our diving to compressed air, for the simple reason that to become involved in mixed gas diving is very expensive. Also, listening to divers talking, I am quite sure that there is a lot still to be learned about it. It is mainly restricted to oil rig diving, which is very well controlled and where finance is not the first problem. There is also the odd occasion, such as the recovery of the gold from HMS “EDINBURGH” where money was not really a problem once the target was located. The diving on that particular job was really quite straight forward, but it was written up in a book, “The Discovery of Stalin’s Gold” as being a fantastic feat. From a professional diving point of view, it was the sort of thing that is done every day on oil rigs around the world. Nevertheless, it must have been a tremendous sensation to be picking up these bars of gold.

Our diving here is largely scuba. We do on occasion use face masks, positive pressure systems, if we are using communications. We find that communications can be used quite well with ordinary scuba equipment if you have someone who has been diving with you as a buddy, as the topside operator. It is quite possible to talk with an ordinary water mike. We leave it dangling and when we want to say something, we put it up near the regulator and somehow squawk out a noise. More often than not, the communication that we want is fairly simple such as “up” or “down” when lifting something, or “on” or “off” when using a hydraulic circuit. Quite often we use surface supply to avoid the problems of putting heavy tanks on and of filling them. It is much easier and cheaper to operate on hookah if we are operating in deep water. By deep I mean below 100 feet. Diving with a hose, we use either an ordinary demand regulator or perhaps full face mask. We also use a small bail out bottle to enable us to get back to the decompression chamber or to make a safety stop and carry out decompression with the air that is on our back.

We try to make our system as safe as possible in that the particular diver who is down there working is entirely responsible for his own safety. He may need support for carrying out the particular task, this is in the form of lifting and hydraulic power. But from a safety point of view, I subscribe to the school that every man should be on his own. So many of the accidents that have occurred have been a third party involvement, where they take the wrong mixture down, or something strange has happened, and that has led to an accident and often a fatality. We have done a little bit of experimenting with the fibreglass helmets that have developed from the original hardhat. We do not use them now. We do not need them for protection. We do not need them from the point of view of safety. If you are going into a particularly tight situation where there is a possibility that you may get hung up, the full face mask is more than adequate. The full face mask that we use is a positive pressure system. What would happen if somebody blacked out with a full face mask like that on I cannot say, because I do not know of any case histories. But certainly it would not be any different to wearing one of the "Rat Hats" as they are sometimes referred to. They are ridiculously expensive to buy. They are expensive to maintain. And all they really use, except for the sophisticated communication system, is an ordinary demand valve. In fact, a lot of them do not even have the refinement of regulators.

The Scubapro Pilot regulator came when we were diving on the "PRESIDENT COOLIDGE" We found the Pilot regulator of immense benefit, particularly as we were working down around the 200 foot level on compressed air. We were sometimes spending an hour and a half or even two hours at that depth. This is in the US Navy exceptional exposure tables. We found it more productive to do one long deep dive each day, rather than shorter dives, with all the inherent decompression and problems. It has always amazed me that they have not introduced Pilot regulators or power breathing into the deeper systems. Some of the modern gas recovery systems for mixed gas diving are good, but still we do not see, to my knowledge, power breathing. We have all had power steering and power brakes on our cars for years. I wonder why we cannot have power breathing, particularly in the commercial world. I think there is an opportunity there for someone to get in and to push power assisted breathing.

We have found when pushing new systems, I think that this applies more to oil rig diving, that people are very reluctant to accept something new. The rig bosses tend to use what they have operated with over the last decade or so and anything new is regarded with suspicion. There is good reason for this. These operations are obviously very expensive and a small problem can sometimes develop into a major one. It is amazing how a small event can be magnified and can stop the whole proceedings.

With our type of diving, on compressed air, we are really limited to the topside of 200 feet. We have done inspection photographic dives down to a maximum of 270 feet. We used an ordinary Nikonos camera and found that they work quite well at those depths, although I would not recommend it. We are lucky in that where we have done this, it has been clear water in lagoon conditions. By lagoon conditions, I mean a calm sea state and very little current. I think that this has a tremendous part to play in compressed air dives. I understand that there is a lot of research going on into compressed air diving, particularly in America. We have noticed that we can perform quite well to that depth to 270 feet if the water is warm and it is clear. But as soon as you change either one of those things, concentration starts to wander and it is very easy to become distracted by the slightest thing. I would suggest that perhaps the clarity of the water, the general ambient light, has more to do with it than the temperature. It is fairly easy to keep yourself warm with hot water suits. If necessary, a hot water hose stuck into a wet suit is a very comforting feeling when you are decompressing and you start to get the shivers, which can happen even in warm, tropical waters. But at depth, I would say light, or the ability to orientate has more to do with success than anything. Some of you may remember that, at the SPUMS meeting in Suva in 1978, one of our divers gave a talk on a bad attack of narcosis at 270 feet. He was one of the divers who had never experienced narcosis severely and, like a lot of us, believed it could not happen to him. He saw lights dancing and could not concentrate and if he had not had someone with him, he probably would have drowned. The other person with him was able to guide him back to the surface. He only ascended a matter of 50 feet before he was completely in control again, and wanted to go down again and continue what he was doing. I think that was probably brought on by physical work. Since then, we have limited our people to photographic surveys.

There have been peculiar things that have happened in very deep water. I have just come back from Aberdeen, where they have taken to filling lift bags with helium. You can imagine what it costs to fill a 10 lb lift bag at 1,000 feet with helium. They were using compressed air for lift bags up until recently. However a bubble of compressed air happened to get under the skirt of a diver's mask and he suffered nitrogen narcosis, at something like 1,000 feet. You can imagine the effect of that. You can also imagine the cost of the other way around.

Our reason for not going into mixed gas, although there are plenty of targets in which we could use it, is one of cost. It is not just the cost of the gas, but the cost of setting up the whole diving system. Today, one would have to spend something like 1,000,000 dollars to buy a good system and this would only be a 800-900 feet system. This would enable us to go after a lot more of the lost cargoes in our area. There are something like 250 merchant ships sunk in the Second World War in this part of the Pacific. We have done some research to turn up the worthwhile recoverable cargoes. We now have a few of these on the topside of 700 feet of water and we are wondering whether we will go with diving equipment, putting man down there, or use remote control to place explosive charges and use grabs and cranes to do the recovery. It is not a very difficult thing to cut a hole in the side of a ship and reach in with a crane grab and lift out the nonferrous cargoes that we are interested in. It has been done before. When the gold was recovered from the "NIAGRA" during the Second World War, they used pieces of water pipe packed with explosives to cut the side out of the ship in 400 feet of water, and then lifted out the gold after removing the door from the strong room. All that was done with a small observation chamber and grabs operated by a little coaster 400 feet above. I think that today using modern technology and integration of electronics and hydraulics and remote systems, it is all quite feasible and can be done economically, but we have yet to prove it.

We have a team of men and equipment. It is a little bit like the fire engine and the firemen situation, we get sick of polishing the fire engine and we look about to see what is worth recovering. We have finished the cargoes in shallow water on the topside of 200 feet. Some of the vessels were wrecked well before we started off operating in the area, but we have worried them over the years to the point where we have now cleaned them up. This is the main reason that we are looking now at deeper operations.

Whether you go to the 200 foot line or to 2,000 feet or in fact to 20,000 feet, the operational problems of remote systems are very similar. It is very easy to get an electrohydraulic power pack down to 20,000 feet of water to perform useful work. It is then easy to send excellent TV pictures from 20,000 feet and to operate manipulators. These systems are a little bit experimental. This was the sort of thing used by the US Navy with the Hughes group of companies, in recovering parts of the Russian submarine. A lot of the technology that is in the oil industry today has developed from that. The US Navy developed a remotely operated vehicle (ROV), an early seeing-eye TV camera. It is operated by nearly every company using mixed gases in deep water. Most of the divers prefer to have one of these flying eyeballs watching them. It gives them an extra sense of security. There is always the old worry of looking over your shoulder to see if you are going to become part of the food chain. These flying eyeballs operate to 20,000 feet just as easily as they operate at 2,000 feet. The electrical and hydraulic systems operate just as easily. There are a few problems with extra depth like the dynamics of cables and all the equipment that is needed to get it through miles of water, but these problems can be overcome if the economics justify it.

The ROV systems have developed to the point where a TV camera can be dynamically positioned with plus or minus half an inch from the surface in many thousands of feet of water. Heading direction can be maintained to an eighth of a degree. The equipment can more or less be bought off the shelf, thanks to the space race. It is the same equipment used to guide the space shuttle. It can be integrated with microprocessors and with a simple joy stick can be controlled by a pilot, who preferably is a diver, to inspect a wreck, or a well head, and to do simple tasks like turning valves on and off, placing explosive charges, and operating the controls of hydraulic manipulators to do large work tasks. It is all feasible and is being done in industry today. A lot of it is still experimental.

Some companies are pursuing ways to keep a man down there under pressure and there is a lot of work being done on that. Others are taking the tack of putting a man into an armoured suit, the JIM suit. I do not think that system will be with us for very long, I think that we are going to see either a breakthrough in medical technology so that man can work successfully below 1,000 feet, or we are going to see completely remote systems. It will be very interesting, from our salvage diving point of view, to see which way it goes in the next decade. In the film that we had taken on the WAIGANI EXPRESS, a lot of discussion was going on with chain caught up in 200 feet of water. We are frustrated by not being able to work in that depth which is really fairly shallow. We have decided at this stage to go with a ROV and ROV remote pilot vehicle, so that we can send a camera down to that depth very easily, deployed from a boat of opportunity, which could be anything as small as a 35 foot workboat. We could send this camera and a manipulator down to 2,000 feet if we wanted to, by quite simply lifting it off the back deck. You cannot send a diver down to 2,000 feet by dropping him off the back deck. We can then use this machine to attach lift bags to heavy weights. We can use it to place explosive charges so that it can cut 3" chain cable, or 3" wire rope. We can then direct the force of the explosion to chop a piece from a coral head in 400 feet of water. I think that modern technology in the form of hydraulics and electronics is ahead of man at the moment.

We have been frustrated because we cannot work in 400 feet of water, but we have found this little machine that we feel we can make do useful work. At the moment, if we do get a chain caught up at 400 feet, we have to go through the problem of manoeuvring a tug at the surface. We then may run into bad weather, such as we experienced on the WAIGANI EXPRESS where we had 100 ton tow lines broken like pieces of cotton and all the problems that they cause. I cannot blame the people working on the back deck who say "That's enough" when a rope like that breaks. It whips back and tears steel bulkheads apart. You can imagine what it would do to a man, if he were unlucky enough to be in the way.

If we stay with long duration compressed air diving, above 200 feet as we did for the COOLIDGE operation, we have found that it is very successful. When we embarked on that programme, we were just a little bit concerned that we were going to be faced with the incidence of bends (about 3%) that is apparently acceptable to the US Navy. We prepared as best we could with a bell that was attached to the side of the ship and a small transportable pressure chamber. We were lucky enough to have the backup of the Australian Airforce for that transport chamber. It would have gone to Prince Henry Hospital to their recompression chamber if there was a serious problem. In thousands of dives, involving exceptional exposures, we only had one suspected limb bend. We do not think it really was a bend. I think it was more a strained muscle, but we treated it on oxygen with a shallow table, and it disappeared and there were no recurrences. I wonder why we were able to make thousands of dives under working conditions, and not have perhaps a single problem. No one really has been able to provide an answer to that other than we were unconsciously putting in an intermediate stop at approximately 90 feet, because that was the depth at which the chamber tether chains were attached. Unless we happened to work immediately adjacent to that attachment on the wreck, we swam horizontally at a depth of between 80 and 100 feet for three or four minutes along the hull so that we were always in contact with the vessel all the time to the chain. Perhaps that deep water stop, which was not part of our decompression time, was providing that margin of safety. Perhaps there is room for a little bit of investigation there.

I feel that a diving bell is most effective for that type of decompression. I am not in favour of surface decompression routine, although it is widely used. We have found that our divers prefer being able to ascend directly to the chamber. They do not like the thought of jumping out of the water, slipping off as much of their gear as they can and immediately getting into a chamber while someone shuts the door and hopefully turns on an air valve, or even leaves it to the diver himself to turn on an air valve, to repressurise him within 5 minutes of leaving his last stop.

Of course the diving bell, and certainly the surface bell, can only be used in calm, relatively current free waters. It would be impossible to tether a bell in open sea conditions, where there was any surge running, the pressure changes during the last stop at 10 feet would be too great. The alternative is to leave the bell down at 40 feet and decompress on oxygen, then a tethered bell could be used readily. However, a ground swell surging backwards and forwards 15 feet, would make a submerged bell very uncomfortable at 40 feet. Perhaps transfer under pressure is the answer. That system is used for mixed gas diving. But it is expensive. It is cumbersome. It requires a lot of topside support and cannot be deployed from a boat of opportunity, unlike our little ROV system. What we are looking for is the impossible. Being able to jump a man off the back of the boat, instead of throwing our little ROV into the water, and say "Go down and see what the problem is at 2,000 feet and when you have finished come straight back up again."

Walter Stark developed the Electrolung more than a decade ago. This certainly enabled you to jump off the back of a boat and go down to 600 feet, perhaps more, swim around, do your thing, and come back up again and then promptly die with massive decompression problems. Perhaps gas changes, perhaps different mixtures may solve the problem in the future. Today, we have the pressure sensors, gas sensors, gas regulators, processors that the whiz kids need to come up with a solution to this. Perhaps by gas changing one can eliminate the decompression problem and then it will be possible to jump off the back of a boat.

I think that the decompression problem is the real one. Other than exploratory dives, such as photographic dives or survey dives, we generally go down to perform some work. We take power packs with us. A small power pack today is readily available in the form of surface support from a cable at anything up to several thousand volts to hydraulic coaxial cables, to explosive contained energy. All these are possible, but decompression is not unless we go into the difficult systems, transfer under pressure and deck decompression, but one certainly cannot operate them from a boat of opportunity.

What does the future hold? By the future I mean the next five to ten years. Are we going to see R2D2 robots taking over? With divers operating them? There is a lot of money being spent at the moment on training pilots for this magical little machine. It is my opinion that they need to have come from the commercial diving world to make a good pilot. How you can project yourself into one of these little machines, down at several thousand feet, and then do useful work is a little bit beyond me. But with these force balanced dynamically positioned systems, with master manipulators it is possible. The integration of these systems is still experimental. Perhaps someone will come up with the magical solution to the decompression problem. I am quite sure that electronics are going to play a major part, because under situations of stress, even our computer tends to break down and make mistakes, and I think that leads to more accidents today than anything else. The push from surveying the various operations around the world is towards machines and not man in the sea. The other school, which appears to be the minority at the moment, are saying "Keep man down there". Only the future will tell.

In our thirteen years of working in a difficult and hostile environment, quite often from boats of opportunity and in places of opportunity, all the accidents that have occurred have been the people factor. We have never been able to explain why somebody, who is experienced, has done a silly thing. Quite often at times that are not apparently of any stress, people have run out of air, when they have had backup systems, when they have had buddies diving with them. They have been diving with communications and suddenly the communications have gone dead for no reason. I think this is one thing that we cannot eliminate, the people factor. I feel sure that even if we are able to solve the problem of decompression, so that we can jump off the back of a boat of opportunity, like our little machine, that we are still going to have a little machine following us. Perhaps the diver is going to be telling the little machine what to do. After all, how many watts of power can we produce for any given period of time compared with what a machine can do? I think this gets back to our power breathing, power brakes, power steering. I think that is the way that the oil industry will be going, and I am quite sure that is the way that we will be going in our salvage diving.

LETTERS TO THE EDITOR

PO Box 79,
NAPIER 4000,
New Zealand

Dear Sir,

The factors affecting the advisability of contact lens use vary as widely as the types of diving, and a blanket rule against contact lens usage in diving as suggested in the January to March 1983 SPUMS Journal is rather an over-reaction.

I certainly agree that contact lens wear is never acceptable in saturation or chamber diving. Anything, such as a contact lens, which could possibly affect or reduce the corneal integrity, allowing the possible entry of pseudomonas, which is such a familiar inhabitant of chambers, cannot be permitted. A pseudomonas infection can result in the very rapid destruction of the cornea, the risk of which is not acceptable in any situation, let alone under the limitations of a chamber or offshore environment.

Simon and Bradley's complete paper on the "Adverse Effects of Contact Lens Wear During Decompression" is an extremely interesting paper because, as far as I know, it is the first time that slit lamp microscope observation of the cornea has been utilised during hyperbaric or decompression procedures.

The point that the unfenestrated PMMA (hard) lens caused bubbling in the pre-corneal tear film is not totally convincing in such a limited study. The fact that no details of the corneal or lens variables are quoted in the original paper unfortunately reduces the value of the study.

There are many different techniques of fitting these lenses, each of which involve a slightly different relationship between the lens and cornea. Some techniques require fenestration (holes in the lens) for adequate corneal ventilation, whilst others offer adequate oxygenation and ventilation by other means.

My own work at the USAF School of Aerospace Medicine confirmed that there are no changes in corneal curvature under pressure so any physiological changes during diving will be related to ventilation (ingassing and outgassing) and not because of any mechanical change in the fitting relationship between the lens and the eye.

A convincing and valuable conclusion of Simon and Bradley's paper, however, is that lenses fitted for diving must have good ventilation. We must remember that this can be achieved by other means in addition to fenestration, particularly including the use of the new oxygen permeable materials.

I am not necessarily convinced that the bubbles in the pre-corneal film had to be nitrogen. As the cornea was oedematous, it could well have been carbon dioxide.

A recent Swedish study investigates the adhesion of contact lenses to submerged eyes. There is no doubt that hydrophyllic (soft) lenses have vastly superior adhesion and are far less likely to be lost. Right from the early days of hydrophyllic lenses we have known that in fresh (hypotonic) water, adhesion was so great that forced removal could actually pull away the corneal epithelium. Lövsund's group found additionally that adhesion was sufficient in seawater.

For sport and light commercial diving, I cannot find any studied arguments against soft lens usage.

I also feel that the use of hard contact lenses is permissible in normal circumstances. Realistically both types of lens are not likely to be lost during normal diving activities, but it must be understood by the wearer that hard contact lenses do not possess the same adhesion as do soft lenses.

The reservations that I have with hard lenses, therefore, pertain firstly to someone with a high degree of ametropia who, in the unlikely event of both lenses being lost, was unable to find his way, operate his instruments, or find his boat or entry.

Equally, someone undertaking diving activities that present high risk of mask loss such as could occur in some rescue, military, or police diving activities, should not wear hard lenses.

Yours faithfully,
Quentin Bennett