UNDERWATER SPELEOLOGY

VOLUME FOURTEEN
NUMBER THREE
May 5, 1987

Tom Morris prepares to do his final decompression stop inside the decompression bell. Photo by Wesley C. Skiles. See article, p. 11.

you don't already know. A hard fact to learn, but one I know all too well is divers who drown in caves seldom do anything creative. Case after case, the rules of accident analysis are broken, and divers pay with their lives. Sooner or later someone will drown, violating some rule, outside the traditional rules governed by accident analysis. When that does happen, we should hear about it in the News. Until then I feel like all "typical" reports should be reviewed and then forwarded to John Crea, the CDS Accident File Coordinator. If the readership feels that it wants to read about all of the accidents, that's fine, and would then recommend that an annual "Cave Diving Accident Report" be published similar to that done by the NSS.

Underwater Speleology is the newsletter of the Cave Diving Section of the National Speleological Society, and should be reserved for news that reflects the goals of our organization: to explore, to study, and to conserve. All individuals reading this newsletter should appreciate that being editor of U/W Speleology is a thankless task. It should also be noted that not enough news is contributed from our readers to offer the diversity necessary for a well-balanced newsletter issue after issue. Anyone with a story of interest should submit it. Please don't assume that your story isn't worthy; let the editor decide that! To help set the stage, I have enclosed an article entitled "The Scientific Future of Cave Diving." I hope you'll enjoy it.

Safe cave diving,

Wes Skiles
Training Chairman NSSCDS

THE SCIENTIFIC FUTURE OF CAVE DIVING

— by Wes Skiles

Cave diving developed initially as a sport; however, as the level of participation and interest grew, cave divers began to study, interpret, and map the fragile, unusual environment they were privileged to visit. In the past five years, cave divers have participated in substantial biological studies. Although these studies are important, emphasis in the future will almost certainly be placed on the caves' role as windows into the aquifer—research laboratories to test aquifer health and aquifer potential as a water source.

Scientists interested in direct study of these resources are increasingly turning to cave divers for data to support their studies. Likewise, geologists and hydrologists are concerned with the specifics of how water moves through the ground so that it may be better managed. In both cases, cave divers able to collect and study information from the underground underwater environment are needed.

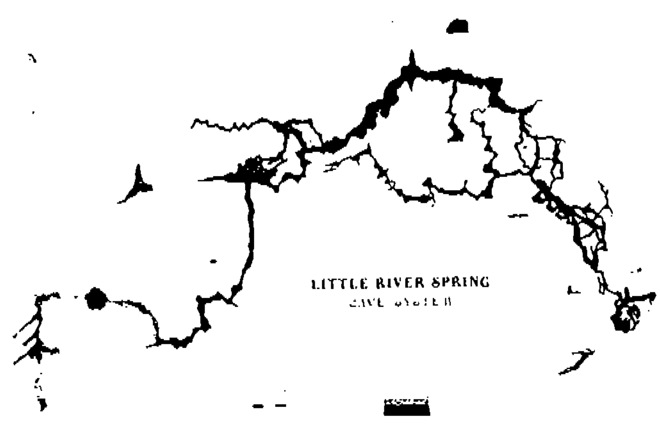
Cave divers are hurried visitors to a beautiful but hostile and potentially dangerous environment. The present state-of-the-art of cave diving allows safe, quick visits to the underwater systems, but does not allow time to be spent for the collection of data or close, careful study of a system without great physical sacrifice on the part of the diver—in increased decompression times, in nitrogen narcosis effects, in bearing the physical burden of stage diving or long swims with heavy loads.

Cave divers can help in many ways with studies of the underground underwater world. The first part of this paper identifies the ways in which cave divers can further scientific research. The second part discusses the improved cave-diving tools, equipment, and procedures needed for safer and more thorough study of underwater systems.

FIELD DATA COLLECTION POSSIBILITIES

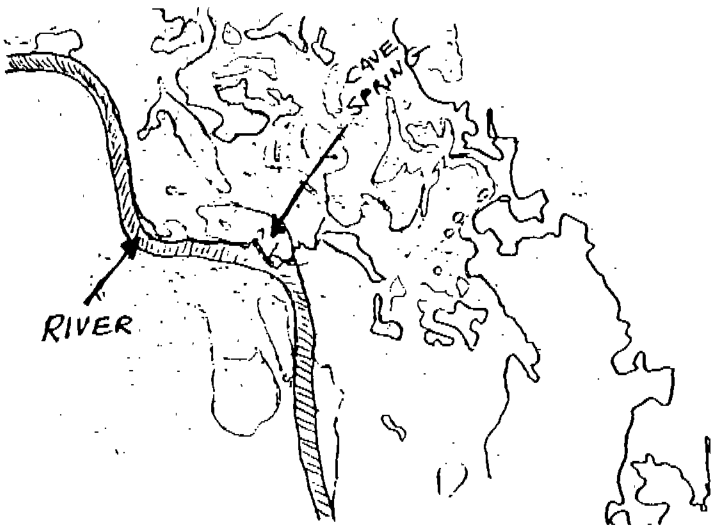
Cave divers, with their direct experience of cave systems and their sometimes encyclopedic inventories of surface karst features such as springs, sinks, and "little holes in the ground," can assist scientists in the following ways:

Survey and cartography. Line surveys of caves can be completed, providing depths, distances, directions, sketched passage features, and vertical profiles. The limited time that cave divers can spend underwater is the single largest factor in preventing more complete, detailed, and accurate mapping of underwater caves.



Little River Springs Cave System. Cartography by Wes Skiles. Newly revised edition now available through CDS Publications, see p. 17.

Dye Tracing. Based on topographic information and the trend of the cave system under study, dye-tracing experiments can be carried out to trace the contributions of (potentially polluted) surface drainage into the aquifer system.



Little River Springs Cave System overlaid on area topographical map.

Water Chemistries. Water samples can be taken through out a system for analysis, allowing scientists to study water quality, dissolved salts, the influence of infiltration from local communities and surface drainage, and changes in water chemistry with depth.

Photography. Photographs can be taken that allow non-divers to view the spectacular, beautiful underground environment, and allow scientists to study such things as passage cross-section relative to flow dynamics.

Biological Collecting. Biological specimens can be collected when this is appropriate, with all due care taken not to disturb the ecologically sensitive cave environment.

Geological Collecting. Rock specimens can be collected at different depths in a cave system and in areas where solutional activity is intense or unusual; thus, scientists will be able to correlate rock units and passage characteristics.

Photo by Wesley C. Skiles. (Subject prefers to remain anonymous.)

BETTER TOOLS AND TECHNIQUES FOR RESEARCH DIVING

The following ideas are the pieces of a puzzle. If we can fit them together, we can realize many research goals. All of them have the goal of staying longer or gathering more information in the underwater environment.

Staying Longer. Presently, our ability to stay in the underwater cave environment for long enough periods of time to do significant work is limited by the amount of air we can, practically, carry and/or stage into the cave before the working dive is carried out.

Multiple Staging. Multiple staging has grown popular in recent years; it is largely being refined by explorers attempting to achieve new penetration records in Florida's larger cave systems. The technique requires detailed planning and multiple set-up dives to be done properly. Five-, six-, and seven-tank stage dives (plus the cylinders being worn on the back) have been completed successfully, but only at the cost of great time and effort on the part of the participating divers. If cave divers wish to advance beyond what has already been achieved, we must develop better and simpler ways to increase bottom time.

Carrying More Air. French, German, and Swiss cave divers have increased their "on-the-diver" quantity of cylinders (as opposed to placing cylinders in the cave in advance of the planned push dive). This method has the obvious advantages that the diver can, on one dive, enter a cave, swim to the desired zone of penetration, and exit without the complex series of set-up and clean-up dives required with the staging system.

Special problems such as excessive negative buoyancy have been handled by mixing high-volume steel cylinders (104 cu. ft. or 140 cu. ft.) with equally high-volume (100 cu. ft.) fiber-composite cylinders that tend to be positive even when full. The excessive negative buoyancy of the steel cylinders tends to be cancelled out by the positive fiber-composite cylinders, thus giving the cave diver a large but neutral load. This allows a diver carrying an awesome mass to make decent forward progress because the mass is neutral.

As with all great ideas, there are drawbacks. The most obvious one is that all caves would need to be the size of Wakulla Spring to use such a system. Since the vast majority of underwater caves do not meet this specification, other alternatives must be sought.

The Australian Sled System. The Australians, in the world-record penetration of Cocklebiddy Cave, used "tank sleds" made up of 16 aluminum 80-cubic-foot cylinders. These sleds worked quite well: they ansported a large volume of air deep into the cave efficiently and without too much diver effort. But the sleds did tend to become extremely buoyant as the tanks were breathed down. Considerable lead had to be carried, and there were occasional underwater problem-solving sessions as sled buoyancy caused hang-ups on the ceiling.

<u>The Tank "Peel Off" System</u>. By mixing the good aspects of American stage-diving techniques and the European bulk-air system, we should be able to come up with an ideal mix. The tank "peel off" concept would allow a diver to begin with an enormous volume of air (690 cu. ft.) and, as the dive progressed, to "peel off" the tanks as individual groups of tanks had been breathed down to two-thirds of the initial volume. This puts the explorer in an increasingly streamlined configuration as penetration increases. The beauty of such a system is that the explorer is shedding the redundant mass of air along the way, allowing better negotiation of smaller passages that may be encountered as the penetration increases. The explorer could end up with a tank configuration as streamlined as a sidemount system as far back as a mile and a half. (See Diagram 1.)

<u>To Stay Longer More Safely</u>. With the pacity to increase bottom times through the use of new tank-configuration systems, thought must be given to the additional time required for proper decompression. Modern cave divers have already pushed bottom times without the use of a chamber to the absolute extreme. Fortunately, the cave-diving community has experienced good success in decompressing. Some of this success can be attributed to the learned fine are of "comfort decompressing." The most common of these important techniques are:

1) fluid and energy replacement,

2) pure oxygen use on a rotating schedule with air for the twenty- and ten-foot stops, and

3) increased warmth through decompression, achieved either by layering wetsuits or by using drysuits with warmth-retaining underwear.

Even though these steps have been beneficial in avoiding decompression sickness, they fall far short as satisfactory methods for sustaining the cave diver through substantially longer bottom times. Possible solutions to the problem of "high-risk" decompression dives might include:

1) Nitrox diving gas mixtures to decrease the saturation level of nitrogen in body tissues,

2) portable decompression bells, and

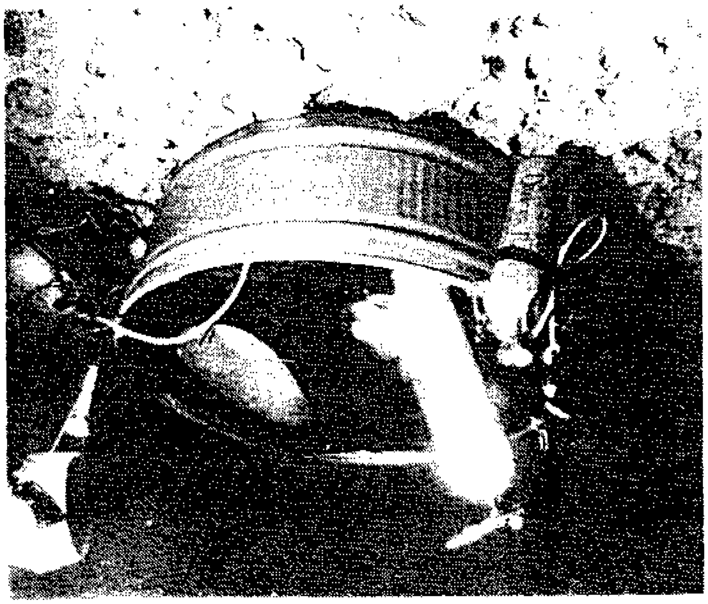
3) use of habitats for saturation cave diving.

These techniques could greatly extend the capabilities of the underwater researcher/explorer.

<u>Nitrox Gas Mixtures</u>. Compressed air, used for all forms of recreational diving, has distinct disadvantages for the cave diver planning a long bottom time. Because of the high partial pressure of nitrogen in air, the body's tissues reach saturation or even supersaturation (once the diver begins to ascend) very quickly. Increased depth causes increased nitrogen intake, thus making deeper and longer dives more "high risk" as far as decompression sickness is concerned. Nitrogen absorption is a problem because the gas is inert, not used directly by the body for any specific purpose. Oxygen, on the other hand, is very much in use by the body and causes no problems, such as bubble formation in the tissues. The drawback to oxygen is that our bodies accept only a maximum partial pressure of the gas. Partial pressures of oxygen that exceed 29.4 psi become toxic to the diver.

Nitrox, a special gas mixture of nitrogen and oxygen, could hold one of the keys to extending bottom time by lowering nitrogen partial pressure and increasing oxygen partial pressure. an ideal mix could be arrived at where the diver has greatly decreased nitrogen absorption while staying below the toxic partial pressure of oxygen. Presently several individuals are studying the feasibility of developing a system to mix the proper percentages of oxygen and air to create a workable and safe nitrox mixture. Specific mixtures will have to be blended for each depth range the diver anticipates exploring; it should be noted that Nitrox can only be used safely in shallow dives. The maximum safe Nitrox depth should not exceed 130 feet, based on a 1.2 pp O2 mixture. Given this limit, a reasonable depth limit for obtaining benefit from Nitrox would be 90 feet. No diver should experiment with exotic gas mixtures unless he or she is fully educated and equipped to work in such an area.

Tom Morris returns to the decompression bell after a penetration dive. Photo by Wesley C. Skiles.



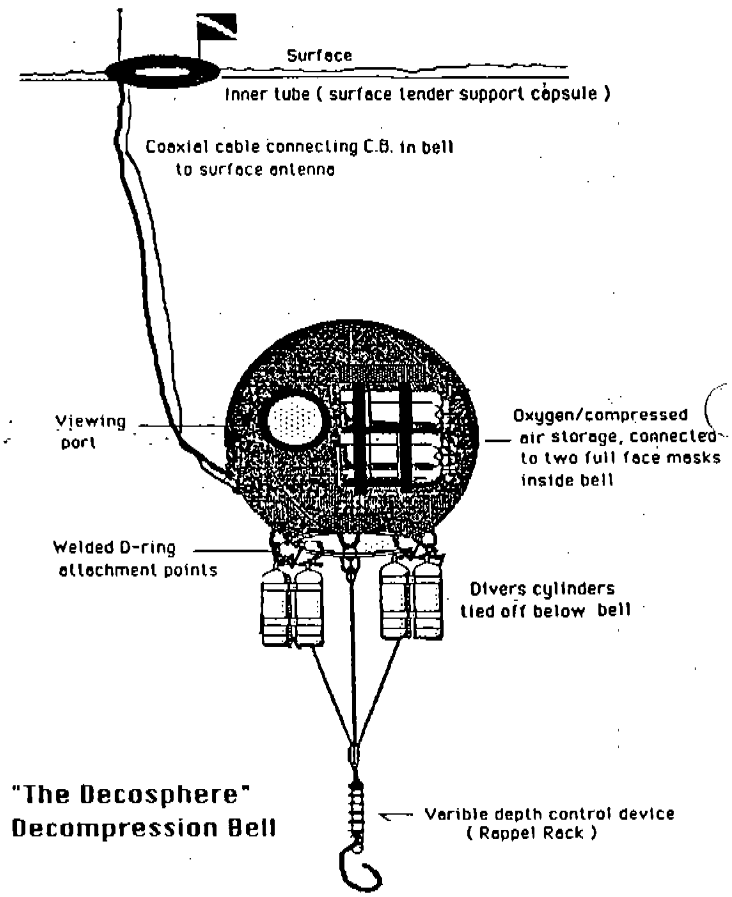
Peacock Springs: inside the decompression bell, a cow trough converted to habitat. Photo by Wesley C. Skiles

Portable Decompression Bells. The major drawback to long decompression schedules in the water is discomfort. Cold, extreme boredom, thirst, needing to urinate, and/or feeling that the decompression is no necessary are primary motivators for a diver to "push" the tables. The word "push" is being used in a broad sense; it could cover anything from leaving decompression early to skimming the tables to fit your needs. Whether any of this is the case or not, there is a problem with divers on long and/or deep dives having the ability to stay comfortable during their prescribed schedule.

Ron Allum from Australia tries out the decompression bell. Photo by Wesley C. Skiles

A portable decompression bell would eliminate all of the drawbacks of racking up long decompression schedules. Since the first stirrings of this idea arose, there have been a number of bell-type environments proposed. The theory behind all of the designs is to make for a more comfortable, safe stay at decompression. Being able to remove cylinders and rise into an ambient-pressure air environment allows the diver to become far more comfortable. A portable decompression bell could be stocked with a variety of options. There are two categories within the bell system concept (no pun intended). They are:

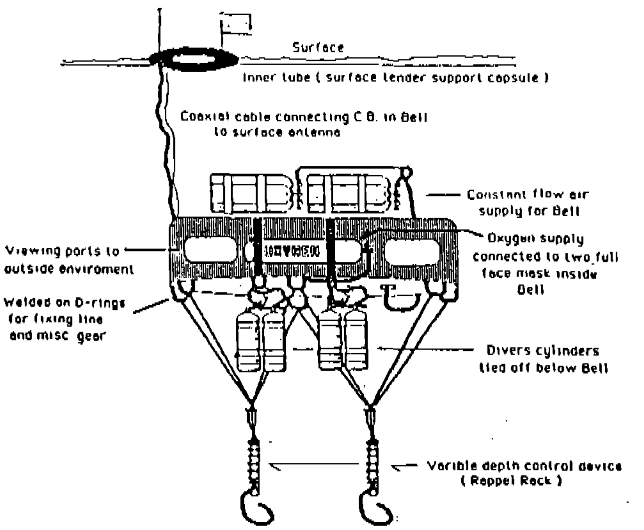
1) stationary (fixed depth) bell, and
2) variable bell depth.



"The Decosphere" Decompression Bell

The Decompression Sphere. Using a surplus World War II-era decompression bell, the cave diver can now feasibly install decompression spheres at sites that warrant them. The spheres presently available measure 5 feet in diameter and weigh 617 lbs. Once it is submerged and filled with air, the sphere creates a total of 3000 lbs. of lift force, which could be countered using either a variable or fixed depth system. (See Diagram 2.) In most cases the ceiling of the cave could be used to achieve the fixed depth.

Once the concept of decompression bells in absorbed, the options for increas-

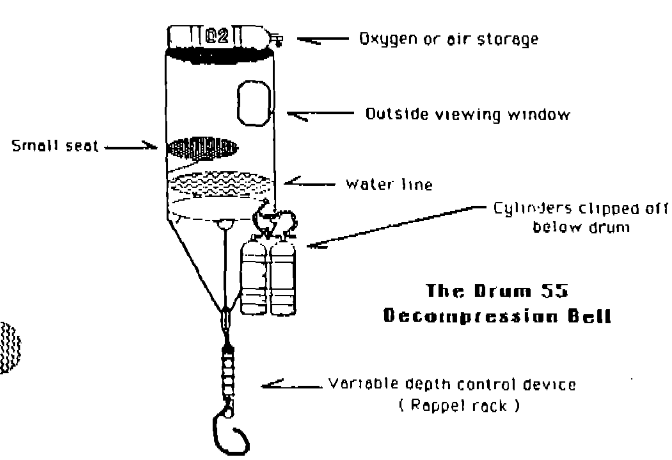


The " Trough "
Decompression Bell

ing the efficiency and comfort of decompression become quite exciting. The list below describes some of the feasible options that could be added to any of the bell designs.

Storage Air Mounted Externally on the Decompression Bell. This method would allow a free flow of fresh air to be constantly bled into the chamber, eliminating the need to keep a regulator second stage in your mouth inside of the bell environment.

Storage Oxygen Mounted Externally on the Decompression Bell. By having an oxygen system with one or several demand face masks, the diver(s) could comfortably decompress using oxygen. [WARNING: Many potentially dangerous scenarious could be created by attempting this; it should only be attempted by individuals thoroughly educated in this area.]



The Drum 55
Decompression Bell

Surface Air Supply (S.A.S.) Feed to the Decompression Bell. This would eliminate the high cost and effort of the storage air option. A small, low-pressure compressor with filtration would be adequate for the application, although there are not too many locations were the use of S.A.S. would be practical.

Decompression Bell Instrumentation and Gauge Console. A variety of important gauges and instrumentation could be integrated into the system to allow users to monitor life-support information at a glance.

Surface-to-Bell Communication System. A citizens' band radio could be installed inside a waterproof compartment in the bell with insulated coaxial cable running up to a float supporting the antenna. This should give anyone within range the capability to speak with decompressing divers.

Wet Bar and Snack Center. The in-bell compartment would contain all of the divers' favorite fluids and energy-replacement foods.

Diver Entertainment Center. The possibilities are limitless. Most common printable suggestions have been games, reading materials, and music.

In closing, anything that helps the decompressing diver become more comfortable will aid the diver's attitude in completing all, if not considerably more, decompression than required.

HABITATS FOR SATURATION CAVE DIVING

By taking a science which is already well understood and applying it to the realm of cave diving, explorers and scientists could take a quantum leap in studying the underwater world. One commonly shared vision is to have a permanent habitat installed in a cave with near-limitless resources to be explored. After successful testing of the habitat concept was completed, explorers and scientists could "lock out" for extended stays, making study and exploration of a specific cave much more complete and thorough than is possible using our present methods.

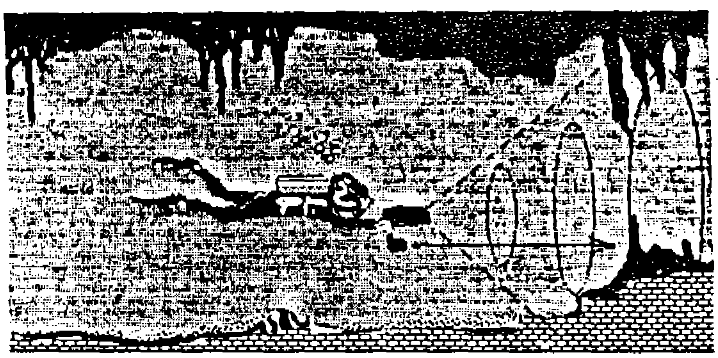
TO PENETRATE ANY ENVIRONMENT

As we continue to explore new realms of the underwater world, we are faced with ever increasing hurdles to overcome. To the adventurer, these types of hurdles are the main motivators for their involvement in the sport. To the researcher, they bar access to the least-known and thus most interesting areas. Cave divers have chosen to work, play, and explore in "ideal" environments, failing to recognize that the greatest potential for future cave-diving exploration lies in the vast category known presently as the "untouchables."

Whether these areas are not explored because they are unreachable or because they are undesirable, the fact is that they do exist. In this section I focus on some future techniques that would allow the explorer to enter environments that may have been considered, in the the past, too hostile or even alien to interest the cave diver. [It was decided to leave "excessive depth" out of this category, since it is still, to date, the most extensive and costly hurdle to overcome.] The following text lists some of the classic "untouchable" zones and discusses potential methods to explore them.

Black-Water Cave Diving--The Use of Sonar and Other Special Gear. Few people will disagree that attempting to swim into, explore, and study a cave without any reasonable visibility is undesirable. Unfortunately, the largest underwater caves in the world remain completely unexplored because they lie in the inky world of tanic-acid water. Several individuals have begun attempting the tedious process of exploring these vast, dark worlds. In making this effort, the need for special instrumentation for navigational assistance and information gathering has been realized.

Initial work is already well underway. Sonar designed specifically for use in underwater caves has already been tested.



"Speleosonics"

LCD reading sonar and compass for use in the exploration and survey of low visibility underwater caves.

The sonar's primary function is to measure the distance from the source to whatever structure it is aimed at. The present maximum accurate read is 200 feet. This sonar is a real marvel. Its accuracy consistently fell within two inches of fiberglass-tape measurement and the sonar measurement was much faster. Passage dimensions can now be accurately obtained and documented in seconds.

Cave sonar is a fine addition to the tools of the cave diver, yet the main application of underwater cave sonar has yet to be discussed. Because of the nature of aggressive black water, most systems that have been entered to date contain enormous phreatic passages. Widths of over 150 feet have been recorded in Gilchrist County, an area with more than its fair share of black-water caves. The sonar's main application therefore could be to identify passage trends. By combining an L.E.D. reading compass with sonar, cave divers will be able to successfully draw pictures of tunnel configuration and direction by panning the instruments and deciphering the collected data. (See Diagram 3.)

Because of the problems associated with communication in black water, advances in the area of communication must be made. The drawbacks of present systems are the mouthpiece requirement and signal reflection because of the cave environment. Hopefully, modifications in design will be made in the near future to permit more effective use.

Extreme High-Flow Environments: Underwater Single-Rope Techniques. There are underwater caves with flow rates so high that there is little to no chance at all that a fully equipped cave diver can penetrate past the entrance. Another extreme-flow condition is that of the Bahama Blue holes. For the most part, major Blue Holes have remained unexplored because of inability to cope with the high flows caused by tidal effects as water is pushed in and then drained out of these dynamic caves.

Our ability to cope with flow is limited now by a lack of the proper equipment to get the job done. Using Single-Rope Techniques underwater could hold the answer to the obstacle of extreme high flow. The use of Underwater Single-Rope Technique might follow this concept:

TO CLIMB IN--Reversing typical SRT, the diver could incorporate either a Jumar or rope-walker system to overcome the pressures of extreme flow. In testing it was found that a diver could overcome 200 pounds of direct pressure exerted on the body. This could be more than adequate force to overcome the flow of any entrance that I am presently aware of.

TO STABILIZE--Among the major concerns voiced about a fast-flowing system is the ability to stay for extended periods of time (decompression) in one place while being exposed to high flows. This concern (which is very real) could be taken care of by using the simple SRT method known as "locking off." This can be accomplished by attaching a Jumar or Gibbs ascender (descender in USRT) to the rope, which in turn is attached to the diver.

TO EXIT--Certainly the most exciting thrill of USRT will be exiting the high-flow environment. This can be accomplished by using the technique known as rappelling. Again, the process is in reverse of the above-water technique but it should still prove effective. The equipment likely to be used will be either a figure 8 or rappel rack with brake bars.

Special concerns in using this technique might be:

1) excessive stresses on the body,

2) gear being ripped off the body

because of the force of the water.

3) the fact that the cave must be entered first without USRT to secure the low-stretch kernmantle rope,

4) the possibility of extreme regulator free-flows during decompression situations, and

5) the requirement for keeping the rope under close control and avoiding potentially dangerous entanglements.

A final note about the future of USRT: it seems likely that some form of flow deflector cone will have to be designed to be threaded onto the rope before entering the high-flow area. By doing this the diver can partially enter the cone, thus avoiding the brunt of the effect generated by the flow.

THE FUTURISTIC CAVE DIVER TODAY

In closing, it is appropriate to spend a moment considering the personality type that makes forward advances in a sport such as cave diving and why that might be relevant to a scientist or researcher. Most cave divers/explorers tend never to be satisfied with the way anything works. With such an attitude, cave divers are endlessly seeking ways to improve. With this comes improved equipment systems, safety margins, and techniques. The areas that I focused on came from my interest in exploration and research. It's up to you to promote any and all new ideas that will make cave diving a better, safer, and more productive activity. If we all work together, promoting excellence from within, we, as a scientific community, will be able to experience and enjoy more of the greatest realm of unexplored territory on Earth.

INTERNATIONAL CAVE DIVING CAMP TO BE HELD IN ITALY

The 7th International Cave Diving Camp, sponsored by the Italian Spelaeological Society Cave Diving Commission and organized by the Corpo Nazionale Soccorso Alpino Sezione Speleologica, is to be held Aug. 29 – Sep. 5 in Cividale del Friuli and Trieste, Italy.

The Camp is intended to be a meeting at which cave divers from various parts of the world can exchange experiences and ideas. During the period of the Camp, technical reports and documentation consisting of photographs and films (prepared by the participants) will be on show. In addition there will explorations of some of the dry caves and underwater caves to be found in Friuli Venezia Giulia, including Karst spring of Grogazzo, which reaches a depth of 90 m., and the waters of Timavo (an underground river).

For copies of the full literature on the Camp, interested parties should contact the Editor, H.V. Grey at POB 575, Venice, FL 34284-0575.

COW SPRINGS MAP AND LITTLE RIVER UPDATE NOW AVAILABLE

Wes Skiles and company have provided the CDS with yet another new, beautifully drafted underwater cave map: Cow Spring. He and his team have also made an updated revision of the Little River Springs cave map showing additional new passageway. Both maps are now available from Map Publications Coordinator Tim Holden through NSS-CDS Publications.

Current available maps:

A.	Green Sink System,	1987 (Exley)
B.	Peacock Springs,	1987 (Exley)
C.	Madison Blue Springs,	1979 (Exley)
D.	Little River, rev.,	1986 (Skiles)
E.	Rock Bluff,	1985 (Skiles)
F.	Blue Hole/Jug,	1985 (Skiles)
G.	Bonnet Spring,	1985 (Skiles)
H.	Cow Spring,	1986 (Skiles)

PRICE	MEMBER	NON-MEMBER
1 per order	7.00ea	8.00ea
2-3 per order	6.00ea	8.00ea
4-5 per order	5.50ea	8.00ea
5+ per order	5.00ea	8.00ea

All maps orders must be accompanied by payment (check or money order made out to "NSS-CDS") and a photo copy of both sides of a Basic Cave or (full) Cave certification card from either the NSS-CDS, NACD, NAUI, or YMCA. Maps are rolled for tube shipment; allow 4-6 week for delivery. Mail orders to:

NSS-CDS Publications
P.O. Box 950
Branford, FL 32008-0950

SCOOTER FATALITY IN MEXICO

Just at press time, there was a late-breaking news report of the first scooter-related cave fatality. None of the participants was cave trained or cave equipped.

The report is that three divers on two scooters ventured into an unspecified cave somewhere in Mexico. The first scooter was operated by a diver towing a 13-year-old boy with "five minutes of scuba instruction." The only lights were the scooter headlights. Apparently the first scooter/divers got too close to a sand bank and silted out that portion of the cave; the second scooter/diver then retreated. Evidently, the riders of the first scooter continued, became lost, and presumably drowned when they ran out of air. There is some concern that there may be serious "repercussions" because the elder of the two lead divers was the son of a Mexican politician (former presidential candidate?). [Is that short enough, Wes?]