Abridged report

Abridged report of the Panel of Investigation convened to examine the fatal accident at Sodwana Bay on 27 November 2000.

CMAS
CONFÉDÉRATION MONDIALE DES ACTIVITÉS SUBAQUATIQUES
WORLD UNDERWATER FEDERATION

Summary

Mr Dennis Harding died on 27 November, 2000, following a trimix dive at Jesser Canyon, Sodwana Bay. The following report describes an investiga-

tion into the circumstances surrounding the accident, and makes recommendations regarding procedural changes designed to prevent possible similar situations from re-occurring that may lead to a similar incident.

Background to the Panel

The panel was convened under the auspices of CMAS Instructors - South Africa (CMAS-ISA), the SCUBA Diver training section of the South African Underwater Union (SAUU). SAUU is the South African member of CMAS, the World Underwater Federation. Although the accident did not occur during training, it was felt that CMAS-ISA was in the best position to conduct an investigation. Most of the team members had links to SAUU and CMAS-ISA, either though training or club membership.

The Investigation Panel has no legal standing. The function of the Panel was to investigate the circumstances of the accident, and produce an objective report analysing the causes of the accident. The Panel seeks to establish facts, and does not seek to apportion any blame.

The Panel members were as follows:

Prof. Johnny van der Walt (Panel Convenor)

Mr Roly Nyman

Mr Mike Fowler

Mr Martin van Veelen

Mr Nuno Gomes

Mr Mike Beresford

Mr Christo van Jaarsveld

In addition to the above, two observers were present:

Mr Don Shirley

Mr Simon Murray

The Panel adopted the procedures used in previous investigations. The witnesses were questioned separately in order to establish the facts. Only once all witnesses were questioned was an attempt made to create a scenario of the actual events.

The actual names of the team are not recorded in this report. The people interviewed were:

Diver A: Dive companion to the deceased, qualified and experienced Trimix and Cave diver

Diver B: Cameraman on the dive, qualified trimix diver.

Diver C: Buddy of Diver B, recently qualified Trimix Diver.

Support Diver A: Support diver who assisted in rescue efforts.

The Victim

The deceased was Mr Dennis Jonathan James Rutherford Harding, a computer specialist living in Johannesburg. Mr Harding was a qualified PADI Instructor, and was trained in trimix diving by Mr Steve Minnie and the late Rehan Bouwer. Mr Harding was a TDI Trimix Instructor, and was well known in the technical diving community. Although the Panel did not have access to his logbook or medical records, several members were able to confirm that Mr Harding had considerable technical experience and did not appear to suffer from any medical ailments. In particular, he had carried out many dives to the depth range (and deeper) of the fatal dive, and deeper, using the Halcyon rebreather. It was confirmed that he had undergone all the Halcyon training required by the manufacturer.

Composite Scenario

Combining the facts obtained from all of the witnesses arrives at the following description:

The Coelacanth Expedition

The expedition originated as a result of the final trimix training dive of Diver C, on a previous occasion. During that dive, a fish was spotted which was believed to be a Coelacanth (*Latimeria chalumnae*, Smith 1939). As a result, a team was assembled for the trip, which included Mr Harding.

The First Dive

On the first day of the expedition, the first group carried out a dive. Support Diver A was part of this group. The team dived to 110m, without seeing any sign of the Coelacanth. The dive procedure was to descend on EAN35 to 35m depth, and then change onto the 10/60 trimix bottom gas. The dive group did not have a permanent buoy-line, but deployed individual marker

buoys from approximately 100m. The group then ascended to approximately 40m, where they switched to EAN35. Further switches to EAN50 and pure oxygen were made at later stages in the ascent. The dive went without incident.

The Second Dive

The rest of the team that had not dived on the first day, but planned their dive for the second day. Mr Harding carried out all the decompression planning on the evening of the first day. The decompression package used was Z Plan V 1.03, using the option to insert "Pyle"- type deep stops. The dive was planned for a depth of 115m, and the team were to commence ascent at 19 minutes elapsed time. The bottom gas was 10/60 trimix, and the intermediate gasses were EAN35, EAN50 and oxygen.

During the dive planning session, Mr Harding requested that the deployment of surface marker buoys be delayed until the group reached 40m, as he did not have enough line on his normal reel for a deeper deployment. After some debate, the group of four4 who were to carry out the dive agreed to this change in procedure. Mr Harding, as part of his decompression calculations, had calculated the critical pressures ("turnaround pressures") for each diver.

Dive Equipment and Configuration

Mr Harding's equipment consisted of:

1. a Halcyon semi-closed rebreather, (the rebreather was supplied with gas by two 10 litre steel cylinders connected by an isolation manifold).
2. a Typhoon drysuit,
3. an Extreme Exposure canister torch worn on the waist-strap,
4. 3x stage cylinders, - (a 7 litre steel cylinder, - EAN35; a 11.2 litre cylinder, - EAN50; a 10 litre aluminium cylinder, - Oxygen),
5. a suit inflation cylinder, and
6. a non-bungee Wings- type BC with a stainless steel backplate.

The rest of the team were utilising open- circuit equipment only. The divers were equipped as follows:

Diver A:

This diver was wearing:

1. A neoprene drysuit and a Wings-type BC with redundant bladder.
2. Twin 14 litre independent cylinders.
3. Three front-slung stage cylinders for decompression.

4. Two Sabrelight torches carried on a helmet.

Diver B:

This diver was wearing:

1. A one-piece wetsuit and a 4 kg weightbelt.
2. Twin 15 litre aluminium independent cylinders, a 7 litre steel cylinder of EAN35, strapped to the back twins in a triple pack configuration.
3. Two additional stage cylinders were carried; a 10 litre cylinder of pure oxygen, a 10 litre cylinder of EAN50.

Diver C:

This diver was wearing:

1. A two-piece 5mm wetsuit with a hood.

2. #9; Twin 15 litre steel independent cylinders.

3. #9; The cylinder size and configuration were the same as Diver B.

4. Equipped with a Dive-Rite Classic Wings BC and Dive-Rite Junior Wings as a redundant bladder.

Pre-Dive

The team decided to assign the task of operating the cameras to Mr Harding and Diver B. The divers did not formally decide on buddy pairs or dive leader, but came to an understanding the rough understanding was that Mr Harding would lead. Diver A had been on previous expeditions with Mr Harding, and the two had often dived together as buddies on previous technical dives.

During the briefing, Mr Harding advised the entire team that, due to the efficient gas usage of the rebreather, he should have the most gas to spare. In an emergency, he advised, the distressed diver should look to him first as a source of additional gas. He detailed the procedure for sharing gas usingwith the long hose from the Halcyon. The team were told that the distressed diver should approach him and signal the problem. Mr Harding would then close the rebreather mouthpiece, flip the hoses up and remove the long hose from its stowed position. He would hand over the long hose and then regain the rebreather mouthpiece.

The critical pressures were discussed. It is not known what critical pressure Mr Harding was using as his reference. Divers B and C were using a critical

pressure of 75 bar in each cylinder, while Diver A used a critical pressure of 90 bar in each cylinder.

Immediately prior to the intended launch time, Mr Harding analysed his bottom gas again. The results of the analysis are unknown, but he decided to delay the dive and refill his cylinders. After a lengthy wait, his cylinders were refilled to his satisfaction. The dive commenced at around mid-day. There were three backup divers to cover the four divers in the water.

The Dive

Descent:

The descent went as planned, with the switch from EAN35 to bottom gas proceeding smoothly on the fly.

Bottom:

The team reached the sea-bed at 96m, with visibility in excess of 35m, and swam down the slope to about 105m. The group then swam horizontally along the face of the slope, examining the small caves as they went. Mr Harding was seen to lag behind the rest of the group by some considerable distance, with the spread between the leading and trailing divers being up to 35m at some stage of the dive. The group travelled an estimated distance of about 200m horizontally during the planned bottom time. There appeared to be negligible current from surfacetop to bottom. Mr Harding was observed to switch several times between closed circuit and open circuit mode on his rebreather unit, but failed to abort the dive.

Late into the dive, a Coelacanth was spotted. The divers swam after the fish, and discovered that there werewas more than one. They were able to obtain good video footage of several of these fish. This chase involved a fair amount of exertion. Due to the excitement of finally finding the rare Coelacanths and the concentration on the filming, Diver B failed to monitor his pressure gauge. When the dive terminated at the planned time, his cylinder pressures were at about 60 bar.

Ascent:

The group ascended to the first of the "deep stops" at 77m.

At this point, Diver B experienced difficulty breathing. He was able to confirm that the problem was due to the low gas content in the cylinder, and swapped regulators to draw gas from the other bottom gas cylinder. During this time he drifted up to about 70m. The second cylinder emptied soon afterwards, leaving Diver B without bottom trimix gas. At this time, he felt that he had two options, either to ascend immediately to about 40m and swap to

EAN35, or descend and share gas with the team. He elected the latter course of action, as an immediate ascent would have entailed skipping some deep stops. He approached Mr Harding, as briefed. Mr Harding was seen to go through the expected drill. The two divers stabilised and continued sharing gas. Diver B seemed a bit agitated, but not unduly so. At this point Mr Harding's gas also ran out. Diver B then switched to what he thought was his EAN35 mix and commenced an immediate ascent. Mr Harding also commenced a rapid ascentfollowed diver B. Divers A and C followed them up to about 50m, at which stage Diver B and Mr Harding were still ascending. Divers A and C stopped at this point, and deployed their marker buoys. Diver B has no recollection of these events, and appears to have lost consciousness shortly after switching to the nitrox mixtureEAN35. He does recall operating his power inflator.

Surface:

The surface crew were expecting the team to deploy their surface marker buoys at around this time, and the support divers were kitted up, ready to descend. They were surprised to see Mr Harding surface, followed almost immediately by Diver B, after only 24 minutes into the dive.

Mr Harding was conscious. The first support divers in the water went to Mr Harding, and asked him if he wanted to go down again. Mr Harding indicated that he wasn't feeling well, and asked to be taken into the boat. After some delay After some difficulty releasing all of his equipment, Mr Harding was pulled onto the boat. He lost consciousness and stopped breathing shortly thereafter. Efforts at reviving him proved unsuccessful, and he was declared dead by a doctor on shore at 416:10 pm.

Diver B was lying face down in the water, breathing from his regulator. Support Diver A went to the assistance of Diver B. Diver B was pulled into an upright position, at which stage he regained consciousness. Support Diver A noted that Diver B was breathing from his EAN50 stage cylinder. Support Diver A then asked if he wished to go down and complete the decompression procedures. Diver B indicated that he felt clear well enough to do so, and the pair descended to 40m. The surface time was less than a minute. At the deeper stops Diver B used air from Support Diver A's twinset, but later switched to his own stage cylinders. The pressures in Diver B's trimix cylinders were noted as 50 bar and 35 bar. The two divers completed the profile, extending the last stop by 15 minutes.

On surfacing, Diver B was placed on pure oxygen, and taken back to camp, and placed on pure oxygen. As he was still not feeling well, it was decided to transport him to Richards Bay for treatment in a decompression chamber. Due to the lateness of the hour it was not possible to transport him by helicopter, and a road transfer was required. Diver B was recompressed and released from the chambers the following morning. He appears to have made a full recovery.

Analysis

After interviewing all the witnesses, the Panel had a discussion session regarding the facts then available. The following summarises the discussion.

General

The Panel were all of the opinion that there were actually two separate incidents. Diver B running out of gas precipitated the first incident. Mr Harding switching to open-circuit while on the bottom, and then running out of gas while assisting Diver B initiated the second incident. The first incident exacerbated the second.

In both cases, an out-of-gas situation triggered the emergency. However, a number of factors exacerbated the extent of the problem.

1. Lack of formal organisation: The team did not have a definite leader, and the responsibilities of each member sometimes led to conflicting requirements. The "spotters" were required to swim ahead and look for the fish, but were also required to act as buddies to the cameramen. This lack of a firm team arrangements structure lead to the large spread of the group. It was noted that a diver operating a camera requires a dedicated buddy.
2. Insufficient reserve bottom trimix: At the critical pressures calculated by the group, there was insufficient trimix to support two divers through to the first change-over point to Nitrox.
3. Lack of buildup dives: Some of the team members were diving with their chosen configurations for the first time., Nno shallow check-out dives were carried out to check functioning of equipment, to test the dive plan (scouting and filming) and to determine a comfortable swimming pace.
4. Insufficient disaster planning: The team had no agreed plan for In-Water Recompression (IWR), or even agreement on the use of IWR.

Incident 1: Out of Gas Emergency, Diver B

The primary cause of this incident was failure to monitor gas pressures throughout the dive and failure to abort the dive at critical pressure. A related aspect was failure to note that gas consumption was higher than expected, which meant that the gas ran out sooner than would have been expected. Diver B did, however, follow the agreed emergency drills in approaching Mr Harding.

Incident 2: Out of Gas Emergency, Mr Harding

Facts:

The primary cause of this incident was also a failure to monitor gas pressure, and/or failure to react to the situation. In Mr Harding's case, the situation was compounded by the high drag factor created by the large cross-sectional area of the rebreather plus 3 side-slung stage cylinders, and the speed at which he was swimming to try and keep up with the group. The decision not to abort the dive on switching to open-circuit would also have contributed to the severity of the emergency.

When approached by Diver B for gas, Mr Harding went through the normal drills. The trimix bottom gas ran out shortly after initiating buddy breathing, causing Diver B to switch to one of his stage cylinders (found at surface on to be EAN50) and to immediately commence his ascent. It is thought that Mr Harding pursued Diver B with a view to stopping him at about 40m, and switching to the EAN35 mix. There is some evidence that Mr Harding did plug in his own EAN35 mix to the rebreather switching block.

Reasonable conclusions:

At this stage Mr Harding was probably ascending rapidly. In this situation, he would have been required to control at least three separate airspaces, namely his BC, his drysuit and the rebreather loop. In addition, it is believed that he was attempting to effect not only a gas switch, but was also attempting to assist Diver B. Under these circumstances, the degree of task loading was obviously extremely high. It was noted that Mr. Harding might have been positioned vertically, tilted slightly backwards, with Diver B supported above. In this position, the spring-loaded overpressure valve on the Halcyon Rebreather loop would have then been beneath the level of his lungs. With the heavy task loading, and a possible desire to conserve as much gas as possible in the loop, it is possible that he may have had difficulty in venting properly. This scenario is not inconsistent with the findings of the *post-mortem* examination, i.e. severe decompression illness, which by definition may include a degree of pulmonary barotrauma.

Discussion Points

Several points emerged during the discussions. Each is summarised briefly below.

1. Dive Planning:

   It was generally conceded that the decompression profile (as well as other aspects of the dive planning such as critical pressures) were all worked out by Mr. Harding, and not individually checked by each of the deep diving team. This is contrary to CMAS-ISA technical diving procedures.

2. Buoy Deployment:

   The CMAS-ISA standard requires deployment from the bottom. It was also noted that some divers are deploying at depths in excess of the length of line available on the reel, and letting the marker buoy pull them up to stop depth. It was agreed that the deployment technique as described in the training schedule must be adhered to scrupulously, and that some form of permanent/drifting shot be deployed that carries extra gas for decompression purposes.

3. Rebreather:

   This accident is the first known fatality on the Halcyon rebreather, and the Panel devoted some time to discussing the role the equipment may have played in the situation. It was noted that the regulators were later found to be functioning properly, but that the cylinders were both virtually empty. It was noted that the long-distance cave dives successfully completed with the Halcyon unit had all made use of scooter propulsion. The Halcyon unit was thoroughly examined and no evidence of any malfunction was detected.

4. Bottom Gas:

   An analysis of the trimix gas remaining in the cylinders suggested that the oxygen fraction of this gas was about 20%. A discussion with the Scubapro agent suggested that, if the pressure in the supply cylinder was low enough, the first-stage valve seat would remain in the open position, causing the gas flow to reverse. Such a flow and the resultant mixing could have occurred if a travel gas was connected to the switching block. This was the most likely explanation for the unexpectedly high oxygen level.

5. Group Experience:

   Several panel members expressed surprise at the depths being attempted by divers with relatively little trimix experience. Although the CMAS-ISA trimix diver qualification does not have a depth limitation after the course, it is expected that divers would under normal circumstances gradually work up to depths such as these.

6. Cylinder Configuration:

   Most of the Panel stated a preference for the use of an isolation manifold on twinsets. CMAS-ISA Trimix standards recommends the use of an isolation manifold, but is not dictative in personal preferences of

the individual diver. It was also noted that only Mr Harding was carrying a long- hose regulator, all the others being in contravention ofcontrary to the equipment requirements stated by CMAS-ISA.

7. Cameras:

   The experience of the panel was that a person operating a camera underwater is often distracted from the critical safety checks, such as monitoring of pressure. It was agreed that a camera operator ideally needs a dedicated buddy.

8. Gas Consumption:

   The dive team had utilised an RMV of 20 litres/minute in their planning, which turned out to be inadequate for the extended horizontal swim at depth.

9. Critical Pressure:

   The concept is taught on all basic CMAS-ISA recreational courses, but needs to be extended and amplified in the technical training courses.

10. Motivation:

    Members of the panel felt that Mr Harding may have continued the dive, even with his low cylinder pressures, to avoid disappointing the rest of the group. He may not have foreseen that other divers were also critically low on gas.

11. Disaster Plan:

    The lack of a disaster plan was debated in some detail. It was agreed that, Support Diver A had done a good job of the rescue of Diver B. However, it was felt that the group should have had a pre-agreed method of determining the required profile.

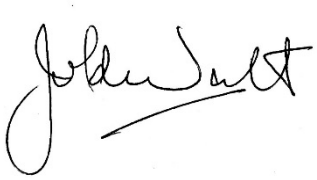
Prevention and recommendations

1. It was decided that the CMAS-ISA Technical Training Committee should meet as soon as possible in 2001 to discuss the matters and recommendations noted by the panelnoted above. This Committee is to re-examine current CMAS-ISA training materials and protocols and make firm proposals, all of which should be incorporated as far as possible into the relevant training manuals.

Conclusion

The Panel concluded that:

1. There were actually two separate accidents.
2. The primary cause of the accidents was a failure to monitor gas pressure, which led in turn to an out of gas situation.
3. The group failed to plan for a sufficient gas reserve, and did not take into account the exertion involved in swimming at depth.
4. Mr Harding probably died as a result of Severe Decompression Illness. The high degree of task loading coupled to a possiblethe high speed ascent and his efforts to rescue Diver B, distracted him from the the vital self-preservation action of venting the rebreather loop.



Professor JG van der Walt

Chairman: CMAS-ISA Accident Investigation Panel

The current CMAS-ISA training materials and protocols must be re-examined to incorporate the recommendations noted by the panel as far as possible.