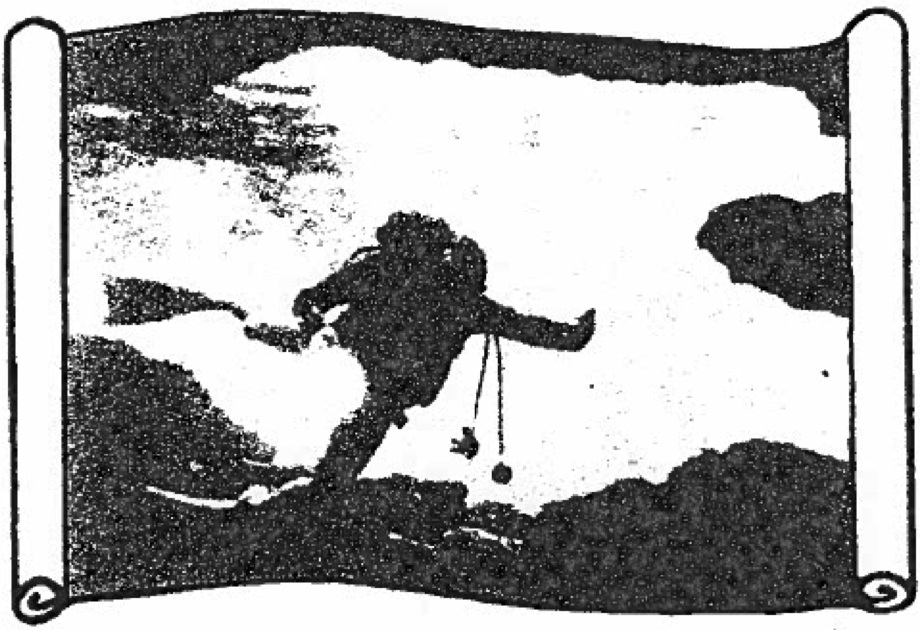
BASIC CAVE DIVING

~ a blueprint for survival ~



by Sheck Exley

BRAND NEW FIFTH EDITION

NATIONAL SPELEOLOGICAL SOCIETY
NSS
CAVE DIVING SECTION

FOREWORD

In 1974 no fewer than 26 divers perished in underwater caves in Florida. Fortunately, since that time the number of victims has declined sharply despite a probable increase in the number of participants, thanks at least in part to the educational efforts of the Cave Diving Section of the National Speleological Society (NSS) and other volunteer training agencies such as (alphabetically) FSDA, NACD, NAUI, PADI and YMCA. Certified "Cavern Diver" courses (for diving short distances under ledges in large sun-lighted areas within 130 ft. linear distance of the surface) and "Cave Diver" courses (for diving further into underwater caves) are now widely available, and a list of NSS instructors and other training agencies is given on p. 46. However, NSS recovery divers have noticed a distressing fact about recent cave diving fatalities: interviews with friends and relatives of the victims have shown that in many cases the deceased had actually heard of the special procedures used in safe cave diving, but for some reason chose not to follow them.

In 1973, this writer had to hurry home from a NSS Cave Diving Workshop in Bloomington, Indiana, for an important meeting in Florida. At the time the speed limit on the interstate highways was 70 mph, and I was doing all of that... and then some. By chance I stopped at a rest area in Tennessee and noticed gruesome pictures of automobile accidents and victims, posted there by the state highway patrol. The impact of these pictures was such that I did not exceed 55 mph the rest of the way home! As a driver I knew that high speed on the highway could be hazardous, but not until I was reminded of this by the accident photos did I choose to drive at a more reasonable speed.

Dixie Cavern Kings Cave Diving Manual (Exley, 1969), *Cave Diving Manual* (Mount, 1972), and *Safe Cave Diving* (Mount, Dickens, Exley et. al., 1973), though now considerably out-of-date, imparted to their readers the cave diving procedures that were accepted at the time, but did little to convince them of the importance of following those procedures. Why not borrow an idea from the Tennessee Highway Patrol and underline the importance of cave diving safety procedures by using actual accidents that were caused by ignoring them?

Basic Cave Diving - A Blueprint for Survival does just that, as well as providing the reader with an up-to-date introduction to the currently-accepted fundamentals of cave diving in Florida. While the names of the victims have been changed, the accidents given at the start of each chapter actually happened as described. The stark reality that they so vividly protray is a very possible end result of the reader's not following the safety procedures we discuss on these pages.

It must be emphasized that the procedures described in *Basic Cave Diving - A Blueprint for Survival* are not based on mere theory and conjecture: they have been proven repeatedly in actual field conditions, and <u>they work</u>. These procedures have been the author's "blueprint for survival" for an <u>unprecedented</u> 2000 cave dives, and they'll work for you, too. However, please keep in mind that the procedures described herein are merely the basics, and are applicable only to cave diving in Florida: cave diving conditions in other states can vary considerably and may require quite different procedures. The *NSS Cave Diving Manual*, to be published in 1979, will be a comprehensive text on the subject going considerably beyond our limited scope here and will deal in detail with the problems of cave diving under virtually all geologic and environmental conditions.

Finally, we would like to draw the reader's attention to the importance of cave conservation:

NSS POLICY FOR CAVE CONSERVATION

The National Speleological Society believes: That caves have unique scientific, recreational, and scenic values; That these values are endangered by both carelessness and intentional vandalism; That these values, once gone, cannot be recovered; and that the responsibility for protecting caves must be assumed by those who study and enjoy them.

Accordingly, the intention of the Society is to work for the preservation of caves with a realistic policy supported by effective programs for: the encouragement of self-discipline among cavers; education and research concerning the causes and prevention of cave damage; and special projects, including cooperation with other groups similarly dedicated to the conservation of natural areas. Specifically:

All contents of a cave—formations, life, and loose deposits—are significant for its enjoyment and interpretation. Therefore, caving parties should leave a cave as they find it. They should provide means for the removal of waste; limit marking to a few, small and removable signs as are needed for surveys; and, especially, exercise extreme care not to accidentally break or soil formations, disturb life forms or unnecessarily increase the number of disfiguring paths through an area.

Scientific collection is professional, selective and minimal. The collecting of mineral or biological material for display purposes, including previously broken or dead specimens, is never justified, as it encourages others to collect and destroys the interest of the cave.

The Society encourages projects such as: establishing cave preserves; placing entrance gates where appropriate; opposing the sale of speleothems; supporting effective protective measures; cleaning and restoring over-used caves; cooperating with private cave owners by providing knowledge about their cave and assisting them in protecting their cave and property from damage during cave visits, and encouraging commercial cave owners to make use of their opportunity to aid the public in understanding caves and the importance of their conservation.

Where there is reason to believe that publication of cave locations will lead to vandalism before adequate protection can be established, the Society will oppose such publication.

It is the duty of every Society member to take personal responsibility for spreading a consciousness of the cave conservation problem to each potential user of caves. Without this, the beauty and value of our caves will not long remain with us.

The author would like to thank the many members of the Cave Diving Section of the National Speleological Society for their assistance, particularly John Zumrick, 1979 chairman; India Young, 1980 chairman; Tom Cook, 1979 vice chairman; Greg McCarty, 1980 vice chairman; Stephen Maegerlein, treasurer; Bill Fehring, secretary; Forrest Wilson, training chairman; Gene Melton, newsletter editor; J. Friend, 11th workshop chairman; Troy Young, 13th workshop chairman; Mary Ellen Eckhoff, 14th workshop chairman; Rory Dickens, instructor; and Terry Leitheuser. Special thanks go to Claudette Finley, Jamie Stone and Carol Vilece, whose brilliant work *Hand Signals for Cave Diving* (published by NACD) has proven a milestone in cave diving safety. Carol also did most of the illustrations herein, and Jamie provided the probability figures on p. 18. Ned DeLoach of New World Publications donated the cover photo.

Criticism and comments to improve this manual are invited, and should be sent to the author at 10259 Crystal Springs Rd., Jacksonville FL 32221. Persons interested in cave diving are also invited to join the National Speleological Society by writing NSS, Cave Avenue, Huntsville AL 35810 for an application. NSS members may join the NSS Cave Diving Section by sending the $3.00 annual dues to PO Box 60, Williams IN 47470. Non-members may subscribe to the Section's newsletter, *Underwater Speleology*, by sending $5.00 to the latter address.

May all of your cave dives be safe, productive and enjoyable!

-- Sheck Exley
May 1979

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1 THE GUIDELINE

ACCIDENT REPORT

On May 7, 1978, two young sailors from a nearby naval base arrived at Royal Springs. Neither Jim nor Mike had any training in basic scuba diving, much less cave diving, and had only been cave diving a couple of times previously. They entered the water without a line, and Jim did not have a light or submersible air pressure gauge.

After quite some time had passed and the two had not surfaced, a friend became alarmed. The sheriff's dept. was contacted, who in turn called our NSS recovery team. NSS divers quickly found Jim 175 ft. back in a small, silty cave at a depth of 30 ft., and Mike's body was found some 225 ft. further. There was no air in their tanks.

ANALYSIS

As in most cave diving accidents, more than one thing went wrong on the dive. The victims' lack of proper training was reflected in their failure to use the proper equipment and procedures for cave diving. However, even with all of these mistakes both divers could have probably made it back out of the small cave alive due to the shallow depth involved, if they had known the way to go.

Unfortunately, while the large basin at Royal is a very safe open water dive and a favorite of instructors for checking out their students, the hard-to-find cave is considered difficult by experienced cave divers because of the deep silt (soft mud) on the floor. When disturbed by passing divers, this silt mixes into the water, mud-dying it to the point where one cannot see a hand in front of his face even with the brightest lights. As a matter of fact, some suspended silt disturbed by the victims' fins was still in the water when their bodies were recovered more than 24 hours later. Searching blindly through the cave without a guideline, it would have taken even a cool-headed expert much too long to find his way out of the cave, not to mention two beginning divers.

Always use a single, continuous guideline from the entrance of the cave throughout the dive.

THE GUIDELINE

Natural fibers such as manilla and sisal quickly rot when wet, and synthetics such as polyethylene and polypropylene float up into the water, increasing the possibility of a diver becoming entangled in the line. Nylon is preferred since it neither rots nor floats. Experimentation by NSS divers has shown that a white guideline is most easily seen in most cave diving situations.

Since the guideline is to be followed, not pulled on, the line need not be extremely strong. 165-lb. test line is probably sufficient, and most nylon lines and ropes of 1/8 in. diameter or larger are even stronger. The 1/8 in. diameter is probably the minimum for a cave diving guideline since smaller lines are hard to see and to feel, particularly if the diver is wearing gloves. Very large (1/2 in. or more) diameters should probably be avoided since it is very difficult to get an appropriate length of such line on a practically-sized reel.

Generally speaking, for any given diameter of nylon line, the wound or twisted construction is stronger than the braided construction. However, experience has taught that cave diving lines part more often as a result of abrasion against a sharp rock projection than insufficient strength. Thus, braided line is preferred because it is more resistant to abrasion.

200 ft. of line is sufficient for all cavern diving situations, and 500 ft. is plenty for cave diving. Longer lengths of line should be avoided since reeling in line is a tiring and time-consuming task.

THE REEL

A reel (fig. 1) keeps the line from spilling into the water, thereby entangling the diver, and enables the diver to take the line back in when coming back out. Suitable reels for cave diving are available at many dive shops, especially in north Florida. The addresses of these shops are in dive magazines; contact them for information.

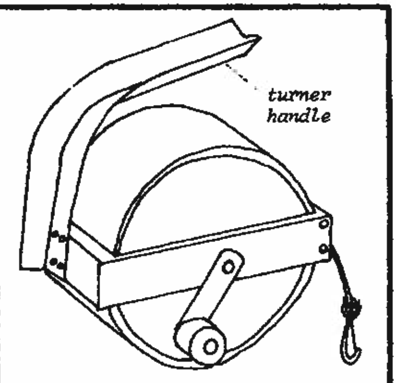


fig. 1 - *WILSON "JAM-PROOF" REEL*

The handle of the reel should be designed so that you can hold both the reel and your light in the same hand, enabling the other hand to be free to pull on rocks, handle problems, etc. Flat handles and the L-shaped "Turner" handle seem to be the preference. There should also be a handle for cranking the reel. The drum of the reel should be large enough to accommodate the supply of line you plan to carry, but small enough to be easily managed in the water. The diameter of the drum should be large enough that a good length of line is taken in on each crank. There should also be a line guide to prevent the line from spilling out at random. The entire apparatus should be non-corrosive, impact-resistant and jam-free. Neutral buoyancy for the reel is ideal, slightly negative buoyancy is next best.

USE OF THE REEL

Practice using your reel out of the water first, then in shallow open water before using it in an underwater cave. Make sure you can hold the reel and your light comfortably in one hand when laying line or taking it back in. Practice using one finger against the drum to provide drag while laying the line so that you can keep it taut, reducing the possibility of line entanglements. Jam the reel on purpose so that you know how such jams might occur as well as how to unjam them. You'll find that slack line coming off the drum and getting wrapped around the hub is a prime cause of such jams. Practice tying the line off and following it by maintaining hand contact with an "O" formed by forefinger and thumb, making sure that you do not pull on the line. Finally, do the same with your eyes closed and the other arm extended to protect your head - in very bad visibility or total light failure it may become necessary someday to do this in a cave.

When cave diving, tie the line off to a sturdy log or boulder underwater outside the cave entrance so that you can get back out even in zero visibility. However, do not tie it off out of the water or in shallow areas where casual campers and swimmers might tamper with it. Likewise, be sure to resecure the line once inside the entrance by wrapping the line around a log or boulder so that open water divers tampering with your initial tie-off do not cause catastrophic problems. Metal clips are usually used for tying off for their convenience, but a sturdy knot such as a bowline backed with an overhand knot (fig. 2) is probably more dependable. Tug on your tie-off to make sure that it does not come loose before proceeding into the cave.

The reel man is always the first man into the cave and the last man out, ensuring that everyone is between him and the entrance and therefore has a guideline to follow. Under no circumstances should someone be further into the cave than the reel man.

Experiments by NSS divers have shown that serious air- and time-consuming delays are caused by each wrap that is encountered in following a line through zero visibility, such as would be caused by extreme silting of the water or a total light failure. Do not wrap or tie the line any more than is absolutely necessary to keep the line from drifting into an area too small to swim through. If it becomes necessary to wrap the line, be sure to use only a single loop of line around as small a rock as possible, so that it will be easier to feel your way around the wrap in bad visibility and only a minimum of slack will be caused should the wrap be inadvertently pulled loose.

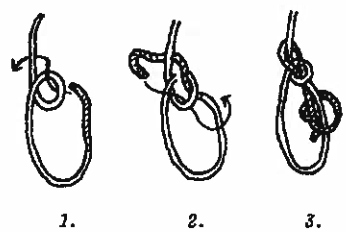


fig. 2 - *BOWLINE WITH OVERHAND KNOT*

If the water is clear and there is no immediate danger of silting of the water, it is acceptable to follow the line using eye contact rather than actual physical hand contact with the "O" formed by forefinger and thumb. However, always remain within a single arm's reach of the line so that it can be quickly reached if silting or light failure should occur. Silting of the water can occur suddenly and unexpectedly from several causes, such as diver's fin strokes, air bubbles dislodging silt from the ceiling, and even a heavy rainstorm outside causing sediment to wash down through cracks in the roof.

If it is necessary to cross the line, always do so by swimming over it while pushing it away from your body and equipment. Never cross a line by swimming under it - to do so is to invite an entanglement. For the same reason, be sure to keep all equipment such as backup lights as close to your body as possible.

When reeling in the line, be careful to maintain plenty of tension in the line so that it does not go slack. A slack line not only increases the likelihood of a diver becoming entangled, it also greatly enhances the possibility of the reel becoming jammed. If it becomes necessary to stop to vent your buoyancy compensator, etc., be sure to place a finger against the drum of the reel to keep it from freewheeling and causing the line to go slack. If you find yourself going faster than you can reel, slow down.

If the reel should become jammed or some other emergency should occur, always remember that you can tie the line and reel off and come back for them on a future dive. While it is a poor practice to leave a guideline in the entrance of a cave, enticing novices with poor judgment to follow it beyond their safe limits, it is still preferable to tie off your line and bring the reel to the surface to unjam it if there is any question at all of having enough air to do the job underwater.

It may at first seem a good idea to carry two reels and run the two lines simultaneously in case one were to break. However, in reality NSS divers have found that doing so generally causes more harm than good since running two lines enormously increases the possibility of a diver becoming entangled.

For information on how to handle cut lines or line entanglements, see chapter 8.

SUMMARY

A guideline provides a certain, direct route to the surface. Becoming lost from the lack of a guideline has been a primary cause of a large number of cave diving accidents. The guideline should be of proper construction and carried on a suitable reel. Proper use of the guideline and reel takes practice, and such practice should take place on dry land and in shallow open water before going into a cave.

2 AIR SUPPLY PLANNING

ACCIDENT REPORT

In Feb. 1977, two certified scuba diving instructors entered Devils Eye Springs. Dale had just finished a basic cave diving course, but Chuck had no training in cave diving and had never been in Devils Eye before, so Dale led the dive. Chuck planned his dive on the "third rule," allowing himself no more than 1/3 of his starting air supply for penetration, while reserving 2/3 of his air for coming out and handling emergencies. However, Dale used the "half-plus-two" rule advocated in an old cave diving manual as acceptably safe in high-outflow caves such as Devils Eye. (With the "half-plus-two" rule the diver reserves only 200 psig more than half of his starting air supply for coming out and handling emergencies, considerably less than would be reserved by the "third rule.")

During the dive Chuck happened to glance at Dale's submersible air pressure gauge and noticed the remaining pressure, which indicated that Dale had in fact gone past the safe turnaround afforded by the "third rule." Soon afterward extreme silting of the water occurred and the divers became separated. Chuck waited as long as he could, then started out, abruptly coming across Dale's body near the entrance to the cave. Since he was unfamiliar with the cave and uncertain of how far it was to the entrance, and had only 150 psig remaining in his doubles, Chuck had no choice but to leave Dale there in an effort to save his own life.

Just barely making it out of the cave, Chuck surfaced without any decompression, got another tank and went back down after Dale. Bringing the body out, he once again surfaced and began cardio-pulmonary resuscitation efforts in an attempt to bring Dale around, developing decompression sickness in the process. Fortunately, Chuck's recompression was successful, but efforts at reviving Dale were futile.

ANALYSIS

As on most fatal dives, there were several errors made here. Even though Chuck was a scuba instructor, he was not a trained cave diver and should not have been cave diving, especially that far back (800 ft. or more) in a strange cave. Second, the divers had "jumped gaps" between permanently-installed lines in the cave at least twice, not connecting them with line and therefore not providing themselves with a single, continuous guideline to the surface. However, despite these mistakes the less experienced diver (Chuck) survived. Clearly, the fatal factor was that Dale did not reserve sufficient air for coming out and handling emergencies.

Always use the "third rule" in planning your air supply.

PLANNING AIR SUPPLY

While additional limiting factors such as depth, distance and duration may be incorporated into a dive plan, air supply is the most important limiting factor and a safe turnaround pressure should be calculated for each diver before each dive. Not surprisingly, the NSS has found that failure to allow at least two thirds of the starting air supply for coming out and handling emergencies has been a close second to not using a continuous guideline as a prime cause of cave diving fatalities.

In planning your air supply, merely divide your starting air supply by 3 and subtract that amount from your starting air to get your turnaround pressure. For example, if your starting air supply is 2400 psig, subtract a third of that amount (800 psig) and you get a safe air turnaround of 1600 psig. Should it become necessary to "round off" your air supply calculations, be sure not to round so that you leave yourself with less than 2/3 reserve. If you have difficulty remembering your air turnaround, write it down on your slate or even make a mark on the lens of your submersible air pressure gauge with a grease pencil.

During the dive, monitor your air by continuously chacking your submersible air pressure gauge. It may not be a bad idea to check your buddy's gauge as well - you may need some of his air in an emergency!

The author devised the third rule in 1968 based on two assumptions: (1) it takes twice as much air to buddy-breathe two divers out as it takes to get a single diver out, and (2) a total air supply failure at maximum penetration uses more air than any other type of emergency. The rule makes allowances for divers with widely varying breathing rates by turning the entire team as soon as the first diver hits his turnaround pressure. However, testing by NSS divers has shown that in some circumstances it may take as much as five times as much air to get a partner out as it takes to get one diver in, due to environmental factors like direction and velocity of current, visibility, restrictions, etc. Further, there is no reason why a total air supply failure is the only problem that could occur. On one fatal accident (see chapter 6) the divers also became entangled in the line at least 4 times. Additional air should also be allowed for decompression requirements. Therefore, the 2/3 reserve as provided by the "third rule" for coming out and handling emergencies should be viewed as the bare minimum - frequently it's a good idea to add to your reserve air.

Another important factor in planning your air supply is to make sure that each member of the team has a similar starting supply volume. For example, a diver with a single tank and a very good breathing rate may not have enough air left to buddy-breathe out a diver with a terrible breathing rate who has expended 1/3 of a set of triple tanks going into the cave.

SUMMARY

Not allowing at least 2/3 of the starting air supply for coming out of the cave has been the second biggest single cause of cave diving fatalties. When planning your air supply, make sure that all team members have similar air supplies. Monitor your air constantly throughout the dive by checking your submersible air pressure gauge. Turn the entire team as soon as the first diver reaches 2/3 of his starting air supply. Frequently it's a good idea to add additional reserve air for factors like current, visibility, restrictions and decompression time.

3 TOO DEEP

ACCIDENT REPORT

Two divers from Miami, Barry and Luke, drove up Thursday night, met some other divers and entered the water at Eagle's Nest Sink at 12:40 AM. Barry was an experienced cave and deep diver, but Luke, while experienced at open water diving, had only minimal experience at cave and deep diving. Despite the fact that Luke had never been below 200 ft. amd both divers were tired from the long drive, a dive was planned to 270 ft. depth. When Barry and Luke failed to surface, the other divers called the sheriff's dept. on 6/2/72.

We found Luke's body at a depth of 260 ft. some 500 ft. from the cave entrance, and Barry's inert form about 100 ft. closer at a depth of 240 ft. Both divers were completely out of air and the silt on the floor around the bodies did not show any signs of struggling.

ANALYSIS

Again several errors were made. A continuous guideline was used and the divers may or may not have planned their air properly (we have no way of knowing), but a diver with Luke's limited experience at cave diving did not belong 500 ft. back in a cave, especially at a depth at least 60 ft. deeper than he had ever been before. From the lack of signs of a struggle it would appear that both divers lost consciousness before running out of air, probably due at least in part to the effects of breathing compressed air at great depth.

Avoid deep diving in caves.

HOW DEEP IS DEEP?

The sport diving community advocates limiting dives to 130 ft. or shallower and it would appear that there is a very good reason for it. An analysis by the author of cave diving accidents in Florida has shown that the small percentage of accidents where a continuous guideline and the "third rule" were used all involved dives to depths of 155 ft. or greater. Further, the shallowest depth at which "depth blackout" - the most likely cause of Barry and Luke's deaths - has been observed to occur is 150 ft.

THE "DEPTH BLACKOUT"

A victim of "depth blackout" appears to be asleep with his eyes open, and does not move other than continuing to breathe. It is not known why the victim retains his mouthpiece, but it's a fact that victims of depth blackout will go on breathing, lying inert on the bottom, until they run out of air.

An analysis of the diving history of the 15 known survivors of depth blackout has shown that in every case the problem occurred on the deepest dive they had made up to that time. The shallower instances also involved heavy exertion on the part of the victims. Perhaps most frightening is the fact that several of the victims do not recall feeling any unusual symptoms prior to blacking out. A vertical ascent of approximately 50 ft. was generally sufficient to bring the victims back to complete consciousness so that they could continue their ascent unaided. Depth blackout is probably the cumulative effect of nitrogen, oxygen and carbon dioxide - the chief constituents of dry compressed air - at extreme depth.

PREVENTION

The most important prevention of "depth blackout" is, again, to avoid deep diving. Chances are you'll hear of experienced cave divers occasionally going deeper than 130 ft. However, they do so only when utilizing very special equipment and procedures. One of these procedures is to build up an adaptation to depth very slowly over a series of repeated dives under controlled conditions in open water before attempting a deep dive in a cave. It is beyond the scope of this manual to go into detail regarding these procedures and we strongly recommend that you contact a highly experienced deep cave diver for personal guidance beforehand if you decide to ignore our warnings and attempt to deep dive in a cave anyway. It should be added that most of the small percentage of accidents involving experienced cave divers have occurred on deep cave dives.

SUMMARY

The small percentage of cave diving accidents where the victims did use a continuous guideline and the "third rule" all involved diving to depths of 155 ft. or deeper. The maximum safe depth for cave diving is 130 ft. Divers may actually "black out" from breathing air at greater depths, appearing to fall asleep with their eyes open until they run out of air and drown. The foolhardy who insist on diving to deeper depths anyway should contact experienced cave divers first for guidance.

4 PANIC

ACCIDENT REPORT

On July 20, 1974, two vacationing divers from Canada, Mel and Leroy, entered the cave at Little River Springs. Both divers were certified basic scuba divers but neither had any training or experience in cave diving. The divers knew that a guideline was recommended for cave diving but decided to enter the cave without one. With no knowledge of silt technique, the divers soon caused silting to reduce their visibility to a few feet and they became lost only 100 feet from the cave entrance. Eventually Mel got to where he could see daylight coming in from the entrance and returned to try to get Leroy to follow him to safety. However, Leroy did not respond and instead swam off frantically into a side passage, causing silt to again obscure the visibility. Mel waited as long as he could, then had to surface since his single tank was running out of air.

NSS divers found Leroy's body only 40 ft. from the point where daylight is normally visible and a scant 160 ft. total distance from the entrance - almost close enough to get out on a single breath.

ANALYSIS

These divers hardly did anything right. They weren't trained for cave diving, they didn't use a guideline, they didn't have enough lights - the list could go on and on. However, the critical factor is that despite the fact that Mel found the way out and tried to get his partner to follow him, Leroy swam instead into a side passage and drowned. Leroy's frantic swimming pattern is a clear indicator of the reason he did not respond to Mel's signal - he was in the highly anxious state known as panic.

Avoid panic by building up experience slowly and being prepared for emergencies.

PANIC

Even though our analysis has shown that in every fatal cave diving accident so far, the divers either did not use a continuous guideline or the third rule or were diving at depths of 155 ft. or deeper, it is of course possible to have an accident while observing all three of those safety procedures. As a matter of fact, there are instances such as depicted above where, despite the divers violating one or more of the three cardinal safety procedures of cave diving, a way out of their predicament was at hand and they should have survived if they had been thinking clearly. Unfortunately, they drowned because they were not thinking clearly but subject instead to that sudden unreasoning and overwhelming fear which attacks people in the face of real or fancied danger - panic.

Some researchers have actually claimed that in cases of extreme anxiety, divers can actually die from panic and the physiological changes it causes. This would account for a handful of "mystery" deaths in shallow caves where NSS divers found the victims with air still left in their tanks.

PREVENTION OF PANIC

Prevention of panic is simply to remove the causes - the real or fancied dangers. The real dangers can be handled by taking care to make sure that you and your partner(s) are properly trained and equipped so that you can handle emergencies (see chapter 8). The imagined dangers stem primarily from man's natural fear of the unknown. By building up your knowledge of underwater caves slowly you can gradually eliminate these unknowns without having to confront them abruptly under catastrophic circumstances. Before going cave diving make sure that you have extensive experience in open water night diving and "dry" caving in air filled caves. When starting cave diving, begin with large, shallow, well-lighted, relatively silt-free caves with few side passages, then build up to more difficult caves. At each spot don't try to see the entire cave on the first dive, but gradually extend your knowledge of the cave by going just a short distance on the first dive, then extending your penetration distance in short increments over a series of dives. Try to always go into a new cave with an experienced cave diver who has already dived there previously.

It also helps if you avoid diving when you are more susceptible to panic, such as when you are tired or emotionally upset. On this latter point, it is interesting to note that psychologists tell us that fear and anger are closely related emotions. People who become angry easily as well as easily afraid should be discouraged from cave diving.

TREATMENT OF PANIC

Under the proper combination of circumstances anyone can panic, so it's a good idea to know what to do when it occurs to you or your partner. Some of the symptoms of panic while diving include a marked increase in respiration as exhibited by rapid, shallow breathing, and difficulty in concentrating on the task at hand. We are all familiar with the wide-eyed facial expression of fear, but underwater it may be difficult to recognize this through a diver's mask. Probably more appropriate signs of panic to look for in your partner are erratic, jerky swimming movements and inappropriate actions.

There is no 100% effective treatment of panic, but certain things help. Naturally, one of the best things to do is to remove the causes by beginning a slow, controlled exit from the cave. Do not exit in a frantic, headlong rush - that only makes things worse! Also, try reducing the symptoms of panic by forcing yourself to take slow, deep breaths, slow down your movements and concentrate on something other than whether or not you are going to die. Worrying about it won't help! Try monitoring your depth gauge or some other task that will take your mind off the dangers confronting you. Strange as it may seem, injecting a little humor into the situation may help: more than once a humorous gesture accompanied by a grin has relieved tension in an anxious diving situation.

SUMMARY

Panic is the sudden unreasoning and overwhelming fear which attacks people in the face of real or fancied danger. Panic has caused divers to die when the means of getting out of their predicament was available, and may even have caused divers to die before running out of air. Panic can be prevented by building up experience slowly and being prepared for emergencies. It can be treated by removing the causes and controlling the symptoms.

5 LIGHTS

ACCIDENT REPORT

On May 11, 1978, two divers from Georgia prepared to enter the cave at Blue Springs near Madison. Pete had started a cave diving course but dropped out after the first of four weekends. Like Pete, Roger was a certified scuba diver but had no training in cave diving and had made only a few cave dives. Other divers at the spring noticed that Pete had only two lights and Roger three, despite the fact that their primary lights were not expected to last the entire planned dive (more than 60 min. bottom time). They offered the pair additional lights but they were refused.

When the pair failed to surface after a couple of hours, one of the other divers at the site entered the cave and soon found Roger's body about 500 ft. back with two lights, neither of which would work. Later that evening HSS divers found Pete's body near a restriction 400 ft. further into the cave, his primary light drained and snapped off on his chest, his one backup light around his wrist and turned on but not working. He had been breathing from a tank that had been left in the cave by other divers after the fatal pair had already started their dive. In the restriction 25 ft. from Pete's body was Roger's lost backup light (turned off but working fine) snagged around a rock and also another tank and regulator with 1000 psig left. The air in that tank was enough to have gotten Pete out of either the Blue Springs entrance 900 ft. away or a smaller sink hole entrance 450 ft. away. According to friends Pete was familiar with the location of the sink hole and had been there before.

ANALYSIS

As in most accidents, many things went wrong on the fatal dive. There was no continuous guideline - the line to Blue Springs ended over 100 ft. inside the cave and there was a 30 ft. gap from the line they were following to the line going to the sink hole. It is highly probable that the divers were totally without any working lights for part of the dive. This would account for Pete's swimming past the turn-off that goes 150 ft. to the sink hole at least twice when he went to get the tank that had been left by the other divers and he was found with, and swimming further into the cave to the restriction instead of heading out. Air planning was probably not a factor since additional tanks provided by the fatal pair and other divers had given Pete and Roger several times as much air as is needed to swim in and out from the most remote parts of the relatively small and shallow cave. The end of the dive probably consisted of the divers wandering back and forth along the line in total darkness until their air ran out. If the divers had possessed working lights or a continuous guideline to either entrance they should have made it out alive.

Always use at least three lights per diver.

PURPOSE OF LIGHTS

As the preceding accident report illustrates, lights are actually a backup system: the line is used to find the way out of the cave. However, finding one's way out along a line when unable to see can be a very time- and air-consuming task, especially if the person installing the line has wrapped it around several projections (see chapter 7). Try following a line with your lights turned off and compare time and air expended thusly to your performance with lights on and you'll see what we mean. Further, lights are used in communication (see chapter 8) and in keeping track of your diving partner.

CHARACTERISTICS OF LIGHTS

Ideally, diving lights should be as bright as possible, but it is more important that all divers in the team have lights of approximately the same brightness. The human eye is capable of adapting quite well to different levels of illumination, and divers with dimmer lights can often see nearly as well as those with much brighter lights as long as a brighter light isn't present to ruin their eye adaptation.

The lights should be small and as close to neutral buoyancy as possible. Large lights get snagged on rocks in narrow areas and can be hard to maneuver with in strong current. Each light should also be dependable: water- and pressure-proof, easy to repair and maintain, and with as small a failure rate as possible (ask an experienced cave diver or a dive shop for advice). Each light should also last at least as long as the planned dive - if not, then take along more lights than the minimum three.

NUMBER OF LIGHTS

NSS has advocated three independent light sources for caving for nearly forty years. The best underwater lights will probably fail at least once in 50 dives, even when properly maintained, due to bulb burnout, implosion, leakage, corrosion, battery failure, loss, etc. If you are using one such light and make 100 cave dives, there is a 86.7% chance that you will be totally without light on at least one dive. If you have two such lights, then your probability of having both lights go out on the same dive (leaving you totally without light) at least once in 100 dives drops to only 3.9%. However, the chance of both lights going out over 1000 dives increases to 33.0%! Two American divers have made more than 1000 cave dives; by taking along three good lights apiece, they reduce the possibility of being totally without light on at least one dive in 1000 dives to only 0.8%.

As mentioned previously, each of the three lights should be designed to last at least as long as the planned dive. In the accident reported at the first of this chapter, Roger's three lights were not enough because he knew before the dive started that his main light would run down before the end of the planned dive. Further, he permitted his diving partner, whose main light would also run down, to dive with only two lights. Just because your partner is more experienced than you are does not mean he can ignore safety procedures! As in the Blue Springs accident, your life may depend on your partner's equipment just as much as it does on your own. Make sure that you and your partner have all the required equipment, including a minimum of three lights. If some of your lights cannot be reasonably expected to last the entire planned dive, carry more.

The author always carries at least four lights. Normally as soon as one light goes out, the entire team begins to leave the cave. However, by making sure that all the lights run long enough for the planned dive and carrying a fourth light bright enough to be used as a primary light, if the author's normal primary light goes out he can switch over to the other without having to cancel the dive. Since he still has two additional working lights left, he does not jeopardize his own or his partner's safety by doing so.

USE OF LIGHTS

The use of lights in communication is covered in chapter 8. However, we should mention that it is important not to shine your light directly into your partner's eyes since doing do will ruin his eye adaptation. If a diver swimming in front of you looks back to check on you, be sure to point your light away from him. Also, try to hold your light steady: erratic movements by lights are frequently mistakenly considered emergency signals by divers swimming in front of you.

PRE-DIVE CHECK

Lights, like all items of cave diving equipment, should be checked immediately before the dive, then checked again by your diving partner. This is usually done after putting on all equipment by a procedure called "matching." In "matching" the leader will call out "primary light" after the dive team is assembled. When this is done all team members will turn on their primary lights at the same time, verifying that their own light and that of their dive partner are working properly. Next the leader will call out "backup light" and so on until at least the following is matched and checked: primary light, first backup light, second backup light, knife, watch, depth gauge, slate and submersible decompression tables. Both regulator second stages are also checked by breathing on them underwater. Then the divers "ADDD to their safety" by establishing four limits for their dive plan based on Air turnaround, maximum Depth, maximum Distance from the cave mouth and maximum Duration (bottom time). Finally, the divers do a quick "S-drill" (see p. 29) if there is any doubt whatsoever about their ability to perform emergency procedures. When done properly all of this takes only a few minutes.

SOURCES OF LIGHTS

Most of the lights produced by the major diving equipment manufacturers are acceptable as backup lights, but few of them are really desirable as primaries. Fortunately, several NSS divers make excellent primary lights that can be purchased through dive shops, particularly in north Florida.

SUMMARY

Lights are an important backup system for finding your way out of the cave, as well as a tool for communication and keeping track of your partners. Lights should be small in size and as dependable as possible. Do not let partners dive with primary lights of greatly varying brightness. Each diver should have at least three lights - carry more if any of the lights cannot be expected to last the entire dive.

6 SCUBA

<u>ACCIDENT REPORT</u>

On May 15, 1973, two divers failed to surface after a dive in a cave at Tarpon Springs. Frank was an experienced, trained cave diver. Jim had made a few cave dives and had just started a cave diving course, but was not qualified to dive the 210-ft. depths of Tarpon.

We found Frank's body on the first dive, some 400 ft. back. However, after a week of efforts hampered by poor visibility and the depth, the search was called off without locating Jim's remains. We did find that the permanent line had been cut in 4 places including once at the end of the line some 800 ft. back. The victims would have had to have done this since the line was intact on a dive made just before the fatal dive.

When we checked Frank's regulator we found that it free-flowed air violently and would not cease despite exhaling vigorously and banging on the second stage. Using a screwdriver, we opened the second stage housing and found that the lever that opens the downstream valve had become wedged against the housing. Investigation showed that whenever a sharp, deep breath was taken on the regulator, depressing the lever to a certain point, it would stick and cause a rapid air loss which could only be stopped by opening the housing for repairs.

Later it was learned from a partner that Frank's regulator had behaved similarly during decompression at the same cave the preceding week.

<u>ANALYSIS</u>

Frank's regulator failure is probably the factor which started the tragic chain of events. The line being cut by the victims at the end proves that they went beyond any distance that they could have reached on the "third rule" with their small tanks. While depth blackout probably did not occur, impairment from narcosis may have hampered attempts at buddy-breathing and helped cause the vidtims to become entangled in the line at least four times so badly that they had to resort to cutting it. However, despite the depth and apparent poor dive planning, the accident probably could have been avoided if Frank had used the "dual valve" manifold and its redundant regulators preferred by cave divers today. Unfortunately, while an NSS diver had already invented the manifold, it was not commercially available at the time.

Always use the safest possible scuba.

SCUBA CONFIGURATIONS

The key to all cave diving equipment and procedures is redundancy - include as many backup systems as possible. This is especially important with the air supply equipment - your scuba - the heart of your life support system. The dual valve manifold now available from several different manufacturers (not to be confused with the standard double tank manifold - see fig. 3) permits the use of two complete regulators. With the dual valve manifold, if one regulator free-flows as in the accident at Tarpon or even totally shuts off, the diver need merely turn off the supply to the bad regulator, switch to the other regulator and head for the surface. The dual valve manifold is designed so that both valves provide access to the entire air supply, so shutting off a malfunctioning regulator does not deprive you of part of your air supply as would be the case with parallel singles or a pony bottle. For you single tank divers we should add that one company now manufactures a dual valve for singles.

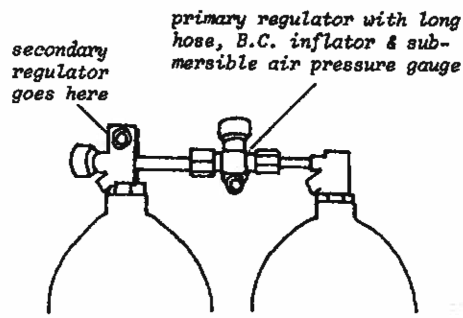


fig. 3 - *DUAL VALVE MANIFOLD*

J valves are avoided by most experienced cave divers for a number of reasons. While it is true that a J valve might notify you of a low air supply when a sticking needle on a submersible air pressure gauge would possibly not, it is also true that your partners also have pressure gauges that should have notified them long before your J valve is activated if you are diving with similar air supplies as dicussed in chapter 2. Further, the 300-500 psig reserve provided by a J valve is simply not enough to get you out from a point that it may have taken more than 2000 psig to get to. J valves are also easily knocked down by ceiling projections, leaving you with no reserve air that you might be counting on. They can also malfunction from several possible causes, and even without a malfunction you can actually "breathe through" some types of J valves, depleting your air supply considerably beyond the 300-500 psig cutoff point. Finally, J valves are one of the most likely sites for a line entanglement,and an especially bad one: behind your head, where you can't see it to free yourself.

REGULATORS

Just about any premium, top-of-the-line single hose regulator is acceptable for cave diving. Most NSS divers prefer a downstream second stage with a balanced diaphragm or flow-through piston first stage. The things to avoid in purchasing a regulator are tilt-valve (or upstream) second stages because they have a tendency to shut off if a first stage malfunction occurs (downstream valves have a tendency to open, which at least permits you to continue to get air for a while), and J-reserve first stages for the reasons we have already discussed under J valves. If you aren't sure if your regulator has any of these features, ask your dive shop.

For ease in sharing air in an emergency (see chapter 9), one of the regulators should have a hose of at least 4 and preferably 5 ft. in length. For monitoring your air to observe the "third rule" it should also have a submersible air pressure gauge. To inflate your bouyancy compensator (see chapter 7) more efficiently and without having to take your regulator out of your mouth, another low pressure hose with a a valve for filling your compensator should be added. The other regulator need have only the one hose and second stage. Your local dive shop can help you set your regulators up.

BEFORE THE DIVE

At the start of the dive check both your regulators (and your partner's regulators - you may need one of his in an emergency) by breathing through them underwater. If you get any water or air leakage or the regulator "breathes hard" (excessive inhalation resistance), then cancel the dive and go to your dive shop for repairs. With the possible exception of air leakage (free flow), these problems will generally get worse as the dive progresses - it is better to miss a dive that you can always make later than to miss the rest of your life!

It is also a good idea to check your hoses and other connections for air leakage before starting the dive - a good way to do this is to sit down in shallow water and have your partner look for air bubbles. If you find some and can solve the problem by changing an "O" ring, fine. However, if the leakage persists, head for your dive shop.

Another thing to check on before the dive is to make sure that you can reach both tank valves and turn them off quickly. Some divers find it necessary to loosen the waist strap of the tank harness and hitch the tanks up by grasping a shoulder strap in order to reach their valves. One NSS diver actually wears his tanks in a specially-designed harness "upside down," with the tank valves near his pelvis, to make it easier to reach them in an emergency. At any rate, practice turning both valves off and on before diving - the dual valve manifold is not much safer than a standard double tank manifold if you can't reach your valves.

DURING THE DIVE

During the dive both valves are turned on all the way. Do not turn the valve on all the way, then half a turn back as some diving manuals recommend. On more than one occasion cave divers have forgotten they had already turned on their air, then unwittingly turned their air all the way off and back on half a turn. The result was a constricted orifice that made the diver seem to run out of air when his pressure got down to about 1500 psig! It may sound ridiculous, but this writer and others have almost drowned from just such an incident. A handy way to remember which way to turn your valve is the word "cough" ("coff"), which stands for clockwise = off. Counterclockwise is always on.

By having both valves turned on all the time, regulator malfunctions during the dive can be ascertained as soon as they occur. Further, if a regulator does malfunction, all you have to do is turn off the valve going to it, rather than turn one off and also turn one on as would be the case if one valve was left off instead.

Most cave divers put the regulator with the long hose, compensator inflator and submersible air pressure gauge on the center valve for several reasons. First, the regulator first stage is more protected from banging into the ceiling there than it would be on the end valve. Second, the short inflator and gauge hoses are closer to the diver's body and more protected. Finally, an extra 4 inches or more of hose is available to a buddy when sharing air in the preferred positions (see chapter 8), giving each of you more freedom of movement when buddy-breathing.

Most NSS divers probably prefer to dive breathing from the regulator with the long hose. When a partner approaches you needing to share air, chances are that he is quite out of breath and needs help fast. The easiest regulator to locate quickly is of course the one in your mouth. By giving him the long hose initially, it is not necessary to swap hoses for the trip out. Further, experience has shown that the regulator not being used frequently collects sand and silt during the dive, which takes time to clean out. An out-of-breath diver might not have that much time.

There are a variety of ways of storing the extra length of the long hose to keep it from snagging on rocks and getting in the way. The important thing is to make sure that it can be freed instantly when needed. A popular position for the five-foot hose is simply to coil it once around the diver's neck. When this was initially conceived we had visions of a panicky diver becoming an underwater version of the Boston Strangler, but our fears were allayed when tests showed that snatching the mouthpiece out of a buddy's mouth merely partially flooded the buddy's mask, if anything. The four-foot hose will not go around the head comfortably, so it is usually run under the arm instead of over the right shoulder.

SUMMARY

It is important to have as safe an air supply system as possible when cave diving. The dual valve manifold with two separate regulators is the safest system now available. Make sure that one regulator has a longer hose to make sharing air in an emergency easier, as well as a submersible air pressure gauge and a buoyancy compensator inflator. Check your equipment and your partner's equipment before diving. Dive with both of your valves turned on and the regulator with the long hose in your mouth. Should a regulator malfunction, turn off its supply valve and start the entire team out of the cave together.

7 SILT

ACCIDENT REPORT

On Oct. 27, 1972, two highly experienced cave divers, Craig and Rob, entered Orange Grove Sink to make a traverse to another surface opening 1800 ft. away. After 1150 ft. they came to a fork where two permanent guidelines were tied together, and veered off into the left-hand tunnel. After 600 ft. of very narrow and silty passage they were amazed to find that the line and tunnel ended, and realized that they had taken the wrong tunnel past the fork.

Fortunately, they had planned their dive on the "third rule" (never assume that any line you follow will go to another opening - it may be broken or even go into a side passage instead), so each diver still had more than 2/3 of his starting air left to get out on. However, on the way out they found to their horror that their visibility was down to zero for the entire 600 ft. back to the fork. Apparently their swimming movements had riled up the silt from the floor and their exhaust bubbles had also knocked silt down from the ceiling. Blindly following the line by feel only was a nightmare and seemed to take forever. Several delays were caused by having to figure out which direction the line went past projections that it had been wrapped around.

Finally reaching the fork, visibility improved and they swam the remaining 1150 ft. out of the cave without further incident, which was lucky for them. They surfaced with only a few hundred pounds of air left in their tanks...

ANALYSIS

The dive above was not a fatality but could have been fatal if the divers had not used the third rule or another emergency had occurred simultaneously. For example, if a total air supply loss had occurred also, the time- and air-consuming silt-out experienced by Craig and Rob could easily have cost them their lives. By carefully checking behind them to see if silting of the water was occurring, the divers could have avoided the problem.

Avoid stirring up silt.

SILT

Silt, or unconsolidated sediment, is found in all underwater caves. It can be a coarse, heavy-grained white sand, a fine red clay or a soft brown muck. When disturbed so that it becomes suspended in the water, it can reduce visibility from over 100 ft. to effectively zero in seconds. As a matter of fact, this can occur in just about any part of any underwater cave under the right conditions. Once suspended in the water it usually stays there for several hours before settling out, though the heavier sands may settle sooner.

The most common cause of silting is the movements of divers causing turbulence in the water that riles up the silt from the bottom. A careless fin stroke too close to the silt can cause instant zero visibility even in large tunnels. Most underwater caves in areas of the U.S. other than Florida also have silt on the ceiling that percolates downward when disturbed by exhaust bubbles. Fortunately, severe cases of this are unusual in the main passages of Florida springs. Still another cause is from external factors such as heavy local rainstorms, which in some springs can result in reduced visibility by washing silt down into sink holes and cracks in the cave ceiling.

PREVENTION OF SILTING

One of the best preventions of silting is avoidance. By checking behind you constantly as you progress into the cave you can gauge fairly well how much silting is occuring. It is also a good idea to avoid passages where you can see silt on the ceiling, or whose ceiling is too low for you to progress without riling up the silt on the floor. If a rainstorm seems imminent, it's a good idea to wait until well after it's over if there is any question at all of that particular cave's reaction to heavy rainfall.

Experienced NSS divers can make relatively silt-free dives in passages routinely silted-out by novices. Our divers do this by using buoyancy to stay off the bottom and substituting propulsion techniques which disturb the silt less. The buoyancy is provided by a buoyancy compensator. A wide variety of these compensators is now on the market, from front-mounted vests to back-mounted packs and stabilizing jackets. All of these have been used successfully in cave diving. The important thing is to experiment in open water to make sure that your compensator has more than enough lift to get you off the bottom and has buoyancy properly placed so that you can achieve a head-down, feet-up swimming position. This position is universally popular with cave divers because it enables the cave diver to use certain special techniques and to keep his fin turbulence as far from the bottom as possible. If you have difficulty attaining this position, try moving steel tanks, lead weights and other heavy items forward toward the head and getting your compensator down as close to the feet as possible. Arching the back and bending the knees may also help.

Whenever the flutter kick is used in a cave, one should be as close to the ceiling as possible. The diver should also be in the head-down, feet-up position so that as much distance is between the fin turbulence and the floor silt as possible. If you notice behind you that excessive silt is still being stirred up, then it's time to substitute another technique. One very relaxing technique is the "pull and glide," where the fins are motionless and propulsion is provided by pulling on rocks and projections with the hands. Still another favorite is to push off a smooth, stable cave ceiling with the ends of the fins by maintaining the head-down feet-up position, plenty of positive buoyancy, and bending the knees. However, if you notice excessive ceiling percolation behind you, the ceiling "push-off" should not be used.

IF SILTING SHOULD OCCUR

As mentioned in chapter 1, it is important to remain within an arm's reach of the guideline at all times so that if sudden silting should occur, you can quickly encircle the line with forefinger and thumb and not become lost. Do not pull on the line: doing so may cause the line to fray on sharp projections or break. It is also important to cancel the dive as soon as you observe that excessive silting is occuring. If the visibility should become so poor that you have trouble seeing and communicating with your partner, then you should both get together on the line using the Rimbach System (see page 34).

SUMMARY

Silting of the water, causing visibility to be greatly reduced, has been an important factor in many cave diving accidents. While silting can occur from heavy rains and exhaust bubbles causing ceiling percolation, the most common cause of silting is careless diver movements too close to the floor silt. A single fin stroke can silt out a large cave passage in seconds. Avoid silt by using buoyancy and special propulsion techniques, and avoiding areas where the ceiling is silty or too low. Check behind you constantly during the dive to make sure that excessive silting is not occuring. Should silting occur, quickly encircle the guideline with forefinger and thumb and start the entire team out of the cave. If visibility becomes so poor that you cannot see your partner or communicate, then get together on the line using the Rimbach System.

8 EMERGENCY PROCEDURES

<u>ACCIDENT REPORT</u>

On July 24, 1966, Lou and Dave stopped by a dive shop to get air before heading over to Little River Springs. The shop owner was out, but a woman from the restaurant next door offered to fill their two single tanks, each of which had a J valve.

At Little River the two quickly entered the water and progressed to a penetration of 150 ft., at which point Lou started violently signalling with his light. Seeing his light, Dave turned and got the "need air" signal from Lou. It took a few extra seconds to get the neck strap unfastened, but Dave finally managed to get his regulator free and handed it to Lou upside down, with the exhaust tee above the mouthpiece. A couple of buddy-breathing exhanges occurred, then Lou abruptly reached out and snatched the regulator out of Dave's mouth before it was passed back, completely knocking Dave's mask from his head. In the ensuing struggle Dave does not remember how he got his mask or his regulator back.

Quite frightened, Dave started to leave the cave, but managed to get a grip on himself when he saw daylight from the entrance, and returned to look for Lou. When he found him, Lou had ceased thrashing around and was lying on his back with his regulator out of his mouth. Dave picked Lou up and towed him to the surface by the tank valve, compressing his chest during ascent to prevent overexpansion of the lungs.

Upon reaching the surface, Dave immediately began mouth-to-mouth resuscitation in the water while towing Lou to shore. After approximately ten minutes of this Lou began breathing for himself, but was quite weak and in a state of shock. Luckily, after spending a couple of weeks in the hospital, Lou began diving again.

<u>ANALYSIS</u>

The date of the dive makes much of the ignorance of these two novices excusable. There was no training in cave diving available at the time and none of the scant safety literature available recommended the use of submersible air pressure gauges. The "octopus" regulator with its twin second stages did not exist, and the dual valve manifold was a decade away. However, they <u>did</u> know to check their tank pressure before diving, but Lou failed to do so. As it turned out, the lady from the restaurant had apparently filled Lou's tank with the J valve up, so that very little air actually entered his tank.

Even with all of those mistakes, the two should have been able to make it out without Lou becoming unconscious. However, they only time they had practiced buddy-breathing together was for a few minutes in a pool during their basic scuba class six months prior to the accident.

Practice emergency procedures with your partner before going cave diving, and review them often.

AN OUNCE OF PREVENTION

"An ounce of prevention is worth a pound of cure." If you can prevent cave diving accidents, you need not worry about how to handle them when they occur. For that reason, the first seven chapters of this book have been primarily concerned with the prevention of cave diving accidents. However, human beings are not perfect and make mistakes, and much of human behavior is unpredictable. For these reasons, it is very important to know what procedures to follow if a problem should occur in an underwater cave.

COMMUNICATION

If you cannot tell your partner what is wrong, you cannot expect him to be able to help you. The first step in communicating to your partner is to get his attention. In cave diving this is normally done by waving your light vigorously back and forth so that the other diver can see a deliberate side-to-side light pattern. It is important that you watch for your partner's light signals continuously - it takes only seconds for an out-of-air, panicky and exerting diver to pass out. Experienced cave divers pride themselves on their quick reactions to light signals. One way to build such quick response time is to imagine that your regulator is an alarm clock that rings every time you take a breath with "where is my buddy?" In addition to watching his light, it's a good idea to actually look at your partner periodically in case you may have missed a signal. If your buddy sees you looking, it will also reassure him that you are keeping track of him.

It is extremely important to get the other diver's attention as soon as you suspect that you have a problem. If you are following another diver into a cave and have a line entanglement, it is tempting to attempt to disentangle yourself first to avoid possible embarassment. However, what if you can't easily disentangle yourself and meanwhile your partner has already gone around the next bend in the cave? At that point it is too late for a light signal, and you can only hope that your absence will be noted soon so that your rescuer will return. Always signal your partner as soon as you observe that something is awry.

fig. 4 - *"ATTENTION"*

An extension of this attention step is the "attention" hand signal (fig. 4), which can be used to ensure that you have your partner's full attention. Simply wave one hand from side to side in front of you with the palm facing out.

After getting your partner's attention, you must tell him what is wrong. This "information" step is done with special hand signals largely devised by Claudette Finley, Jamie Stone and Carol Vilece, which have been defined and standardized in Claudette's book, *Hand Signals for Cave Diving*. The "trouble" signal (fig. 5) is usually the first of these signals in any emergency and consists of rotating the hand back and forth along the axis of the middle finger, palm down.

It is a good idea to practice these hand signals with your partner on dry land in a darkened room to make sure that you can communicate effectively. You'll find

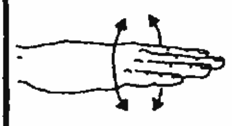


fig. 5 - *"TROUBLE"*

that even though there is a tendency to shine your light through the signal at your diving partner, your partner can see the signal better if you hold your light at an angle in front of you and shine it back at your hand signal.

SELF-RESCUE

After your partner receives and understands your hand signals you begin the "self-rescue" sequence, where you initiate attempts to solve the problem yourself while swimming to your partner or while he is swimming to you. These self-rescue actions are particularly important in that if your partner is inattentive and has completely missed your signals, or is unable or unwilling to help, there may very well be no one around to help except yourself. Nevertheless, if your partner arrives and your self-rescue efforts haven't done the job, let him help. In some situations such as line entanglement he may see the problem better and have more freedom of movement to solve it.

BUDDY-RESCUE

The final step in handling emergencies is the action taken by your partner to help, or "buddy-rescue." Just as in the case with the communication and self-rescue steps, buddy-rescue should be practiced and reviewed often with each diving partner. In the accident report at the first of the chapter, Dave probably could have handled Lou's problem much easier if they had practiced buddy-breathing together just before the dive. For just that reason, NSS divers routinely go through the "S-drill" before the first cave dive of each day with each partner if there is any doubt whatsoever about their ability to perform emergency procedures.

The "S-drill" itself consists of nothing more than spending a couple of minutes before the dive in a shadowy area in shallow water, reviewing the communication and buddy-rescue sequences for air supply loss (see pp. 37-38). You begin the drill by giving a partner facing away from you a signal (fig. 15, p. 37), then buddy-breathe with him for a short distance. Each combination of diving partners goes through the drill both ways, as rescuer and victim. Naturally, the time spent underwater in the drill must be added to your bottom time in calculating decompression requirements, but when done properly the drill takes only a couple of minutes and a minimum amount of air. If not handled properly, the dive should be cancelled in favor of a practice session in open water to eliminate any deficiencies.

CALLING THE DIVE

While in some emergencies such as minor line entanglements it is acceptable to continue the planned dive after the problem is solved to everyone's satisfaction, in most cases it is best to cancel the dive and start out of the cave. The signal for terminating the dive and starting out is the universal "thumbs up" signal (fig. 6). As soon as this signal is given the entire team is notified and starts out of the cave together. Never start out of the cave without the full knowledge of all members of the team unless low air, etc. leaves you with no other choice. Unless all of the other divers know exactly where you are at all times, they will begin the emergency procedures for "lost diver" (pp. 35-37), which could jeopardize their safety.

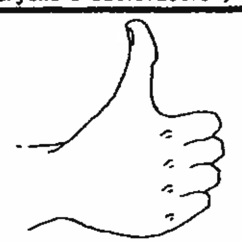


fig. 6 - *"GO UP"*

It is important to recognize that it is not necessary to wait until an emergency occurs or you reach your planned turnaround point on air, depth, duration or distance in order to call the dive and start out of the cave. NSS divers have an old saying, "Anyone can call the dive at any time for any reason." The reason need not be anything more than "I have a bad feeling about the dive."

AFTER THE DIVE

Whether or not an emergency might have occurred during the dive, it is customary to have a post-dive analysis immediately following the dive. Many divers feel that resting for a few moments on the surface before engaging in the heavy exertion of climbing up a steep bank with your tanks on will reduce the likelihood of decompression sickness. This rest also provides an ideal opportunity to discuss the events of the dive while they are still fresh on your mind. Any criticism should be constructively aimed toward making your future cave diving activity as safe as possible. In this post-dive discussion each diver should be honest about any shortcomings; no one should get embarassed since there is no such thing as a perfect cave diver and everyone (including this writer) has lots of room for improvement. You may actually want to congratulate the diver that called the dive for being so safety-conscious, especially since if the dive had been continued instead, it might have cost the lives of you and the other divers as well as his own life.

So that you'll have a permanent record of your team's observations and suggestions for future reference, be sure to record them in your dive log. By recording this data along with information on air consumption and the characteristics of the cave such as visibility, current and depth, you'll find that you can use your dive log to plan and execute future cave dives more safely.

SUMMARY

If you can prevent problems from occurring, you need not use emergency procedures for cave diving. However, everyone makes mistakes eventually. Practice emergency procedures with your partner before going cave diving, and review them often. The first step in handling cave diving emergencies is to get your partner's attention, then communicate to him what is wrong. Next, initiate the self-rescue procedures directed toward getting yourself out of trouble. The last step is assistance from a buddy. Anyone can cancel the dive at any time for any reason, whether or not an emergency has occurred. All members of the cave diving team should leave the cave together. After the dive hold a post-dive analysis with your partners and maintain a detailed cave diving log book so that you can improve more rapidly and plan and execute future dives more safely.

9 TECHNOLOGICAL EMERGENCIES

ACCIDENT REPORT

On 2/19/79, a 45-year-old diver from Chicago named Doug entered Olsen Sink on his first cave dive ever. He had a single tank with a J valve, a single hose regulator with a submersible air pressure gauge but only one second stage, one underwater light, no line and no buoyancy compensator of any kind. When he did not surface, a girl friend became upset and called the sheriff's dept. who in turn contacted our NSS recovery team.

We quickly found the victim near the permanent line some 750 ft. back, over halfway to another entrance to the cave, toward which the victim was heading. The victim's light was not found, and his tank was empty.

ANALYSIS

As in many cave diving fatalities, it is difficult to say precisely what happened. However, one thing is clear - the victim did not have a single, continuous guideline to the cave entrance. The permanent line at Olsen Sink starts about 40 ft. inside the cave, at the base of an overhanging boulder, a position which can appear to a diver swimming back to it very similar to a line tied off in a blind passage with no exit to the surface. By backing up slightly from this point, one can see daylight coming in from the narrow opening above him under optimum conditions. However, the conditions at the time of the dive were anything but optimum - the failing late afternoon sun combined with the relatively poor visibility (only 30 ft. due to recent heavy rains) would have made it very difficult to spot the entrance. This combined with the fact that the victim had enough air to easily swim in and out from the point at which his body was found suggests that he did in fact return to the start of the line, where in a panicked state he became convinced that he had gone the wrong way by mistake, and swam back into the cave until he ran out of air and drowned. A sad fact that adds to the tragedy is that even with all of his mistakes, Doug might have survived if he had taken along a small spool of line or "jump reel" (a standard item of equipment for NSS divers) and used it to search the area near the start of the line for the cave entrance instead of heading back the other way.

Always carry the equipment necessary for handling emergencies, and know how to use it.

TECHNOLOGICAL EMERGENCIES

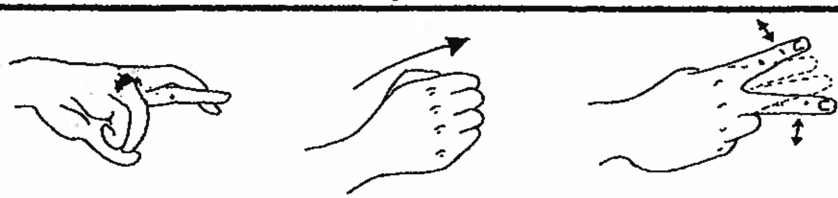
Many cave diving emergencies have causes rooted strictly in the technology of cave diving - equipment and procedures - rather than in the physiology of the diver. These "technological" emergencies should be solved by self-rescue and buddy-rescue sequences involving equipment and procedures rather than medical treatment. For example, Doug's accident was caused by failure to provide a single, continuous guideline to the cave entrance, and even after that mistake he might have rescued himself by using a line on a spool or jump reel to search for the entrance (if he had taken one along).

Let's look at a few of the more common technological emergencies and some of the currently-accepted procedures for dealing with them:

BROKEN LINE

Prevention: Make sure that your line is in good shape before the dive, and take care to install it properly during the dive - in an area away from the ceiling and large enough to swim through easily. Avoid line entanglements (see p. 33). When diving along permanent lines, be constantly aware of the line's position and condition so that you do not unwittingly swim past a break in the line or a dangerous area.

Communication: Get your partner's attention (see p. 28). The "line" signal (fig. 7) is given by crossing the index and middle fingers, then the "bad" signal is given by thrusting a clenched fist toward the line. If your partner still does not understand the problem and the line is actually broken rather than badly frayed or in a dangerous position, you may wish to add the "cut" signal by making a scissors-like movement with the index and middle fingers.



"LINE" *"BAD"* *"CUT"*

fig. 7

Self-rescue: To prevent someone from getting lost, it is very important to get everyone between the break or dangerous area and the entrance as soon as possible, while taking care not to cause excessive silting. For this latter reason it may be a good idea not to attempt to repair the problem until everyone is safely on the side of the break closest to the entrance.

If the line is improperly placed, it should be moved to its proper position - away from the ceiling and in an area large enough to swim through. If it is too taut to permit this movement, or the problem is a weak or abraded section of line, it may be necessary to splice in a new section of line. NSS divers always carry along a small spool of at least 150 ft. of line for this purpose. Before splicing, make sure that the line is safely wrapped around a rock just past the area to be replaced so that when the line is cut, it will not spring loose down the tunnel (nylon is very elastic) beyond the other divers, inviting entanglement. The "fisherman's knot" (fig. 8) is very popular for splicing. Be sure to tie in your splice before cutting the old line, and make sure that your knots are securely tied by backing them up with overhand knots (see fig. 2, p. 9).

fig. 8 - *FISHERMAN'S KNOT*

If the line is already broken, it will be necessary to swim the loose end nearest the cave entrance to the other loose end for the splice. If the resultant splice makes the line too tight, splice in an extra length of line from your spool.

Buddy-rescue: Buddies can be very helpful in this situation by providing light, holding line ends to assist in tying, etc. However, please note that it is a very poor practice for both divers to head for both loose ends simultaneously, since one diver would be without a continuous line to the entrance and in danger or becoming lost.

LINE ENTANGLEMENT

Prevention: Line entanglement is probably the most common cave diving emergency. The judicious use of "tuck" tape and taking care to keep all of your equipment as close to your body as possible will help prevent many entanglements. For example, NSS divers reverse the straps on their fins so that they cannot snag the line, using a couple of wraps of the tape to ensure that the straps do not slip loose. Also, make certain that you always cross over the line (rather than under it), so that if you do become entangled, you can more easily see and reach the point of entanglement.

Communication: Get your partner's attention (see p. 28). To signal that an entanglement has occurred, give the "line" signal (fig. 7, p. 32), moving it around in a "figure eight" pattern. Next, point at the area of entanglement.

Self-rescue: Most line entanglements can be cured quickly by simply reversing whatever movement you made to cause the entanglement (ie., if you were going forward and got snagged, back up to free yourself). This will also put some slack into the line to make freeing yourself easier, as well as minimize the possibility of accidentally cutting the line. Slide your hand along the line to the point of the entanglement and you should be able to quickly unsnag the line. You may even wish to remove the snagged item of equipment for visual inspection. Do not make any wild or abrupt movements while you are entangled - this may complicate the entanglement or even accidentally cut the line.

Buddy-rescue: A buddy can be very helpful in a line entanglement in that he is free to swim to a position where he can observe the entanglement and thereby free you quickly and efficiently. If the entanglement is so severe that it becomes necessary to cut the line as a last resort, he should be the one to cut it, making certain that all other divers are between the cut and the entrance first and following the other procedures outlined under "broken line" on pp. 32-33.

VISIBILITY LOSS

Prevention: For prevention of silting, see p. 25; for prevention of light failure, see pp. 17-19. Still another cause of visibility loss is face mask loss, damage or severe leakage. Inspect your mask for wear and tear before diving, particularly the strap and strap anchors, and reinforce them with "tuck" tape if strap slippage is a potential problem.

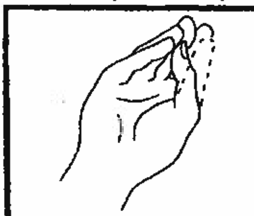


fig. 9 - *"SILT"*

Communication: If silting or light failure has made getting your partner's attention with a light signal impossible, you will have to resort to audio methods such as yelling or banging on your tank with your knife. Fortunately, to an alert, observant buddy the absence of your light beam on the walls in front of him is as dramatic a signal as vigorous flashing of your light. The signal for loss of visibility is even harder to miss - you simply find yourself unable to see. However, a signal that can be useful in avoiding a possible loss of visibility due to silt (fig. 9) is rubbing the thumb back and forth across the fingertips.

Self-rescue & Buddy-rescue: If the mask is damaged or the mask strap comes loose, clear vision can usually be preserved if the mask is held tightly against the face with a wetsuit hood or the hands. If the mask has been lost, it can often be located quickly by feeling around on the floor of the cave or even searching visually with an air-pocket against the eyes provided by blowing air into cupped hands or a wetsuit hood. However, do not spend a great deal of time and precious air in searching for the mask - it is far more important to attain hand contact with the guideline as soon as possible so that you will be assured of a safe route to the surface. Buddies can help immeasurably in finding the line and your mask, and some NSS teams actually carry an extra mask for emergency use.

As soon as bad silting occurs, you should stop, assemble the team, and start out of the cave. If you aren't on the guideline, do so immediately, encircling the line with forefinger and thumb. Do not tug on the line to signal the other divers (or for any other reason, for that matter). The team should begin an orderly exit, staying in constant contact with each other and the line using the system designed by Don Rimbach (fig. 10).

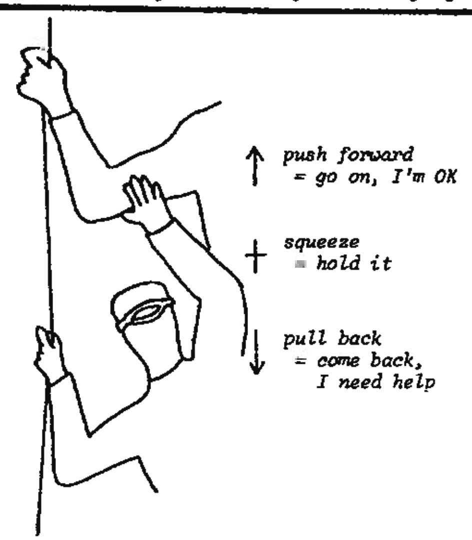


fig. 10 - *RIMBACH SYSTEM*

Note that while using the Rimbach System all divers should be on the same side of the line, with the line in the same hand and the upper arm of the preceding diver in the other hand. In narrow areas it may be necessary to slide your hand back to the preceding diver's thigh to have enough room to get through the tunnel. If for any reason one diver has a problem, he can stop the diver in front of him by simply squeezing the preceding diver's arm (thigh). If he needs the team to back up for any reason, such as in the case of a line entanglement, he merely tugs backward on the preceding diver's arm (thigh). When everything is okay, a shove forward gets the team going again.

If for any reason a diver gets separated from the others, the preceding diver should immediately halt and wait until he feels the missing diver behind him once more. In practice you'll find that the more divers there are, the longer it takes to get out - a good argument for avoiding diving with large groups in potentially silty areas.

STUCK DIVER

Prevention: Even though cave-ins are all but unknown among cave divers due to the role that water plays in providing support for cave ceilings, it is still possible for a diver to become stuck by trying to go through a tight "restriction," or narrow area in a cave. Restrictions should be avoided whenever possible - not only is there a possibility of getting stuck, but also emergency procedures such as buddy-breathing may become much more difficult. If it becomes necessary to pass through a narrow area, pause to study the configuration of the cave before going through to make sure that you pick the largest area. Since a diver's profile is much like a wedge (the point of which is his head), it may be a good idea to go through the restriction feet first so that if you do become stuck, getting out is easier.

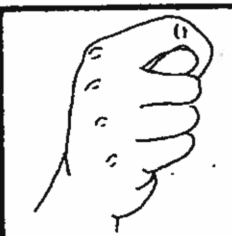


fig. 11 - *"STUCK"*

Communication: The signal for "stuck" (fig. 12) is a clenched fist with the thumb inserted between the index and middle fingers so that it protrudes out of the fist. Of course, if the diver ahead of you is stuck head-first, he may not be able to signal you in this manner. If such is the case, he may try an audio method such as banging or yelling, or a movement of the blade of one fin from side to side.

Self-rescue: As in the case of a line entanglement, most cases of becoming stuck in a restriction are solved quickly by simply reversing the actions which caused you to get stuck (ie., backing up if swimming forward caused you to get stuck). If forward movement is advisable, you can reduce your thickness in the chest area by extending both arms ahead of yourself and hunching your shoulders. Deflating the compensator also helps. However, keep in mind that the thickest part of most divers is that around the pelvis and the base of their tanks - just because you can get your shoulders and chest through does not mean all of you can get through. Do not exhale to make the chest area still smaller except as a last resort - if you don't get through after exhaling, you may find yourself unable to inhale.

NSS divers take care to put on all of their equipment with quick-release buckles and snaps so that the equipment can be easily removed when necessary. This includes the tanks, whose straps are generally left slightly loose in fit. As a last resort the stuck diver may find it necessary to unhitch his tanks and slide out from under them to get free. As in the case of all emergency procedures, this should be practiced extensively in shallow open water before entering a cave. You'll find that having the tanks and the diver each neutrally buoyant makes this maneuver much easier.

Buddy-rescue: The buddy can be invaluable in cases where the preceding diver has become stuck head-first, in that he can assist him in backing up by pushing down on the base of the stuck diver's tank and otherwise guide him through the restriction. Pull on a stuck diver only as a last resort - you may pull something loose from him necessary for his survival, cause him to become panicky, or even cause him to become stuck even worse.

LOST DIVER

Prevention: The prevention of this occurrence has been pretty thoroughly covered in the preceding chapters on guidelines and silt (pp. 7-10 & 24-26). By staying together and constantly checking on all members of the team this should not happen.

Communication: If you become aware that a third diver is not with you, get the other diver's attention (see p. 28). Next, give him the "query" signal (fig. 12) by flexing the index finger in a hook-like fashion. Then give him the "buddy" signal by extending the index and middle fingers together. Finally, give him the number "3" (or "4", etc.) to indicate the lost diver. Since these signals can be interpreted in more than one way, it is especially important to go over them with each partner before diving together.

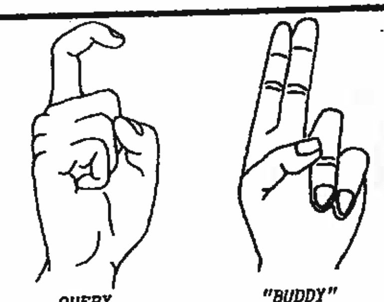


fig. 12

Self-rescue: As soon as you suspect that you have become separated from the rest of the team, you should stop. Not only can swimming aimlessly onward cause silting and enhance panic, it can also carry you further away from your partners and safety. If you are still on the guideline, chances are your partners were headed in the same direction as you and will arrive shortly. Wait as long as your air permits, then head on out of the cave. Do not remove the line.

If you are not on the guideline and can see it, get on it with hand contact immediately. If you cannot see it, attach one end of your splice spool to a sturdy rock or projection and swim toward where you think the line is, taking care to avoid stirring up silt. Two important clues that can help lead you back to the line and the other divers are the trail of air bubbles that you have left in the cave ceiling and the silt that you have left in the water. If you still cannot find the line but are certain it is within range of your splice line, you can use it to begin searching in a slow circle, looking for your partner's light and the sound of his exhaust as well as the line. Be systematic - do not swim aimlessly back and forth in panic.

If you are unsure of the direction along the line to the entrance of the cave look at the line to see if there are any "Dorff" Markers" on it - small wedge-shaped tape arrows (fig. 13) that point toward the nearest entrance. Direction of current

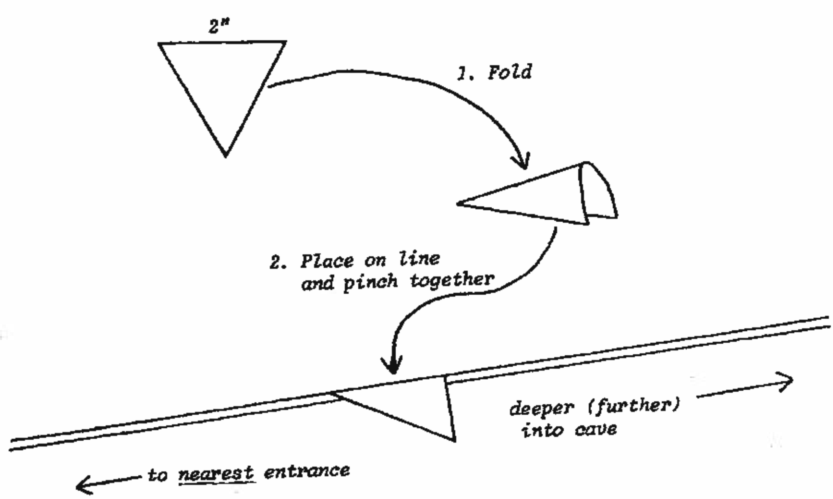


fig. 13

flow can also help, and can often be detected by puffing up a small amount of silt and observing its movement closely. Scallops in the cave walls (fig. 14) are still another method of detecting direction of water movement, even when there isn't any detectible flow. By swimming downstream you should arrive at a spring entrance; upstream will carry you back to a "syphon," or inflowing entrance. A good diver's compass can also help get you to the surface if you took compass readings on the way in or studied a map of the cave prior to the dive.

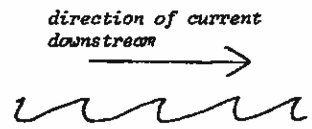


fig. 14 - *SCALLOPS*

Buddy-rescue: As soon as a diver is missed, stop. If you are running a reel, tie off the line to a nearby rock or projection at once - do not reel it back out of the cave until you are certain that all divers have gotten out of the cave. Look for the missing diver's light and listen for the sound of his exhaust. Air permitting, begin a search starting at the farthest possible point from the cave entrance at which he may have become lost. If your search carries you from the guideline, be sure to use a reel or a splice spool so that you always have a continuous line to the entrance. Exhaust bubbles in the ceiling and silt in the water may provide clues as to the missing diver's whereabouts. Finally, shine your brightest lights all around while searching - he is at least as anxious to see you as you are to find him.

AIR SUPPLY LOSS

Prevention: The prevention of this problem is careful dive planning (pp. 11-12) and proper equipment (pp. 20-23).

Communication: Air supply loss is signalled by slashing the throat (fig. 15). The "let's buddy-breathe" signal should not be necessary since the hand slash automatically implies that need.


fig. 15 - *"OUT OF AIR" "LET'S BUDDY-BREATHE"*

Self-rescue: If you are actually out of air, you must of course get to your partner as soon as possible. Air in your compensator can be rebreathed for a short period of time (as with all cave diving procedures, practice this out of water first). If the problem is a regulator malfunction, simply switch to the extra regulator of your dual valve manifold. If the regulator is free-flowing or leaking air, you must close the valve leading to the bad regulator to prevent further air loss. Practice this frequently so that you can do it in as short a time as possible.

Even if you have been foolish enough to dive without a dual valve manifold, all is not lost. If your problem is regulator free-flow, by opening and closing your tank valve on each breath you can continue to breathe and greatly reduce the rate of air loss. If you begin buddy-breathing, be sure to cut off the valve leading to a free-flowing regulator - you may need that air later. If your problem is a total regulator failure with no air at all coming through, you may be able to breathe from the B.C. using the automatic inflator to provide air from your tanks. As a last resort you can even breathe directly from the tank valve.

Buddy-rescue: Not only may buddy-breathing in a cave involve considerable horizontal movement, but also it may involve current, silt, irregular cave configurations with frequent changes in passage direction, crossing back and forth over guidelines, etc. Buddy-breathing with hoses of standard length may be extremely difficult, even with an octopus rig. For this reason NSS divers make sure that one

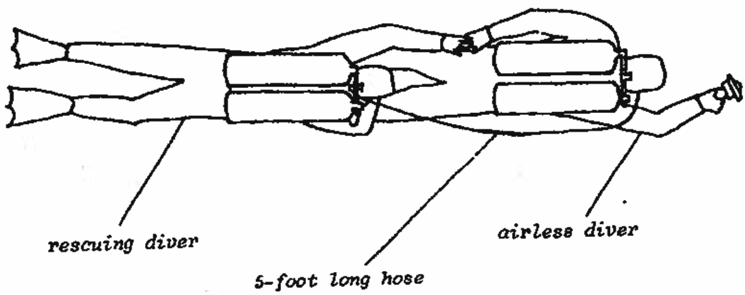


fig. 16 - *SINGLE-FILE BUDDY-BREATHING WITH LONG HOSE*

of each diver's regulators has an extra-long hose. The five-foot hose is especially good in that it permits single-file buddy breathing (fig. 16). This revolutionary NSS technique permits both divers to maintain contact with the line, use the Rimbach System for poor visibility communication (p. 34), and pass more easily through narrow areas. Notice in fig. 16 that the diver with no air swims ahead of the rescuer, a procedure that makes it more difficult for the rescuer to leave the airless diver since he must get by him to get out.

10 PHYSIOLOGICAL EMERGENCIES

ACCIDENT REPORT

On Labor Day, 1971, two highly experienced cave divers and instructors, Carl and Terry, made a dive in a salt water cave in the Bahamas. Carl had a new set of twin steel 100 cu. ft. tanks, and was wearing his diving knife on his leg rather than in the customary position on his forearm. The two swam back approximately 700 ft. to a depth of 280 ft. At that point Carl made Terry wait while he proceeded through a narrow, silty restriction. Terry became alarmed when Carl did not reappear after several minutes, and went though the restriction to investigate despite Carl's instructions.

The only sign of Carl that was ever found was a cut guideline, hanging limply at a depth in excess of 300 ft...

ANALYSIS

The primary cause of Carl's death was most likely diving to excessive depth. Not only was the depth of the dive far beyond the 130 ft. limit recommended for sport diving, it also was deeper than Carl had ever been before. Add to that the unfamiliar tanks and knife plus the fact that witnesses reported Carl appeared to be ill before the dive, and it is not surprising that a fatality occurred.

The big question is, why would someone who obviously knew better make such a dive? At the time no experienced American cave diver (much less someone of Carl's stature) had ever died in a cave. A friend had recalled conversations where Carl spoke of his "invulnerability" to cave diving accidents. Undoubtedly, Carl was overconfident as to his abilities to handle himself in such a situation.

Never permit overconfidence to allow you to rationalize violating recommended cave diving safety procedures.

ETERNAL VIGILANCE

NSS divers have a saying, "Anyone can die at any time on any cave dive."While the probability of a fatality is very remote for a team of properly trained and equipped cave divers adhering to the procedures discussed in this book (and in fact such a fatality has yet to occur), it is still possible, just as you might die right now from any of a dozen unlikely but completely unpredictable and uncontrollable causes while reading this in the comfort of your own home. The point is, no one is invulnerable to cave diving accidents. In fact, experienced cave divers like Carl may be even more vulnerable than novices in the long run in that they make more cave dives and therefore have more cumulative exposure to the hazards of cave diving. "Lady luck" may pull a novice through a few dives, but over a career of a hundred or more cave dives luck runs very thin indeed. All cave divers must rely on eternal vigilance and adherence to all recommended procedures for cave diving in order to ensure their long-term survival.

PHYSIOLOGICAL EMERGENCIES

While unfamiliar equipment may have contributed to the accident, Carl's fatal dive had primary causes rooted in his physiology rather than the technology of cave diving. He was probably ill at the time of the dive and narcosis probably caused him to black out at extreme depth. Many "physiological" emergencies require first aid and even subsequent medical treatment, a good argument for the reader to take courses in first aid and CPR (cardiopulmonary resuscitation) from the American Red Cross or American Heart Association before diving in caves.

NARKED DIVER

Prevention: The primary prevention of narcosis is to avoid deep diving. See chapter 3.

fig. 17 - *"NARKED"*

Communication: The signal for narcosis (or dizzy) is to twirl the index finger while pointing it toward the side of the head (fig. 17).

Self-rescue: By resting and taking a few slow, deep breaths narcosis (and dizziness too, for that matter) can frequently be alleviated. Start up (or out) slowly, taking care to use your buoyancy compensator, etc. to avoid becoming fatigued.

Buddy-rescue: Towing an incapacitated diver is best accomplished by holding the victim's tank valve or manifold. If you are lucky and have a vertical ascent, you should use your buoyancy compensator (B.C.) to provide the needed lift rather than swimming. If your B.C. doesn't provide sufficient lift you can also inflate the victim's compensator, but remember that you will also have to vent it as you ascend to shallower depths. If horizontal movement is necessary, you should inflate the victim's B.C. so that he is neutrally buoyant in order to minimize the amount of drag that you must overcome while towing him out. Obviously, in many caves this type of rescue may be extremely difficult. For example, even if Terry had found Carl in the accident described at the start of this chapter, it would have been virtually impossible to tow him up through the deep restriction. As a matter of fact, such an attempt would have probably caused Terry to black out as well, in which case there would have been two deaths instead of one.

BESERK DIVER

Prevention, Communication & Self-rescue: While there can be drug-related causes for this problem (avoid diving with persons who have been known to take drugs or who have consumed alcohol immediately before the dive!), the most common cause is panic. Prevention and treatment of panic are covered on p. 16. The signal is the same as for narcosis (fig. 17).

Buddy-rescue: This is a highly volatile situation where one may very well have to invoke the American Red Cross lifesaving principle: "losing one's life in an attempt to save another from drowning, in many instances, does not indicate heroism nearly as much as it does bad judgment." If you do not think you can handle the diver and perform the rescue, don't try! There is no point in having two victims. Indeed, if you are very near the cave entrance, it may actually be advisable to get away from the beserk diver until he runs out of air and blacks out, then tow him to the surface and administer CPR measures.

If you choose to attempt to handle an active, beserk diver anyway, try to get behind him with a firm grasp on the tank valve and also the base of the tank. If you become involved in a struggle, flooding his mask, while possibly making him even more panicky, may enable you to get the upper hand. As soon as you are in control you may begin towing the victim in a manner similar to that described under "narked diver" on the preceding page.

DECOMPRESSION SICKNESS

Prevention: Adequate decompression. Avoid exceeding the "no-decompression limits" if possible. Select a good area for possible decompression stops before the dive so that you have plenty of good ledges or logs, etc. to hold onto to control your stop depth. It is also advisable to take care to select an area for stops that is free from hazardous conditions such as strong current, cold water, etc. Know how to calculate decompression using the U.S. Navy tables and keep track of your maximum depth and bottom time.

Since a controlled 60 ft. per minute ascent from maximum depth is frequently impossible in cave diving, NSS divers use "cave bottom time" in their calculations - the time elapsed from submerging until arriving at the first stop. This provides an added safety margin as well. If you want an additional safety margin due to exertion, injury, old age, obesity or some other factor increasing susceptibility to decompression sickness, try decompressing for the next greater scheduled depth or - even better - next greater scheduled bottom time. Some NSS divers utilize oxygen for decompression at depths not exceeding 20 ft. to provide still another safety margin, but oxygen equipment must be specially cleaned, constructed and cared for, and oxygen toxicity and combustion from contact with substances such as lipstick must be avoided.


fig. 18 - *"BENDS"*

Communication: Know the symptoms of decompression sickness, such as joint pain, dizziness, paralysis, extreme fatigue, etc. The first of these symptoms appear within 30 minutes of surfacing for half of the cases investigated by the U.S. Navy, and 85 % of divers suffering from bends experienced their first symptoms within 1 hour of surfacing. If symptoms of decompression sickness should develop in the water, usually a slate and pencil is used so that the symptoms can be described in detail. If for any reason this is not possible or speed is essential, a signal popular with NSS divers to denote decompression sickness or "bends" is to hold one arm up, bending the wrist as far down as possible (fig. 18).

Self-rescue & Buddy-rescue: When symptoms of decompression sickness occur underwater, it is probably best to finish the planned schedule unless the symptoms become so severe that the stricken diver becomes in danger or drowning. Do not attempt to recompress the diver in the water. Administer oxygen as soon as possible, but if you do so in the water, never breathe oxygen at depths in excess of 20 ft. Begin immediate evacuation to the nearest recompression chamber, keeping the victim warm and comfortable in route and monitoring his progress so that CPR or other measures can be taken immediately if necessary. Unless the victim is having respiratory difficulty, some feel that tilting his body at a slight angle (about 15 degrees) so that his feet are higher than his head is a good idea. A list of Florida's recompression chambers and their phone numbers is given on p. 46. If you are not in Florida or are unsure of the location of the chamber, a 24-hour nationwide chamber directory service can be reached by dialing 512-536-3278 (spells "LEO FAST"). It is best to call ahead to make sure the chamber is ready when you get there, but do not waste a lot of time trying to get through. The operator will be more helpful if you identify the call as an "emergency call."

HURT DIVER

Prevention: This situation covers a variety of circumstances, ranging from muscle cramps to broken bones and severe bleeding. Leg muscle cramps can be prevented by eating a balanced diet and avoiding oversized fins, tight straps, unaccustomed exertion and prolonged exposure to cold water. Many divers have also noted that their susceptibility to leg muscle cramps while diving is markedly increased when they have been jogging regularly. More severe injuries can frequently be avoided by using reasonable care in not swimming through or under unstable areas, leaving potentially hazardous marine life alone, and paying attention when handling knives or other sharp objects..

Communication: To signal an injury to your partner, give the "trouble" signal (p. 29) followed by pointing at the affected area of the body.

Self-rescue & Buddy-rescue: To an experienced diver a leg muscle cramp is nothing more than a minor irritation. Usually the cramp can be quickly released by straightening the leg with the foot back so that the muscle is stretched as much as possible. If the muscle is sore, reaching back to knead it will help. By reducing the level of exertion or changing strokes the cramp can generally be kept from coming back. Bleeding can usually be controlled by direct pressure on the wound, such as holding it tightly with one hand. A course in first aid from the local chapter of the American Red Cross can prove invaluable in learning to handle these and more serious injuries.

CESSATION OF BREATHING

Prevention: Avoid hazardous situations, be prepared to deal with emergencies, etc. If your partner's actions lead you to believe that he is about to pass out and lose the mouthpiece of his regulator, it is advisable to immediately swim to his assistance and hold his regulator in his mouth.

Buddy-rescue: When your partner stops breathing, you must get him to the surface as soon as possible, using the procedures described under "narked diver" on p. 40. Be sure to reach around and compress his chest during ascent to minimize the possibility of air embolism or related disorder. Begin mouth-to-mouth resuscitation as soon as you reach the surface. If the heart has stopped, begin external cardiac compression as soon as possible. If oxygen is available, utilize it in your resuscitation efforts. All cave divers should be thoroughly familiar with CPR procedures before diving - see your American Red Cross or American Heart Association.

Remember that you must assume that a diver that has stopped breathing has air embolism - head for the nearest recompression chamber (see p. 41).

a blueprint for survival

TEN RECOMMENDATIONS FOR SAFE CAVE DIVING

1. *ALWAYS USE A SINGLE, CONTINUOUS GUIDELINE FROM THE ENTRANCE OF THE CAVE THROUGHOUT THE DIVE.*

2. *ALWAYS USE THE "THIRD RULE" IN PLANNING YOUR AIR SUPPLY.*

3. *AVOID DEEP DIVING IN CAVES.*

4. *Avoid panic by building up experience slowly and being prepared for emergencies.*

5. *Always use at least three lights per diver.*

6. *Always carry the safest possible scuba.*

7. *Avoid stirring up silt.*

8. *Practice emergency procedures with your partner before going diving, and review them often.*

9. *Always carry the equipment necessary for handling emergencies, and know how to use it.*

10. *Never permit overconfidence to allow you to rationalize violating recommended safety procedures.*

NSS-CDS COURSE DESCRIPTIONS

INTRODUCTION TO CAVERN DIVING - This informal course introduces the trained open water diver to the basic goals and need for a regular Cavern Diver course. This is not a certification course and no certification card will be issued. This informal course is designed to allow an active, certified open water diver an opportunity to participate in a safe cavern dive under the direction of a certified cavern or cave instructor. Participation in this activity does not qualify a diver for diving in caverns or caves on his own, even if his dive partner is a certified cavern or cave diver.

CAVERN DIVER - The course develops the minimum skills and knowledge for cavern diving, and describes the dangers involved with cave diving. Planning, environment, procedures, techniques, problem solving, and other specialized needs of cavern diving are covered. Problem solving in cavern diving includes, but is not limited to: body positioning (trim), buoyancy control, emergency procedures, line following, and propulsion techniques. Accident analysis forms the basis of this learning experience. Special emphasis on the unique environment includes silting, entanglement, disorientation, and equipment modifications. The Cavern Diver Course is in no way intended to provide instruction for cave diving.

CAVERN DIVER REFRESHER PROGRAM - This informal course reviews the basic information a Certified Cavern Diver receives during a regular Cavern Diver Course. This experience is designed to enhance a certified Cavern Diver's performance during cavern dives, review background information for safe cavern diving, and update the diver on current standards. It is designed primarily for divers who have not been cavern diving recently and wish to maintain their skill level through review with a certified instructor. This is NOT a certification course and no certification card will be issued.

INTRODUCTION TO CAVE DIVING - Introduction to Cave Diving is a single diving cylinder overture to the most basic principles of cave diving. Introduction to Cave Diving follows the Cavern course as the Cave Diving Section's second step in the development of safe techniques for cave diving. The basis of this course is aimed at perfecting skills taught in the cavern diving program as well as instructing in additional techniques and procedures required for the most elementary of cave dives. Cave dives are planned around very limited penetrations so that the diver may progress into cave diving at a conservative pace. The Introduction to Cave Diving course is not intended to train divers for all facets of cave diving. Accident analysis continues to form the basis of the training.

APPRENTICE CAVE DIVER - This is the third in a series of cave diver development training courses. Emphasis is upon dive planning and skill perfection through actual cave dives. Techniques learned through the earlier Introduction to Cave Diving and Cavern Diver courses are critiqued and expanded. Exposure to different cave diving scenarios is the foundation of this training. The Apprentice Cave Diver course is not intended to prepare divers for evaluating all facets of cave diving. It is intended to expose students to basic fundamental principles of cave diving. Students are encouraged to move on to the next level of training before attempting to plan and execute complex cave dives.

FULL CAVE DIVER - This is the fourth in a series of cave diver development training courses. Emphasis is upon more advanced cave dive planning and execution. Techniques learned through the earlier Apprentice Cave Diver, Introduction to Cave Diving and Cavern Diver courses are more closely scrutinized to prepare the students for evaluation of their future cave diving needs. Exposure to more sophisticated cave diving scenarios is the foundation of this training. Students are introduced to the basics of surveying and are required to provide an elementary sketch of a cave passage.

BASIC UNDERWATER CAVE SURVEYING - The course is designed to instruct the certified cave diver in the fundamentals of surveying underwater caves. It is intended to motivate more divers to survey caves through a specialty certification, to encourage the use of cave maps in dive planning, and to increase the quantity of published cave maps. Additionally, this course is meant to establish a standardization program for a broa range of future survey projects. The course material covers early surveys and the development of technique to yield standards and procedures. The seven phases of the survey process are followed from conception t completion of a survey project. Topics covered in detail are: accuracy standards, composition of the surve team, use and fabrication of special tools, survey techniques and methodology, safety considerations, dat manipulation and mathematical calculations, symbology, cartography, copyright and publication.

INTRODUCTION TO CARTOGRAPHY - This is a management oriented course and is designed to introduce the basics o underwater cave map presentations. While underwater activities and techniques are discussed, no underwate training or evaluation is provided. Participation is open to anyone with an interest in underwater cav mapping. However, an assumption, for certification, is made that participants will have some knowledge c cave diving and underwater surveying. The course includes a brief review of surveying technique, manual ar computer aided data reduction, verifying data and correcting for errors. Materials and supplies necessary and transforming data into a finished map. A goal of this course is to develop in the student an ability t complete the survey and map-making process by actually producing a map.

INTRODUCTION TO SIDEMOUNT USE - This course is designed to expose the experienced cave diver to alternati tank configurations when back-mounted tanks are not available or appropriate.

DPV PILOT - The purpose of the DPV Pilot specialty course is to expose the trained cave diver to the bas fundamentals of the safe operation of diver-propulsion vehicles in submerged caves while under the dire supervision of a qualified DPV Cave Diving Instructor. Safety practices, procedures, and techniques common most DPV's used in the unique environment of a cave are covered. Conservation considerations and simulat potential emergency situations are emphasized. In addition, the student is able to build practical experien in the field under controlled conditions.

RECOVERY SPECIALIST - The Recovery Specialist Course is management oriented course designed to introduce ca divers to the fundamentals of conducting and investigating a cave-diving-related fatality and recover Participants receive information as to how the Recovery Team is organized and deployed to an accident scen and how it interacts with the local law enforcement officer(s). The responsibilities at the accident sce include but are not limited to: crowd control at the scene, information gathering, organizing a searc determining equipment and diver needs for the recovery, dealing with the media, and completing necess accident investigation reports.