INVESTIGATION OF DIVING ACCIDENTS AND EQUIPMENT

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Los Angeles County has the distinction of consistently having more diving fatalities than any single community outside the state of Florida. We have anywhere from 6 to 16 fatalities a year. Some of them are pretty bizarre. Years ago I became involved with the ESD (Emergency Services Detail) in Los Angeles County, a highly trained group of individuals who do all the rescue and recovery for the Sheriff's Department. They needed to learn to dive. I had to go through a Sheriff's Law Enforcement Training Academy and become a reserve Sheriff before I could teach them. I have been with them for some time now.

In most communities where search and rescue is combined with recovery there is a tendency to treat a fatality as a rescue. One of the most difficult things has been to get them to understand that one rescues someone if there is possibility, or probability, of bringing the person out alive. If the person has been lying on the sea floor for much beyond an hour, it does not make a sense to tackle it in the same way as a rescue. During rescue operations the ESD people are willing to lay their lives on the line. I found, after having trained with them for a while, that they were as willing to lay their life on the line to go down and recover a dead body, as if it was a rescue.

They felt they had to get the body back because everybody in the family would feel so much better when they saw it lying on the dock. There is a great deal of emotion associated with a person who has died during any kind of activity, but particularly when scuba diving. People think that under the water, the crabs and the sharks are going to do their thing, so one must hurry to retrieve the body. We have been able to get them to recognise that it is not worth risking another human life to recover a dead body. This means that body recovery should be treated like any other salvage operation. There is no need for haste, there is no need for going into conditions that are environmentally marginal and there is no need for anyone to feel they have to make a heroic effort to try and bring back the body.

Body recovery

In communities where there is enough diving, there is a need to formalise the way in which the chain of evidence is dealt with when trying to get enough information to understand how the accident took place and where correctly to put the blame. One of the difficulties that we have today in the United States, any time there is an accident, is that if anything is found to not be proper that immediately becomes the proximate cause of the accident. We feel that a thorough chain of evidence is needed to be able to differentiate causes and to make recommendations to the diving community at large about what takes place when there are accidents.

With that in mind, we asked professional law enforcement officers how they go about reviewing a crime scene. What are the kinds of things that they do. They told us about the chain of evidence, the details of the body, the photographs, the identification, where the bodies are, what circumstances might be associated with the environment that the body was found in that might give information about what had happened. This has been taken up by our unit and we have established a group called the Interagency Scuba Committee. This has representatives from the Fire Department, the Sheriff's Department, the Police Department, the Harbours people, life guards and anybody who would be involved in a potential body recovery. As a result everyone knows what to do.

For a scuba diving fatality, or even a serious accident, there is a phone link with the Sheriff's office. This 919 number can be radioed straight into the Emergency Services Detail and they immediately send a trained law enforcement person to the site of the accident or the site of the fatality or to where ever the body is being taken. For example if the person died on a boat, they immediately get the names of witnesses, take charge of the equipment and put into a evidence bag, so that it is isolated, and check that they understand what has happened to the individual and to the equipment during the time since the recovery.

On the other hand, if it is a body that has been down for some time, or we go into a search operation, we use a very different tactic. Instead of finding the body and immediately ditching the weight belt and hauling the body to the surface, as one used to, we now treat it like a crime scene.

When the searchers find a body the first thing is to do a short closer examination to see if there is anything that we will have to spend some time on in relation to documentation. We then do photographs to show things. In one case there was a great deal of swelling in the lips with a relatively small opening and the regulator was out. We could tell that the regulator had been pulled out after the individual had gone into rigor mortis. We check to see if there is anything in the mask or any leaks from the scuba system. We check whether the weight belt been ditched. We take a look at the contents gauge. It is not unusual for the contents gauge to read nearly full. It is really quite rare, less than 1 in 5 cases, for people to be out of air. We have investigated a number of accidents where the tank pressure was 2,800 and 3,000 psi, and at least one of these the diver had simply failed to turn the tank on. We note the maximum indication on the depth gauge and the depth where we find the body, if there are injuries and the state of inflation of the BC. We try to get all the information before we start moving the body.

Records

There are forms for recording the individual's vital statistics, the names of the witnesses, who they were and the name of the deputy filling in the documentation. We get a ID number from the coroner and a serial number associated with the Los Angeles crime records.

We also have a personal inventory. It includes all the diving equipment. If there is some other personal equipment on a dive boat, we also impound that. We have had a number of interesting surprises with what people have in their personal luggage that they probably used just before their fatal dive. The contents of the luggage can help the medical examiner make decisions about the autopsy protocol.

There is also a Supplementary Diving Report. This is where a lot of the statistical information ends up with a description of where the body was found, how deep it was, what kind of position was the body in, who were involved and places to check off some of the circumstances were. I dislike the term "involuntary separation". It should be "separation" because involuntary is a presumption. Many divers perform what I call "voluntary separations". They have different ideas about the dive and go to different places. They only join up periodically. We have a surprising number of cases where, at the time of the accident, the buddy pair were separated by a distance that made it impossible to participate any kind of a rescue.

The next step is an interview with the personal friends, room mates and members of the immediate family to get some information about the victim's physical condition and their diving physical (medical examination) history. Whenever this information is unavailable, an investigator talks to whoever would be knowledgeable. These interviews provide very interesting and often helpful information. In many cases we have determined, from the autopsy, that victims had used cocaine.

We had a local diving cult called the Jelly Beaners. They derived their name from the fact that a number of drugs came in brightly coloured capsules that looked like jelly beans. They would pop a few and dive and see what kind of fun and mystical things would happen underwater. Many of them survived.

We investigate who trained the victims, their level of experience for that level of training, their diving experience during the past year, whether or not they had any previous kinds of accidents and who owned the equipment. We check whether any adjustments had been made to the equipment by anyone.

Equipment handling

The directions are that, from the time of recovery, no one touches the equipment before it has been photographed and examined, unless there is a chance of a free flow. In that case we ask them to make a mark across the handle and the valve and then turn it off recording how far they have to go. We do that because we have had several cases where the divers, instead of turning the valve all the way on and backing it off a quarter of a turn, have turned it all the way off and cracked it on for a quarter of a turn. That does not make a much of difference early on in the dive when there is a sufficient differential pressure. However at the end of the dive, it creates another restrictive orifice which can turn a good breathing regulator into a very difficult breathing regulator, even if the regulator works perfectly.

We have evidence lockers for each of the pieces of equipment so that any time that it is not being tested we maintain its integrity by keeping it in a separated storage area.

Equipment investigation

Each piece of equipment is examined and tested. We make a record of serial numbers. We make a record of how it is attached to the tank. We check that regulator was attached. It is not as odd as it sounds. Over the past three to five years we have had cases where, when we got the equipment, the regulator was so loose that the tank would not hold air. One of the recent deaths was a commercial diver on hookah, using a tank as back up, while working through kelp. Divers on hookah in kelp often have a quick disconnect on the hose so that they can go onto the pony bottle, get themselves out of the kelp and then re-connect and go about their business. They use the pony bottle partly as a tool and partly as a backup. This man was still attached to his hose, lying dead on the bottom and there was no air in the tank. The assumption was that he must have breathed it dry. On the forms it was recorded that the regulators were attached, the control valve was on and that air was not leaking. However that was because the first stage regulator was functionally separated. What probably happened was that the diver made an attempt to get out of the kelp by plugging into his pony tank, which was upside down. As the air pressure went out of the tank and he started moving up and down water got into the tank, because the first stage was loose, and collected at the lower end, where the valve was. Soon his regulator delivered a mixture of water and air, that had a slight pressure head of air behind it. He then aspirated and drowned, with the regulator in his mouth.

We check all the valves. With anything that can be wound in and out we make a mark on the shoulder, and make a matching mark on the handle and count the number of revolutions available. This also applies to dials that will change the breathing characteristics of a regulator. Scubapro produced a regulator that has been referred to as "dial a death". It in fact is a very good regulator, but by twisting a knob one can detune it and turn it into a very bad regulator.

It has about four and a half turns of adjustment. The designer now agrees with me that it should have been made as a screw driver fitting rather than a knob which gives divers the opportunity to change its characteristics at will. There are people who believe that if they increase the breathing resistance on the regulator, their tank is going to last longer. Unfortunately it only seems to them that it lasts longer.

We check the cylinder size, how it is rated and what kind of condition it is in. We look inside the air cylinder. It is surprising that we find water in about 1 in 4 cylinders. We are not always sure how the water gets into the cylinders. If there is even two teaspoonfuls of water in the cylinder and the diver inverts, the water gets into the valve. Then with the next breath the diver gets the water first, this can be as a bolus or as a spray, and then the air. This is a very stressful process.

We check the kind of floatation, how much lift it had and the amount of weight worn. All these things are recorded in order as we go down the check list. The completed check list gives a record of what took place at that particular point in the chain of evidence.

We see some interesting equipment. Sometimes we suspect that the victims were not used to the diving equipment they were using and had not bothered to take instruction. One dead diver was about 1.6 m (5 ft 4 in) tall and weighed about a 55 kg (120 lb). The wetsuit did not fit but he should have been able to operate with half the 10 kg (22 lb) he was wearing.

Some 1st stages did not have a contents gauges, although there was always a port for one. One person died using a sonic regulator. These make a rattle sound when the tank pressure is low. It was a good operational regulator. But it did not have enough low pressure ports to take care of all the hoses that were needed for a buoyancy compensator, drysuit and octopus. This stubborn individual, decided not to put these hoses on because he did not think he would need them. He had a single first stage, no alternative air source and no auto-inflation system. He did not have the rod that operated the J Valve, however the J Valve had been displaced about 6 mm (a quarter of an inch). That was sufficient to release the spring and allow the reserve air to be used. With a J valve the diver normally takes a breath that is hard to breath, then reaches behind and presses down the loop and gets the reserve pressure. There was no evidence that he had done that.

One diver died wearing an Atpak. These are back mounted buoyancy compensators where the back pack is used as a repository for lead shot as an alternative to wearing a weight belt. The idea is that should one need to get rid of it, you reach around the back, put your finger through a wire loop and pull a 16 cm (7 inch) wire out of something like a piano hinge. Then a trap door will open and all the shot should fall out. Unfortunately all the lead up in between the shoulder blades floats an unconscious diver face down. We have had a number of these backpacks come through our hands. One had the wire pushed in a little further so that the end could be looped to keep it out of the way. He had not worked out that when one does that one can no longer pull the pin out.

Some of those who died had very heavy backpacks because of their weighting system. An Atpak, with the cylinder full of air, weighed 38 kg (84 lb) which is an awful lot. One innovative individual cut out the centre of his plastic backpack and slid sheet lead down into the hole. The backpack and cylinder normally weighed around 21 kg (46 to 47 lbs), but it weighed 31 (68 lb) with this modification. He fell over in the surf and was never able to get back onto his feet. He drowned in about 50 cm (18 to 20 inches) of water. One very creative diver did not have an accident. He transferred the weights to his backpack with no system of jettisoning, the result could be described as a poor man's version of the Atpak.

We have seen some interesting weight-belt innovations. We think is a bad idea not to be able to ditch a weight-belt. Apparently some divers feel that they do not want to lose the weight-belt because that they put double buckles on. Then the diver has to undo two buckles before the belt starts to fall. Wearing a knife on the outside of the leg means that if one ditches the weight-belt it can come down behind the knife handle and hang there.

If the weight-belt tongue is more than four or five inches long, we note the fact. In this circumstance if one opens the buckle and the belt starts to fall away, the section with the weights is going to move faster than the section without weights. That causes the belt to go crosswise in the buckle and it will usually jam. We have done this experimentally and seen it happen. In one death a belt had closed its buckle around a fellow's ankles, having been hooked up on his knife and lower leg. A belt with 8-9 kg (18 to 20 lbs) of lead, hanging on a knife handle or round one's legs makes survival difficult.

Tucking the long tail of a weight-belt inside, or round and round the belt is not a solution. If one is depending on ditching weights to provide positive buoyancy if one gets into trouble, then a long belt is not in one's best interest. Nor is tucking it inside, because in an emergency, or a panic situation, undoing the buckle will do nothing towards dropping the belt.

We take some of the gear into a swimming pool to test to see if it is operational. In one case the detontating cord on the CO_2 cartridge had one loop around the CO_2 cartridge so that no matter how one pulled the handle, the arm would not come down to puncture the CO_2 cartridge.

On several occasions recently, we have found there was no low pressure hose attached to the BC. This usually indicates some kind of free flow or malfunction and that the

diver separated it deliberately, because we teach them how to do that in our training program. If the power inflator starts to blow, one must immediately disconnect it because that is the only sure way of being able to shut it off. If you have not done it before, because you have not had the problem, you will find it really awkward to do, particularly if you have one of the smaller disconnect mechanisms.

Equipment testing.

Testing the equipment which is laborious. We have a complete set of catalogues with specifications of all the regulators and equipment that are used in our area. We also have all the appropriate tools as many of the devices take specialized tools. We use our library to see what changes from the manufacturers specifications have taken place.

The first step is to test the regulator. We use a differential pressure gauge attached to the regulator. Then we put the regulator in someone's mouth and get them to breathe normally. We record the inhalation, exhalation and differential pressures. Then we use forceful inhalation and exhalation and record the same pressures. This enables us to decide whether it is a functional regulator. We do the same for all the breathing equipment, octopus, Air II or alternate air sources.

We always check the intermediate pressure to determine whether there are any leaks, and also to determine whether the appropriate intermediate pressure was operating on the regulator.

After this we test the regulator on a breathing machine inside a small hyperbaric chamber. We can flood the chamber or leave it dry. Our protocol requires that we test the regulator on the surface and at 10, 40, 60 m. It is all automated. We measure at 6, 15 and 30 breaths a minute with a two and half litre tidal volume recording the performance under all these circumstances. We also test the regulator at the depth at which the body was found.

Regulator failures can involved tuning, in-leaks or out-leaks. It is very rare that we have a circumstance where there is not enough air remaining in the cylinder to operate the regulator.

In-leaks sites are going to be at the exhaust valve or the mouthpiece. One has to pull on the mouthpiece to be able to detect these cracks. Under normal circumstances the elasticity of the rubber will hold them together. But in a person's mouth, there is enough distortion to let water leak through the mouthpiece. The other site is the exhaust valve. Debris under the flap valve will prevent it seating and will let water in. Entering the water from a boat with the regulator in the mouth, the water pressure may be sufficiently above the pressure in the regulator to drive part of the exhaust valve back into the regulator. That will provide a wet breathing regulator throughout the dive. If one blows very hard the flap sometimes pops back out again and then the leak will stop.

Out-leaks are generated by O rings. That is usually because the tank valve does not match the regulator. One has to be very careful lining up the valve and the regulator or there will be a leak. Valve seats and hoses also have to be checked for out-leaks.

Conclusions

By developing a clear protocol for recording a chain of evidence and co-operation between all authorities concerned the Los Angeles ESD has improved the investigation of diving accidents. The results of careful inspection and testing of the diver's equipment, with evidence gathered at the scene of the accident have allowed us to discover the actual cause of death. This has enabled us to draw attention to dangerous practices in an effort to prevent further deaths.

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