



## Technical Note

## Recovery of deceased scuba divers from within flooded subterranean caves

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## ABSTRACT

Each year in the US three divers, on average, perish inside flooded caves and their remains require recovery. Recovery is a hazardous undertaking often performed by members of the International Underwater Cave Rescue and Recovery (IUCRR) team, in collaboration with local law enforcement and medical examiners/coroners. Since forming in 1999 the IUCRR have established standard recovery procedures for cave diving fatalities. This article reviews each stage of the recovery; the call out, arrival on site, the search, recording/preserving the evidence, the recovery, the handover and post-recovery record-keeping. A series of five cases highlight the challenges IUCRR divers are trained to face. It is strongly recommended local dive teams do not attempt to recover bodies from within flooded caves. IUCRR divers are trained to utilize a uniform procedure that is acceptable to the local law enforcement Incident Command System.

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## 1. Introduction

Recreational scuba divers enter flooded caves for a number of reasons including exploration, adventure tourism, citizen science and/or photography. Each year in the US three divers, on average, perish inside flooded caves and their remains require recovery [1]. This number is far lower than in previous decades [2]. Nonetheless, recovery is a hazardous undertaking often performed by members of the International Underwater Cave Rescue and Recovery (IUCRR) team, in collaboration with local law enforcement and medical examiners/coroners.

The most common cause of death in cave diving is drowning after getting lost when a diver loses visual or tactile contact with the lifeline, either because of inattention while navigating through a complex system or else because of suspended particulate in the water column [2,3]. Other causes of drowning include arterial gas embolisms, cardiac events, central nervous system oxygen toxicity seizures, hypoxia, and others [1–3]. Preservation of the forensic evidence is important, therefore, to establish the likely chain of events that led to death. Since forming in 1999 the IUCRR have

established standard recovery procedures for cave diving fatalities. Training in these procedures is conducted by leading cave diver training agencies, independently of the IUCRR, (though the instructors are all IUCRR members).

## 2. The call-out

The IUCRR has a Board of Directors including a Training Coordinator and an Accident Analysis/Database Coordinator. A Law Enforcement Oversight Board (LEOB) consists of Law Enforcement Officers who are also certified cave divers, trained in the management of a rescue and/or recovery operation. Various domestic and international regions are organised by Regional Coordinators who maintain a database of IUCRR members within their region. As soon as the IUCRR are made aware of a cave diving fatality then the local regional coordinator calls out local members to assist with the recovery.

## 3. Arrival on site

All IUCRR members are trained as Rescue/Recovery Surface Operations Managers (SOM), which ensures they are able to assist local law enforcement with an underwater cave rescue/recovery through coordination with the on-site officer-in-charge. They may

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also provide resources and expertise not normally available to law-enforcement agencies. Ideally the recovery team are allocated space away from bystanders and interested parties, to concentrate on planning and preparation without interacting with the public or grieving relatives.

#### 4. The search

Rescue/Recovery Divers determine a search strategy based on witness accounts, (i.e. dive buddies who were with the deceased or other divers who were in the cave before or during the incident), and conditions at the site. Considerations include the complexity of the system, maximum possible dive depths and distance penetration, direction and velocity of flowing water, anticipated visibility, and the required equipment/gasses for the anticipated search. Deeper caves necessitate replacing a portion of the nitrogen in the breathing mixture with helium, thus reducing both inert gas narcosis and also, because of the lower density of helium, the work of breathing. Dives with longer anticipated decompression obligations are typically conducted using “rebreathers”, a highly specialized form of scuba that recycles exhaled gas after cleaning it of carbon-dioxide so the diver literally “re-breathes” his/her own exhalations, (astronauts use the same technology during extra-vehicular activity).

#### 5. Recording/preserving the evidence

Once the deceased is located then the scene is recorded, typically using underwater video and lighting, and still photography if possible. Assuming ideal visibility and ample dive time, the area around the diver should be surveyed from all angles by slow pan, or multiple photographs. Similarly, slow pans/still photographs of the decedent from all possible angles, with the purpose of creating a set of overall images of the body, should be captured before the body is disturbed. The body may then be moved or turned over in order to complete overall photographs. Once these general images have been established, focused images are of interest for the following circumstances:

- The direction the diver is facing, position in the cave (ceiling or floor), depth of the body and its relationship to the flow of water in the area.
- The display on any dive computer(s) and gauge(s) worn by the deceased.
- If the diver was within reach of a continuous line back to the exit, and any entangled line or equipment.
- If the diver had deployed an emergency spool of line, indicating a “lost line” drill.
- If a back-up light had been deployed and if any lights were still burning; whether any photographic equipment is powered on.
- Remaining gas pressures.
- Whether each tank valve was fully or partially open, or closed. Recovery divers can close the valves, noting the number of complete (360°) turns it takes to close the valve. It is noted if the valves take a modest adjustment to close, such as a quarter turn, because this may indicate a restriction of breathing gas that might only be felt at depth. Subsequent testing at the surface, at atmospheric pressure, may not detect such a restriction.
- The position of hoses (including connections of drysuit and power inflator hoses), second stages, inflators, straps, cutting tools (present or absent) and buckles (fastened or unfastened) as they are on the body, with consideration as to whether all items are appropriate and accessible.
- The position of the mask, and if in place, whether there is blood, froth, or fluid in the mask and the condition of the fingernails.

- Any marks in the floor or ceiling of the cave (in many caves the most recent marks are obvious in the white limestone, in stark contrast with the dark, tannin-stained surrounds). In muddy or silty caves there is often evidence imprinted in the floor which requires documenting.
- Any dive equipment not attached to the diver such as a diver propulsion vehicle, staged scuba cylinders, mask, fins, arrows or non-directional markers attached to the guideline, released weighting system, or emergency spool. Also of note is the presence of any dive equipment not typically compatible with cave diving such as a snorkel, pistol-grip light, single scuba tank or recreational buoyancy control device. All such equipment should be retrieved with the body.
- Any entanglements encountered.
- Water temperature.

Of course, the ability to document all of these findings may be severely limited by dive times/gas supplies and visibility. In those situations, the recovery divers should discuss ahead of time the role each will play in the documentation process, and pare down the documentation as needed. If time is limited, priority is given to overall images, gas pressures, and closures of valves. If equipment items must be removed for body recovery, images of the equipment in situ also receive priority. If visibility is restricted, equipment should be left undisturbed as much as possible.

#### 6. The recovery

In the US, local law enforcement in conjunction with the medical examiner/coroner is always in charge of the extraction, since in most cases the dive site would be considered a crime scene. IUCRR divers consult closely with local law enforcement and medical examiners before commencing the recovery effort, to address any questions that arise after the body is located. In the simplest recoveries, bringing a single body back through a flooded cave to the nearest exit may involve little coordination beyond one diver in the lead pulling the body via a “tether” while a second diver “steers” the deceased through the flooded passages. Though it is nowadays rarer than it was last century, occasionally a double fatality necessitates recovering more than one body from within the same cave. Triple fatalities are extremely rare. In more complex recoveries the deceased may need to be handed over to fresher divers as the lead recovery divers commence required decompression. In very low passages, for example where divers wear their cylinders beside their bodies instead of on their backs, and where even a diver’s head must be turned sideways to fit through the lowest sections, then the recovery may need to be accomplished in stages, sometimes over a number of days. Where the flooded section of a cave can only be reached via air-filled cave passages, (these flooded caves are known as “sumps”), then dry-caving teams may be required to assist recover the deceased once the body is removed from the water. When circumstances dictate then the recovery divers may employ a body-bag designed for underwater use (Fig. 1).

#### 7. The handover and post-recovery record-keeping

As the deceased is brought to the exit point for extraction from the water then the body and all diving equipment is formally handed over to local law enforcement. Due to weight, generally equipment must be removed from the body before it is removed from the water. If documentation of equipment placement was not possible during the dive, then it should be completed at the exit before any equipment is disturbed. As soon as practical after exiting the water then the recovery divers complete an IUCRR recovery form which is supplied to both the investigating officer

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