DeepTech JOURNAL

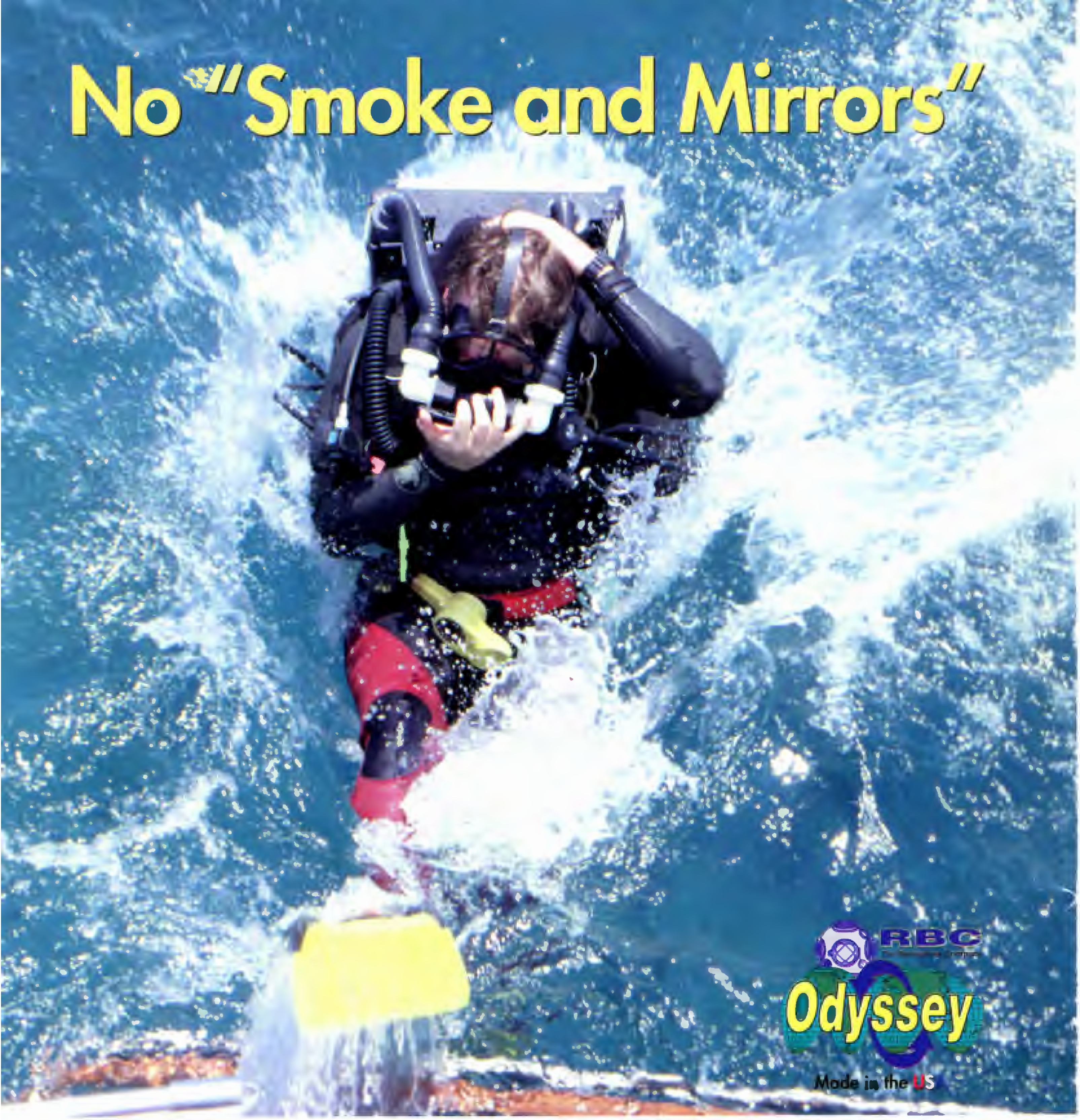
ADVANCED DIVING TECHNIQUES

Issue 2
June 1995

Jim Bowden's

World Record Open Circuit Dive (925 feet/285 m)

The Monitor • Decompression Safety • Women Tech Divers • Karst Hydrology



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DeepTech JOURNAL
ADVANCED DIVING TECHNIQUES

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WARNING:
Diving is a potentially dangerous activity. Neither DeepTech Journal, nor it's contributors accept liability for diving injuries incurred by our readers. The materials contained within this journal are for informational purposes only and are not intended as a substitute for dive training.

Cover photo by Ann Kristovich.

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The Philosophy of Technology

Photo Courtesy Technical Diving Video Library

Like almost everything on this planet, the sport of diving is dramatically influenced by the current state of technology. The question is, does the implementation of new technology always add value, or do the advantages provided by new inventions sometimes come with the price of increased risk?

Lets look at dive computers for example. It's hard to discredit the persuasive arguments presented by the dive shop sales persons when extolling the virtues of these technological wonders. "No square dive profiles, tracks nitrogen absorption, monitors ascent rates, measures offgassing, calculates time to fly, uploads data to your PC," and on and on. Who can resist?

Something that they don't tell you, however, is that the 25% of active divers using these little miracles are responsible for 50% of the DCS hits recorded by D.A.N. Hmmm, now there's a reason to stop and think a moment.

The potential hazards that new technology can bring were made profoundly obvious to me recently while visiting Disney World's Magic Kingdom in Orlando, Florida. They have an excellent attraction in Tomorrowland called the "Carousel of Progress" where the audience is presented with four short performances by audio-animatronics actors (humanoid robots). These actors, by showing us realistic snapshots in time during the last century, clearly demonstrate that technology has a long history of simplifying our lives and simultaneously making them more complicated.

For example, in the last sequence, a modern family is gathered in their home for a holiday celebration. The mother has just finished explaining to the father how to use the new voice activated oven. The father then verbally programs the oven to cook the turkey at 350°F. A few moments later the teenage son, who is playing a virtual reality space blaster game with the grandmother, says, "Hey Dad, grandma just scored 550 points." The dad replies, "Wow, 550 points." The oven, of course, interprets this exclamation as an instruction to increase the temperature to 550°F. The turkey is burned and the meal is ruined but the family laughs it off and closes with a song about progress.

The point of this example is that new technology can improve our lives, but only after we become accustomed to the nuances and applicable operating procedures. Dive computers do, in fact, make good on most of their promises. However, these devices must be used correctly—this means used conservatively. Divers who perform their decompression exactly according to the computer calculations are living on the edge. They are statistical accidents waiting to happen. And D.A.N.'s figures bear this out. Too often, though, I have heard dive computer usage explained as, "Just keep the bar graph under that red zone and you will be OK." Do these people wait until the tachometer needle reaches the red-line before they shift their car?

Extended range diving is not about who can be the most reckless. It is about exploration, excitement and fun. Tech-divers will always be the first to embrace emergent dive technology. But with it comes the responsibility to also embrace emergent philosophy. The trend away from deep-air diving and towards mixed gas diving is a perfect example of divers embracing emergent philosophy. A few short years ago helium was considered an exotic breathing gas used by only the truly insane. Now that the advantages of helium are more widely understood it has become almost commonplace. Lower ppO2s plus reduced narcosis equals reduced risk.

Most tech-divers have passionate feelings about how technical diving should be done. This passion is admirable, but only as long as it doesn't interfere with open-mindedness. Every day more and more dive shops are offering Nitrox and Trimix. Indeed, Nitrox has become almost mainstream. As closed circuit systems and other new technology come on-line lets not forget that we may need new guidelines to go with our new gadgets.

Win Remley

Win Remley
Co-Publisher

DeepTech's Version of Letters to the Editor

What Does That Mean?

Enjoyed the premier issue a great deal. Looking forward to a longer second issue. Just a suggestion, an occasional glossary section may be of use for those of us unfamiliar with a few of the technical terms.

Robert Plant, Ph.D.
PADI Divemaster

[Thanks for the suggestion Robert, see page 43 for a general glossary to the journal. Some articles may also have specific glossaries.]

General Comments

Just wanted to let you know that I thoroughly enjoyed your premier issue. I'm a PADI Instructor and I'm just getting my feet wet with nitrox and deep diving. I don't have to be an advanced cave diver to appreciate your article on *Underwater Surveys*. I also enjoyed your article *The Deep Chill*—welcome to Midwest diving. I'm looking forward to the next issue and especially the article on *Women in Technical Diving*. Great Publication!

Darice K. Szurkowski
PADI Instructor
South Holland Illinois

I just got the Premier issue of DeepTech Journal and guess what? It' full of "information." It is also easy to read. This is great. Congratulations to the initiator of this journal.

Michel Therrien
via the Internet

I like the format. It's certainly easier to read than that "other" magazine, and the graphics are nice enough. The content put me off a little though. Most of the information can be found in a book on a given subject. For example the *Redundancy & Configuration* article was really obvious. Maybe not to an open water diver, but a tech diver should already know this. And if they don't, they should read books, not bite sized magazine articles. And they should take classes and research to learn the material. The same comment applies to the Nitrox article.

The one section I was very happy with was the *News and Information* section. Hearing about events and news like that is very useful. It's new and leading edge. It's not something I'll get from a book. And it will keep me up to date in the field. More stuff like this would be appreciated.

Devon Olsen
via the Internet

I just got the premier issue and I loved it. Great illustrations. The articles on *Redundancy & Configuration* and *Underwater Surveys* were very nice. Please continue reviews of technical dive equipment, it's very interesting. I can't wait till the next issue arrives.

Sigmund Lundgren
Sweden, via the Internet

The Deep Chill

Just thought you might like to know that there was another accomplished diver on the Lake Wausee dive described in your premier issue with Greg Zambeck and I [*The Deep Chill*]. Lenny Beedon accompanied me to the bottom of Lake Wausee.

Mike Zee
Lake Wausee, Wisconsin

Redundancy & Configuration

My congratulations on the premier issue of DeepTech Journal. You have succeeded in supplying solid information about diving while avoiding the temptation to add too much flash (ala aquaCorp).

I found the article about *Redundancy & Configuration* a little anemic though. After describing the standard doubles setup, the next two pages could have been summed up as: (1) add a stage bottle; and (2) add two stage bottles. The space could have been better used by discussing independent doubles, side mounts, regulator second stage configuration/access/control, inverted tanks for valve access etc.

Keep up the good work—I'm looking forward to the next issue.

Daniel R. Fountain
via the Internet

Correction

[In our article titled "The Truth About Nitrox" (premier issue page 17), DeepTech erroneously reported that Luxfer openly stated they have no problem with Nitrox mixtures in their tanks. To clarify we present the following Luxfer official policy as presented in their technical bulletin dated January 1993.]

Luxfer Technical Bulletin, Jan. 1993
Subject: Oxygen in Scuba Cylinders

Warning: Luxfer has been made aware that some scuba divers are having scuba cylinders partially filled with pure oxygen, then having them topped off with air.

This practice should be ceased immediately since catastrophic failure and loss of life or serious injury can result. Scuba cylinders, valves and other components are not specifically cleaned for oxygen use. Also, the lubricants typically used in the industry are generally not compatible with pure oxygen, which could result in ignition, fire and/or rupture.

Oxygen enriched air may be introduced into Luxfer cylinders only if the cylinder is properly cleaned and maintained for oxygen service. Cylinders and components must be maintained as hydrocarbon free with only oxygen and aluminum compatible lubricants utilized.

The Fundamentals of Decompression Safety

by David R. Miner

Whether diving on a shallow reef or deep inside a cave or wreck, dissolved gas (silent bubbles) builds up within body tissues. Consequently, decompression becomes an obligation all divers must deal with on every dive. Every time a diver descends below the surface breathing compressed air, or any mixed gas, the inert constituents in the inspired gas dissolve into solution in the divers body.

A buildup of dissolved gas brings about the possibility and dangers of decompression sickness (DCS). Without proper offgasing, silent bubbles can quickly grow in size causing the onset of DCS. Some of the factors that can contribute to DCS include:

- Age; generally an older person, especially over 40, has a greater risk to DCS.
- Obesity; individuals with a leaner makeup are less disposed to DCS.
- Injuries; injury sites are more prone to bubble formation and DCS.
- Temperature; colder environments can increase the susceptibility to DCS.

The risk of DCS is ever present, but who is responsible for determining the amount of risk each of us must accept? Are the researchers who develop the algorithms and use

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them to develop software and tables responsible for determining risk factors? Do equipment manufacturers determine the risks for divers purchasing their equipment? Who is responsible for determining what risk each of us must accept when venturing into the underwater world? It is a fact that no matter how conservative and careful we are, DCS is a statistical possibility. The following suggestions can help reduce DCS risk and improve decompression safety. Each of us must determine the amount of risk we are willing to accept and then plan our dives around that level of acceptable risk.

Advances in Decompression Safety

In recent years, many technological advances have been made that aid divers in diving conservatively. Divers who stay within no-decompression limits as well as divers who use advanced decompression schedules have benefited from these advancements. The diving market is currently flooded with underwater dive computers. These range from simple digital depth gauges, to high tech programmable computers that support multiple gas mixtures. The use of computers provides a wide range of information, from the simplicity of listening to an ascent rate warning alarm (and complying), to the complexity of conducting required multilevel decompression stops. Dive tables of varying complexity and risk level have also become available. Almost all training organizations have developed their own dive tables and train students to use them conservatively. Decompression software is also available for divers to plan no-decompression dives or high tech multilevel decompression dives. This software allows the diver to enter a safety factor variable, expressed as a percentage, to decrease DCS risk. Additionally, the use of nitrox and oxygen have both been employed to increase no-decompression limits, reduce decompression requirements, and increase the overall safety for a wide variety of dive plans.

A variety of decompression safety aids exist on the market today, but none of them will work without the diver's commitment to safety. Many of the computers and tables used today are being abused and pushed to their limits. Some divers have the perception that, "It says I can ascend, so I must be fine." This blind faith in dive computers is beginning to statistically show up as increased incidence of DCS in divers using this technology.

Divers Alert Network (DAN) reports that about half of the DCS incidents last year happened to divers using computers. Yet only about 25% of all active divers own computers. What does this mean? This means that DCS is a real and present danger and steps to increase safety precautions for dives is extremely important. Each of us must ascertain our own level of acceptable risk and plan dives and decompression around that risk. Never assume your computer or table will prevent DCS. They are merely tools that provide models and averages for planning decompression for the individual, you.

Ascent Rates

Ascent rates have been under controversy ever since the first set of dive tables was developed. Even so, rate of ascent is critical in determining how quickly the body off-gases. Ascending at a prescribed rate is extremely important in the decompression process.

Development of a doppler bubble detector in the 1970s led scientists to perform a scientific study of the Navy Dive Tables. The study revealed that divers had a high incidence of silent bubbles present after surfacing from what was considered a no-decompression dive. Another study revealed that the average ascent rate among recreational divers regularly exceeded the 60 feet per minute (FPM) rate by huge margins (120 to 160 FPM!). A slow ascent rate allows for proper offgasing and thus does not allow dissolved bubbles to expand and come out of solution causing symptoms of DCS.

Practicing slow ascent rates (33 FPM) by either following your computers ascent rate warnings or by following a pre-planned ascent rate when table diving, will help incorporate safety margins in your dive plan and reduce the risk of DCS. Only you have the control when deciding on how fast to return to the surface. Assess the risk and incorporate good judgment when planning your dives.

Safety Stops

In addition to slow ascent rates, safety stops should be incorporated into every dive plan. A safety stop is a delay in a divers ascent before reaching the surface. The delay is not obligated as it would be if the diver were ascending from a decompression dive. This delay allows the body additional time at pressure to offgas the absorbed nitrogen, thus lowering the risk of DCS upon surfacing.

A study at the University of Southern California's Catalina Marine Science Center looked at how safety stops could influence the effects of silent bubbles. Volunteer divers made dives to 100 feet for 25 minutes (the Navy no-decompression limit). The divers divided into three groups with the first group ascending directly to the surface, the second group made a 2 minute stop at 10 feet, and the third group made a 1 minute stop at 20 feet and a 4 minute stop at 10 feet. Figure 1 shows the comparisons of the three. Note the high occurrence of silent bubbles in the no-stop group. The second group showed a reduction of half the amount of silent bubbles, and the third group almost had no evidence of silent bubbles. This evidence proves that safety stops will dramatically reduce the amount of dissolved gas and the risk of DCS.

Safety stops should be conducted at a depth between 10 and 20 feet. This depth range produces the greatest percent change in the volume of air filled spaces (Boyles Law). Therefore, conducting a safety stop within this zone provides the best results for offgasing absorbed nitrogen. Safety stops may not always be necessary, but they can greatly reduce the risk of DCS.

Deepest Dive First

All the major training organization's advocate and train divers to conduct their deepest dive first when planning a day of repetitive diving. We have all heard this throughout our training, but do we practice it?

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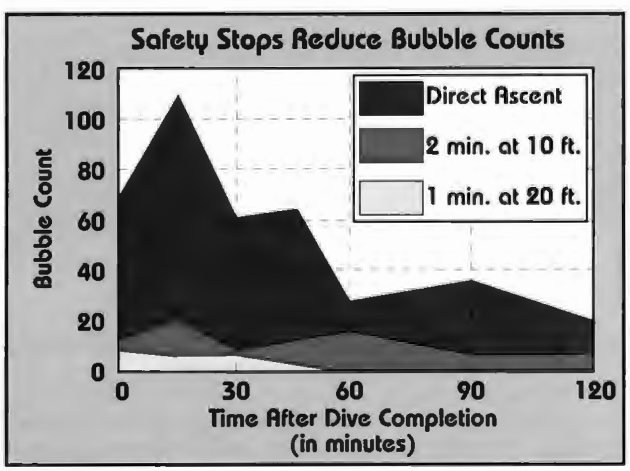


▲Figure 1: Silent bubble formation. Divers performing safety stops in the 10-20 foot range dramatically reduce the formation of silent bubbles, thereby reducing the risk of DCS.

Studies have shown that by conducting the deeper dive first allows the body to absorb less nitrogen on repetitive dives to shallower depths, while doing a deeper second or third dive may send the diver into a decompression schedule and increase the risk of DCS.

Nitrox

Nitrox is any combination of nitrogen and oxygen. Nitrox with a higher percentage of O2 is considered Enriched Air Nitrox (EAN). Much controversy has surrounded this gas for its safety and validity in the sport diving community, however, nitrox is now beginning to receive widespread recognition for its safety and practical use. The technical diving community has been using many variations of nitrox for years with great results.

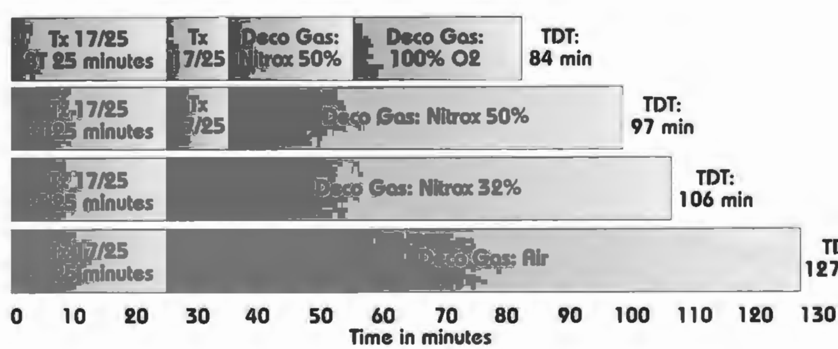
By using nitrox with an increased percentage of O2, you can increase your no-decompression limits and reduce decompression requirements. Higher concentrations of O2 will reduce the amount of nitrogen buildup in the body and thus help reduce the risk of DCS. This occurs due to the reduced partial pressure of nitrogen at the alveolar level. Nitrox can be used as the primary breathing medium as well as a decompression gas. By using a variety of nitrox mixtures during multilevel decompression stops, divers can drastically reduce decompression requirements by flushing out nitrogen at a faster rate. This helps reduce the amount of silent bubbles and thus reduce the risks of DCS, (see Figure 2).

Using nitrox has the potential to be dangerous if not used properly. Divers should seek proper training before using this gas. For more information on nitrox and nitrox training, contact IANTD, TDI, ANDI, or any of the other dive training associations. These organizations offer proper training to safely use nitrox in all diving applications.

Oxygen

During the past few years, oxygen use for decompression has become a frequently discussed topic. Although there are many aspects to consider when using oxygen for decompression, it is becoming more widely accepted throughout the diving community.

Breathing pure oxygen deeper than 20 feet is dangerous due to oxygen toxicity, but at 20 feet and shallower,



▲ **Figure 2: Decompression Gas Profile Comparisons. By reducing the percentage of inert gasses in the decompression breathing mixtures, decompression times can be significantly reduced. However, this practice increases the partial pressure of oxygen as well as the risk for oxygen toxicity. Partial pressures of oxygen in the range of 1.2-1.6 ATA are considered appropriate by most divers, however, some divers advocate even lower ppO2s. Factors such as physical activity and water temperature may also affect oxygen toxicity.**

it can offer some beneficial results. Oxygen, the princess of gasses, is the gas we can use to rid the body of silent bubbles (nitrogen buildup). Increasing the level of O2 in the breathing medium increases the rate of removal of nitrogen from the body tissues. By breathing pure oxygen, we introduce absolutely no nitrogen and thus this allows for the greatest possible rate of removal. By offgasing more nitrogen at depth, you lessen the likelihood of silent bubble expansion and the chances of DCS. When introducing pure oxygen into a dive plan for decompression, you decrease decompression requirements and reduce the risk of DCS. See Figure 2.

There are many requirements that must be observed and practiced when handling and using pure oxygen. Divers should seek proper training before introducing pure oxygen into your dive plan. For more information on oxygen and oxygen training, contact any of the technical dive associations.

Additionally, there are a number of other proven practices that all divers can implement in dive plans to help reduce the risks to DCS. These are:

- Maintain proper hydration. Be sure to drink lots of liquids before every dive.
- Avoid the use of alcohol before, during, or immediately after a dive.
- Avoid excessive exercise before, during decompression, or directly after a dive. This can agitate the dissolved bubbles causing them to come out of solution. (Like shaking up a soda)
- Maintain proper body warmth, especially during long decompressions.
- Decompression sickness exists and we all must face that fact, but by implementing some very simple practices, we can all reduce the risks of DCS. These practices will not eliminate the possibility of someday getting DCS, but they will help you determine your acceptable risk and plan dives around that risk.

Divers who implement some or all of these safety practices are still not guaranteed avoidance of DCS. As John Crea, of Submariner Research, says, "the only way a diver can guarantee that he will not get DCS is to not ascend." However, divers who implement these safety practices will significantly reduce their risk.

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THE FUTURE IS HERE

COCHRAN'S TECHNO MASK GIVES DIVERS A HEADS-UP DISPLAY

by Win Remley

Cave and technical divers attending the recent National Speleological Society Cave Diving Section Workshop in Branford, Florida in May, were treated to a glimpse into the future by Cochran Undersea Technology. Pablo Perez, scuba products manager for the Texas-based dive instrument manufacturer, formally announced a heads-up display mask, tentatively named Spectacle, much like the heads-up displays now used in military aircraft.

The Spectacle is a futuristic mask that projects a virtual image of the Nemesis computer data into the

The Spectacle mask receives data transmitted by any of the Nemesis computers. The wrist mounted receivers can be worn with the Spectacle, thereby providing divers with redundancy.

Spectacle is a futuristic mask that projects a virtual image of the Nemesis computer data into the divers field of vision. From the divers perspective, it appears that the ghost-like image is suspended in the water in the lower right hand side of the divers field of vision.

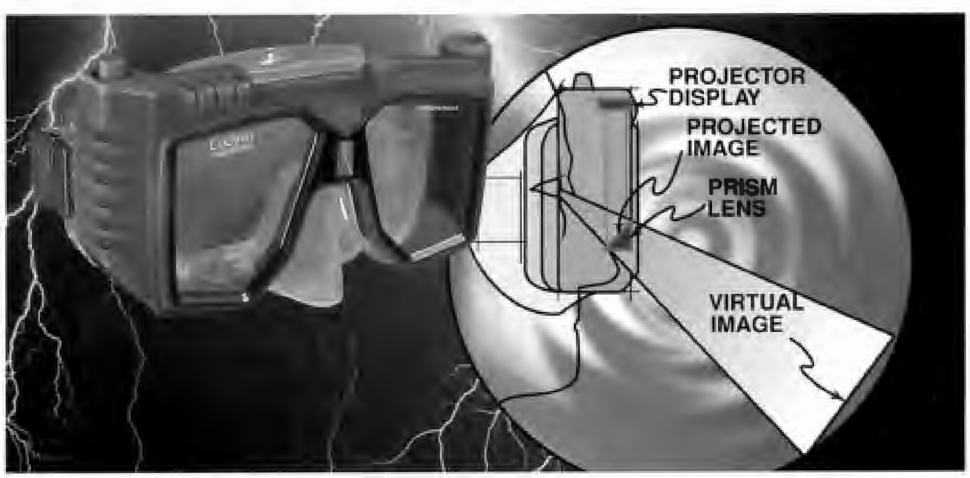
diver's field of vision. From the diver's perspective, it appears that the ghostlike image is suspended in the water in the lower right hand side of the divers field of vision. Due to its location, the image does not obstruct the diver's normal view when looking straight ahead.

The announcement stirred up a great deal of excitement among the divers present at the workshop, and was greeted with a robust round of applause. The lightweight, low-displacement mask looks much like a conventional two-lens dive mask. Closer inspection reveals a slightly enlarged lens frame housing a miniature electronics package and a small, mirrored prism lens at the bottom of the right-side face plate. This lens intercepts an image projected from a small solid-state liquid crystal display projector and converts it to a "virtual image" of the Nemesis display about eighteen inches in front of the diver. The format of the Spectacle display is identical to that of the Nemesis wrist mounted display, thereby making transition simple for current owners of a Nemesis computer. The unit automatically controls display brightness based on ambient lighting conditions, which makes it suitable for use both in daylight and at night. The virtual image is seen only by the diver wearing the mask.

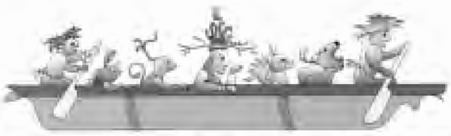
The Spectacle mask acts as a receiver and display for computer data transmitted by any of the Nemesis transmitters. These computer/transmitters are highly advanced in their own right. Unlike the other hoseless computers currently on the market, the Nemesis units use magnetic induction to transmit the signals from the computer to the receiver, once per second. The magnetic induction transmitters were developed by Cochran while under subcontract to NASA. Cochran developed scuba instrumentation to work with the astronauts in the pools simulating zero-G environments. The magnetic induction transmitters and receivers are not subject to the transmission/interference constraints common to radio and infra-red transmitters.

The Spectacle mask is compatible with the Nemesis, Nemesis II, and Nemesis II Nitrox transmitters. The wrist mounted receivers can be worn simultaneous with the Spectacle, thereby providing divers with redundancy.

Pablo Perez was quick to point out that the Spectacle is a design prototype at this stage and is not yet available for sale. He would not comment on the availability of the Spectacle other than to say "sometime next year." Final pricing has not yet been set, but Perez said it will be under $500. The Spectacle mask will be sold separately so divers can buy a Nemesis II now and add the Spectacle later when it becomes available.

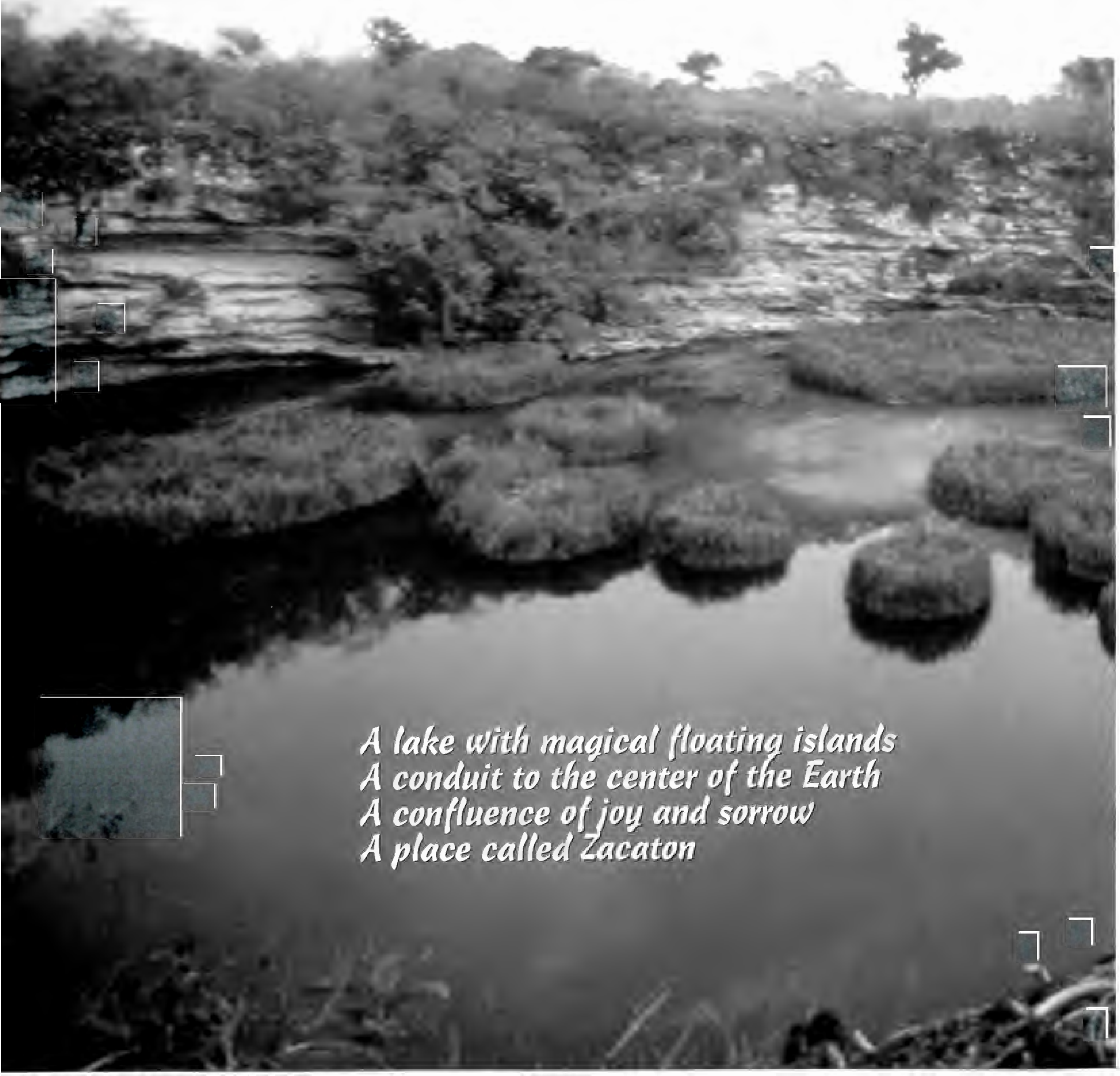


The lightweight, low volume Spectacle has a slightly enlarged lens frame, which houses a miniature electronics package and a small, mirrored prism lens at the bottom of the right-side



ZACATON

Jim Bowden's World Record Dive



A lake with magical floating islands
A conduit to the center of the Earth
A confluence of joy and sorrow
A place called Zacaton

With Respect

Jim Bowden's record setting dive into Zacaton has unfortunately been overshadowed by the death of Sheck Exley, Jim's friend and team member. Jim's record setting dive occurred at the same time as Sheck's fatal dive into this same cave. DeepTech Journal acknowledges the human achievement made by Jim Bowden and simultaneously acknowledges the tragedy of Sheck Exley's untimely passing.

by Win Remley

Zacaton, a sink hole located deep in the jungles of Mexico (pictured on the previous page), is over 300 feet across, and over a thousand feet deep. The surface lies at the bottom of a 70 foot sheer cliff encircling the entire hole. The floating islands of hydroponic vegetation drift lazily by in a surrealistic setting from a science fiction novel. This is the site of Jim Bowden's world record open circuit dive.

Prior to his record setting 925 foot dive into Zacaton, if you mentioned the name of Jim Bowden to a group of cave divers, they would likely say "Isn't he that sump diver from Mexico?" Jim Bowden is, in fact, a full time cave explorer. He spends seven months of each year exploring caves and studying the geological structures so well hidden from mankind through inaccessibility. The remainder of the year he spends giving speeches and planning for future adventures. Virtually all of his time is spent in support of this activity.

Contrary to what many people think, Jim's purpose in diving Zacaton was not to set a depth record. He had merely located a profoundly interesting cave system that happened to be very large and very deep. He simply wanted to explore it.

Few people have any concept of what is required to prepare for a dive of this magnitude. Jim had to cut his ties with almost everyone in his life who was close to him except for his exploration partner Dr. Ann Kristovich and a small band of team members. The personal sacrifice required to live this life-style is beyond that which most of us are willing to endure.

The guru divers selected by DeepTech Journal are divers who have spent countless hours broadening their own diving abilities, and contributing to the sport of diving as a whole. Jim Bowden's dedication and lifetime accomplishments have proven him to be a guru diver *par excellence*.

Jim Bowden, Background and History

It's difficult for some to understand the motivations behind extreme life-styles like Jim Bowden's. The desire for adventure, adrenaline flow, excitement, new discoveries, and the feeling of accomplishment, are certainly elements of this drive. The physical sensation of using advanced dive technology to go where no modern human has been before is hard to describe. There are few thrills as exciting as a deep push into a sump system and discovering human relics and cave paintings from another era. These experiences have long since become commonplace to Jim's exploration team.

Jim's chief exploration partner is Dr. Ann Kristovich. She, more than anyone, understands what drives him to excel. Dr. Kristovich wrote, "Jim is an explorer full time. He is firmly committed to the underground world. A day does not pass, no matter where he is,

▲ Regulators–ScubaPro Mark 15 1st stages with D400 second stages; Double's–OMS 121's; Stage tanks–Aluminum 80s; Wings–OMS dual bladder; Main Light–Custom Ralph Hood; Backup Lights–Pelican Saber; Sponsors–Scuba Pro, Dive Com, and Uwatec

without Jim examining some aspect of a project, a piece of equipment, a training technique, etc." Dr. Kristovich has accompanied Jim on his explorations for several years.

Jim trained daily for his record deep dive, by setting his tanks on a bench in his living room so that during his frequently sleepless nights he could sit in his rig, close his eyes, and handle his regulators, breath on them, feel their positions, memorize there rela-tionships, over and over again.

Jim has a reputation for being volatile. His methodical, high energy style, combined with his emotional desire excites and focuses his energies so that every detail is examined and challenged. Every aspect of his record setting dive was thoroughly examined, evaluated, and tested.

Jim acknowledges that he cannot be on the cutting edge of exploration if the responsibilities of a job and a family exist. Jim requires the flexibility and freedom to depart at any time or opportunities may be lost. "That which dictates our distractions may cloud the waters and render the opportunity impossible, unattainable, or lost forever. Time and nature wait on no one." Dr Kristovich remarked.

Jim began dry caving in a park in San Antonio, Texas when he was only seven years old. At that time, he wanted to be two things: a cave explorer, and a Mexican. He certainly succeeded in becoming a cave explorer. As for becoming Mexican, Jim has deeply embraced the people, culture, and country of Mexico. The slide show Jim presented at the NSS-CDS annual workshop in May clearly demonstrates his love for the Mexican people and their culture. His slides revealed breathtaking views of Mexican moutainscapes, rivers, waterfalls, cave entrances, and the local people.

Jim received his open water certification from NAUI many years ago and advanced through the levels to Instructor. Steve Gerrard trained him in cave diving, and the late Sheck Exley was his technical instructor, as well as a close friend and dive companion. Jim became interested in technical diving when the systems he was exploring pushed past the safety limits of air. Jim states his motive for technical diving clearly: "Technical diving in the form of mixed gas and such is merely a tool to get the job done

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and not an end in itself. I have used this tool just as I have used technical climbing aids to accomplish other caving goals."

Jim has been involved in many projects over the past 15 years from Honey Creek Cave in Texas, Rochelles Cave, Rio Santa Clara, El Sotano de las Calenturas, Rio Huichihuayan, and Zacaton, among others. After dry caving for many years, Jim began diving as a tool to explore past the flooded regions of caves (sumps). All of Jim's early explorations were solo, and to this day, he prefers either solitary work or work with very small teams. He disdains sherpas, preferring to bear the full burden of transporting his own equipment to the distant and often logistically difficult dive sites.

During the work in the upstream section of the inland Blue Hole in Belize, Jim had to stash his gear underwater in the cave to protect it from theft. He then ventured alone through the flooded passages. He is credited with completing the difficult connection between St. Hermann's Cave and Petroglyph Cave. Then, by adding the downstream Blue Hole connection to the Boiling Hole, he was finally able to establish this system as the longest continuous passage in Belize.

▲ Bowden's 20ft and 10ft stops on oxygen were completed with an AGA full face mask.

Jim's exploration teams are typically small. Few explorers possess his level of passion and energy. Few can sustain the effort needed day to day and week to week, to persist and succeed under arduous conditions. Jim is a generous leader regarding credit and recognition. A particular team effort in Honey Creek cave in Texas, for example, required more than eight hours, one way, to haul gear through mud and narrow restrictions to a distant sump. In the terminal passage, CO_2 was high, and the teams gasped in rapid breaths. Astonishingly, after all that effort, Jim gave the final dive and credit for the connection to one of his students.

Zacaton

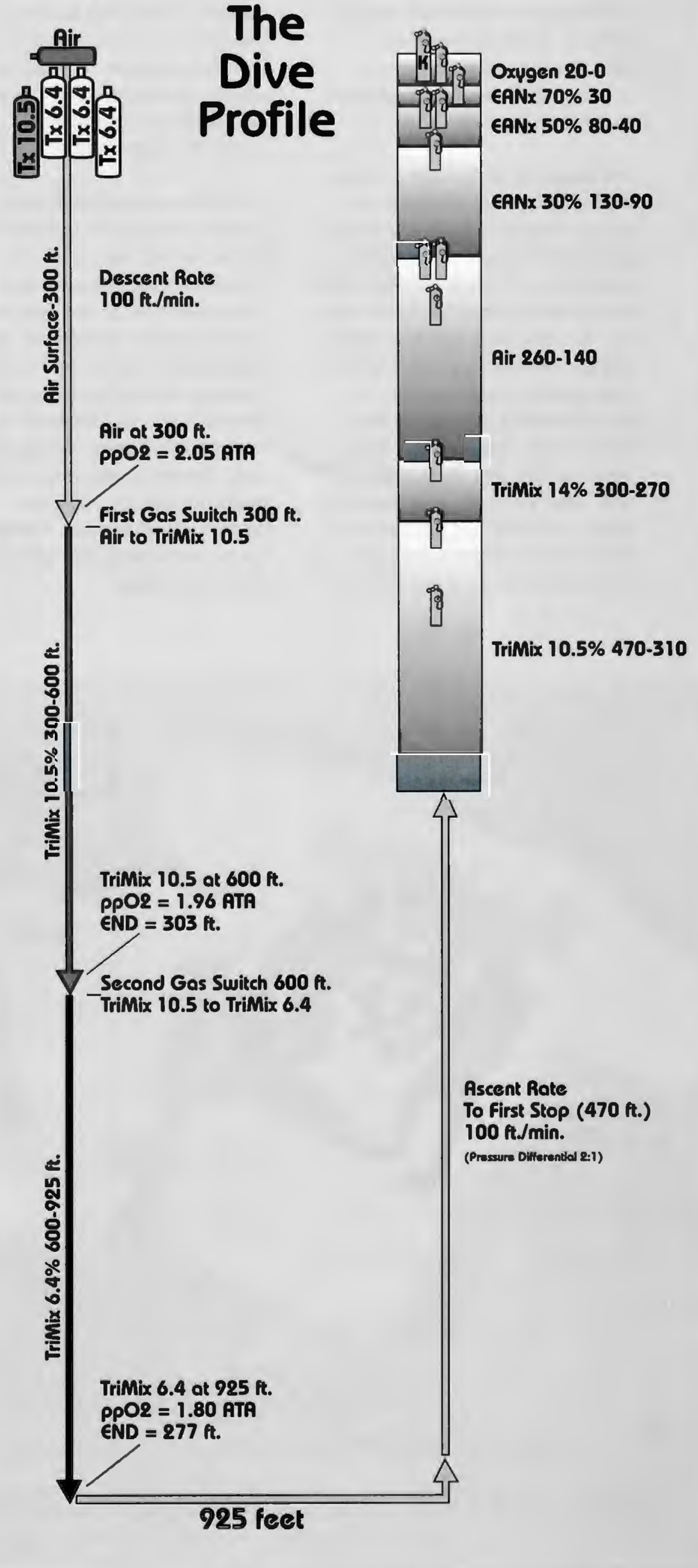
In December of 1993, Jim dove to 825 feet in Zacaton, Mexico. This was his third dive below 500 feet in eight months. He unfortunately surfaced with a type II DCS hit.

Dr. Kristovich managed the DCS on site with a controversial treatment technique using intravenous steroids and in-water recompression. This technique is said to have been first used by the French with some success. Jim's pain persisted for several days but he remained happy and jubilant about the dive. Except for the DCS, his dive had gone perfectly, and he knew he could make 1,000 feet with some adjustments to his ascent profile.

On the morning of April 6th, 1994 Jim prepared for his attempt for the bottom of Zacaton. The wind was howling that morning, which was characteristic of the unusually wet rainy season they had just experienced. Prior to the dive, Jim asked to hear his song, a favorite from the movie sound track to *Wild Orchid.* It's a song about a card game with the devil. "A man must be accountable for his action and mistakes, a man can express his passion, a man can stare at death and the devil and live, even if he dies." Jim had prepared completely for this dive, and nothing had been left to chance. All of the staged gear he would need had carefully been attached to his ascent line and lowered into place.

Jim entered the water feeling excited and emotionally "up". He began the dive by relaxing on the surface, meditating, and slowing his respiration down to the four breaths per minute rate required by his dive plan. He developed this ability over years of self-discipline and practice. While meditating, Jim reviews his dive plan in his minds eye. He visualizes himself making the descent, switching from one gas to another at the required depth. He sees himself reaching his goal of seeing the bottom and then beginning his long ascent back to the surface. This self guided imagery is

(continued page 16)



a technique he and Sheck began using on some of their more difficult explorations together. Jim says the meditation helps him to be more focused.

Jim began his dive wearing double OMS-121 tanks on his back, two aluminum 80s, one clipped under each arm in a cave configuration, and a 13 cu. ft. pony banded to the top of the doubles. The 121s plus one 80 were filled with his bottom gas and other 80 was filled with an intermediate travel mixture. The pony was filled with air and was used for the initial descent to a depth of 300 feet. Amazingly, he only used 12 cu. ft. of air from the pony, just as he had planned. At 300 feet he made the first gas switch to trimix 10.5 (10.5%-O_2, 42%-N_2, 47.5%-He) located under one arm. He continued his descent to 600 feet where he made the second gas switch to his bottom gas, trimix 6.4 (6.4%-O_2, 25.6%-N_2, 68%-He).

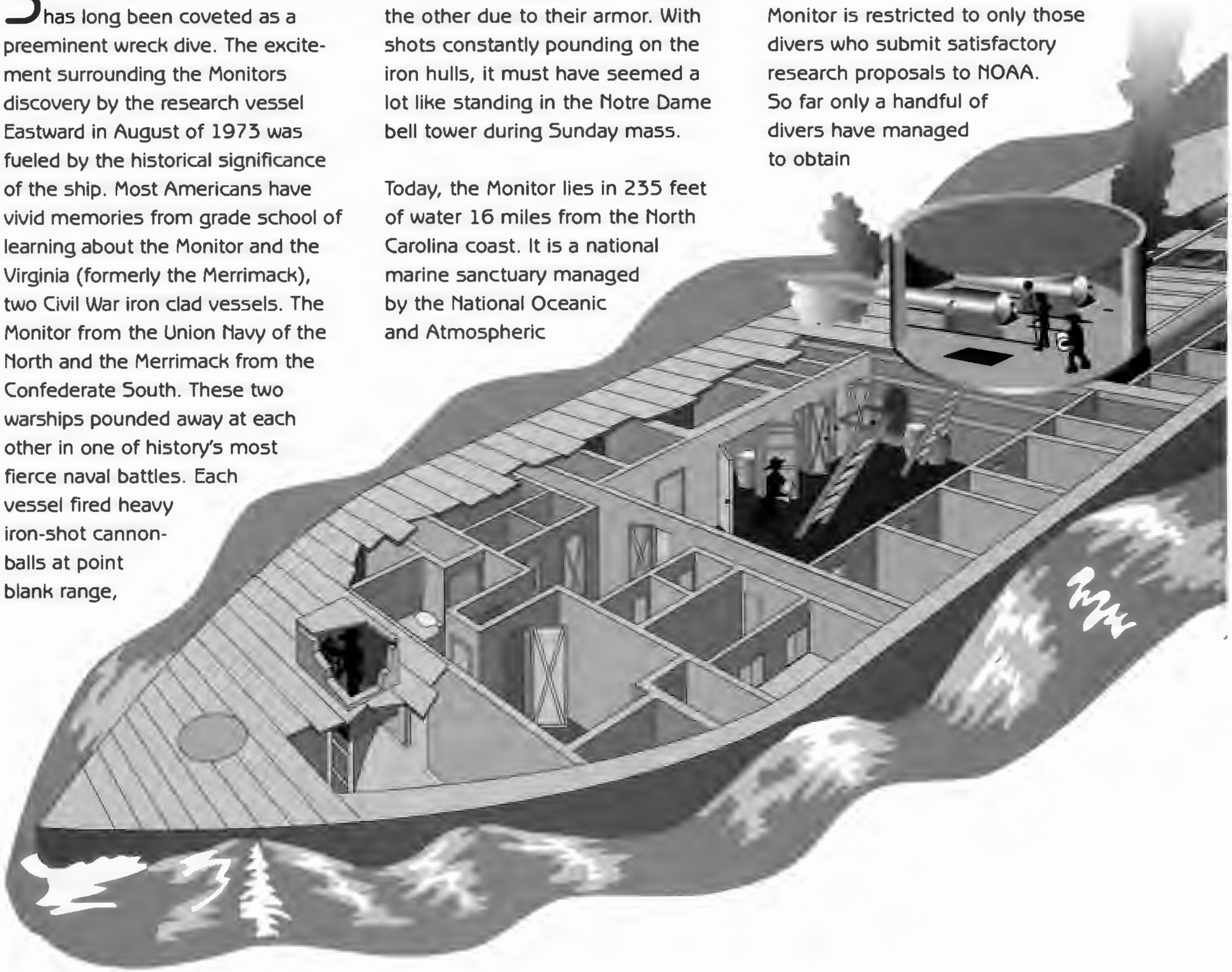
Jim continued his 100 ft./min. descent rate until he grabbed the line at the 925 foot mark. He checked his gas reserves and discovered that he had used more gas than he had anticipated. When asked how he felt at this record breaking moment he modestly replied, "I was embarrassed at having sucked down my gas too fast." He was disappointed that he would not see the bottom of Zacaton (1080 feet) on this dive, but he is confident that he can make it someday.

Jim remained at 925 for only a few moments before beginning his ascent. He quickly ascended (100 ft./min.) to his first decompression stop and stage tank waiting at 470 ft. Jim continued with his 540 total minutes of decompression inching upwards 10 feet at a time in progressively longer stops. A total of 12 aluminum 80 cylinders were staged with various mixtures for decompression. After reaching the surface Jim continued to breathe pure oxygen for about 30 minutes in a "surface stop" to facilitate further offgassing prior to exiting the water.

His greater than expected gas consumption notwithstanding, Jim said the dive had gone "very well" and he felt physically "good" while at the 925 mark. He is planning his next expedition to Zacaton in the Spring of 1996.

THE MONITOR

by Win Remley and Curt Bowen

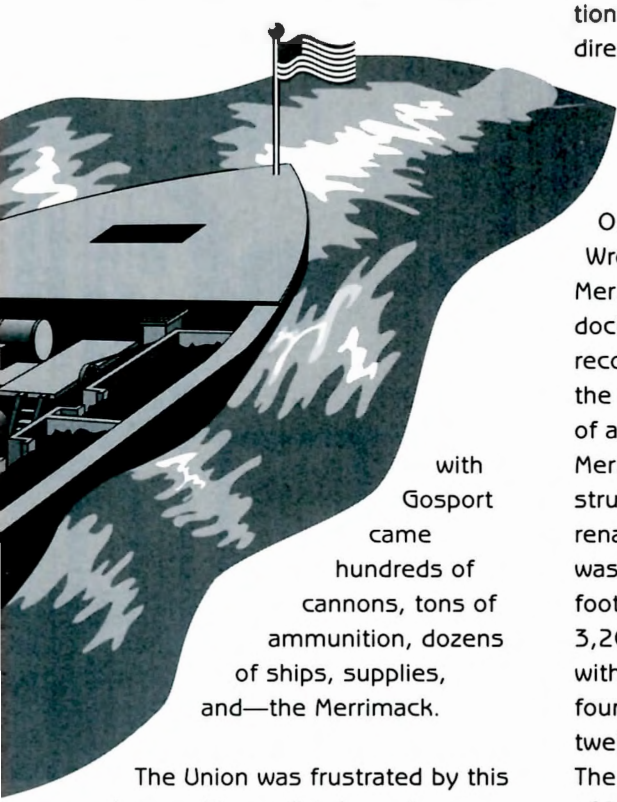


Since its discovery, the Monitor has long been coveted as a preeminent wreck dive. The excitement surrounding the Monitors discovery by the research vessel Eastward in August of 1973 was fueled by the historical significance of the ship. Most Americans have vivid memories from grade school of learning about the Monitor and the Virginia (formerly the Merrimack), two Civil War iron clad vessels. The Monitor from the Union Navy of the North and the Merrimack from the Confederate South. These two warships pounded away at each other in one of history's most fierce naval battles. Each vessel fired heavy iron-shot cannon-balls at point blank range, but neither ship was able to sink the other due to their armor. With shots constantly pounding on the iron hulls, it must have seemed a lot like standing in the Notre Dame bell tower during Sunday mass.

Today, the Monitor lies in 235 feet of water 16 miles from the North Carolina coast. It is a national marine sanctuary managed by the National Oceanic and Atmospheric Administration (NOAA). Diving the Monitor is restricted to only those divers who submit satisfactory research proposals to NOAA. So far only a handful of divers have managed to obtain permits to dive this historical wreck. Surveying and photo documentation have been the stated mission on all permits to date. The rest of us can only examine the excellent photography taken of the monitor and dream a little.

History of the Merrimack

On December 20th, 1860 South Carolina seceded from the union, which was quickly followed by six other southern states. On April 17th, 1861 Virginia also seceded taking with it the Gosport Navy Yard, described as "the greatest navel station, ship and ordnance yard in the United States." Along



with Gosport came hundreds of cannons, tons of ammunition, dozens of ships, supplies, and—the Merrimack.

The Union was frustrated by this loss and immediately sent an infantry regiment under the command of Captain Hiram Paulding to take all he could from Gosport and destroy all that was left. The Confederates feared such an invasion, so they scuttled and sank the Merrimack to prevent Paulding's troops from recovering the ship. After the smoke cleared and Paulding's regiment had retreated back to the North, the Confederates marched back into Gosport and found many of the buildings, supplies, weapons, and small ships unscathed or reparable. Paulding's infantry hadn't fully accomplished their mission.

Virtually all warships of this era, including the Merrimack, were constructed of wood. These wooden ships were no match for the heavy cannonballs launched during battle. One hit near the waterline could quickly sink even the mightiest of ships. In an attempt to gain an advantage over the Union, the Confederate Secretary of the Navy, Stephen Mallory, ordered the design and construction of an iron armored ship. This directive triggered Lieutenant George Brooke to envision the rebirth of the Merrimack into an Iron Clad.

On May 30th, 1861 the Baker Wrecking Company raised the Merrimack and moved her to a dry dock. Work began immediately, reconstructing almost all parts of the Merrimack. After nine months of around-the-clock work, the Merrimack was completely reconstructed with a shell of iron and renamed the Virginia. The Virginia was 275 feet in length, had a 38.5 foot beam and a gross weight of 3,200 tons. The Virginia was clad with one inch of iron on the hull, four inches on the casemate, and twelve inches on the pilothouse. The Virginia's armament consisted of two 7 inch rifles, two 6 inch rifles, and six 9 inch Dahlgren cannons. The Virginia, with the added weight of the iron and a full complement of 300 crewmen, rode low in the water with a 20 foot draft.

History of the Monitor

With the continued reports of the confederate iron clad, which was rumored to be able to destroy the entire Union fleet, the Union responded with it's own defense. After a typical bureaucratic delay and several proposals, the design by John Ericsson, a Civil War ship designer, was drafted. Ericsson began working on the Monitor immediately. A special building was built to house the iron clad so work could continue around the clock and in all types of weather.

The hull was constructed from 1/2 inch thick iron. It was reinforced by floor timbers 15 inches thick, placed in 3 foot intervals. The main deck was built flat, 172 feet long, with a 42 foot beam. The deck was constructed of 1 inch thick iron plates supported by seven inch thick white oak trusses. To protect the hull, an iron belt was constructed around the circumference of the ship. The belt was built from four iron layers each one inch thick plus 26 inches of solid white oak. The deck was constructed with several access hatches for various purposes including human access, coal chutes, venting, etc. On top of the deck amidships was the gun turret, 21-1/2 feet in diameter, 9 feet tall, 8 inches thick, and weighing 120 tons. It rotated on an iron axle 9 inches in diameter and was supported by a series of steel rollers. Twin 11 inch Dahlgren smoothbore cannons capable of firing a 166 pound cannonball were built into the turret. All powder, shot, grape, canisters, equipment, and crew had to be passed through a hole located on the bottom of the turret. The turret had to be rotated to a specific location to gain access. Construction of the Monitor was completed in just 120 days from beginning to end. It was launched on January 30, 1862.

The Virginia Wreaks Havoc on Union Ships

At 11:00 am on March 8, 1862 Captain Franklin Buchanan of the Virginia climbed into the pilot house

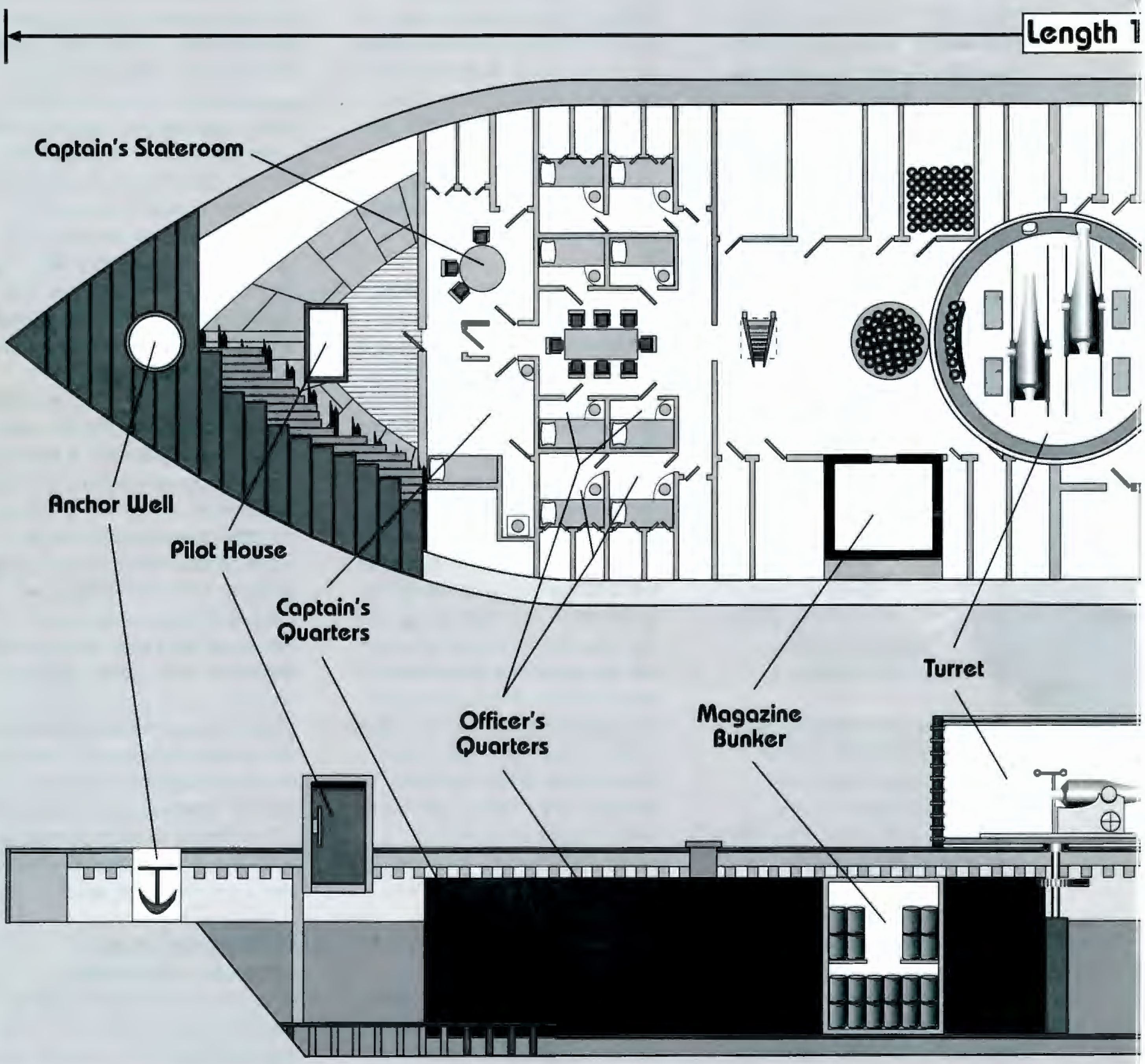
(continued page 22)

The U.S.S. Monitor—A Design by John Ericsson

With the Merrimack refitted and renamed the Virginia, the Confederate threat became critical. The Virginia was rumored to be able to destroy the entire Union fleet. The Union responded with it's own iron clad. After a short bureaucratic delay the design by John Ericsson was eventually drafted. The construction on the Monitor was completed in only 120 days from beginning to end.

Physical Dimensions

Length:	172 feet
Beam:	42 feet
Draft:	12 feet
Weight:	1036 tons
Turret Diameter	21.5 feet
Turret Height	9 feet



Iron Armor Thickness

Entire Hull: .... 1/2 inch
Decking: .... 1 inch
Circumference Belt: .. 4 inches
Turret Wall .... 8 inches
Pilot House .... 6 inches

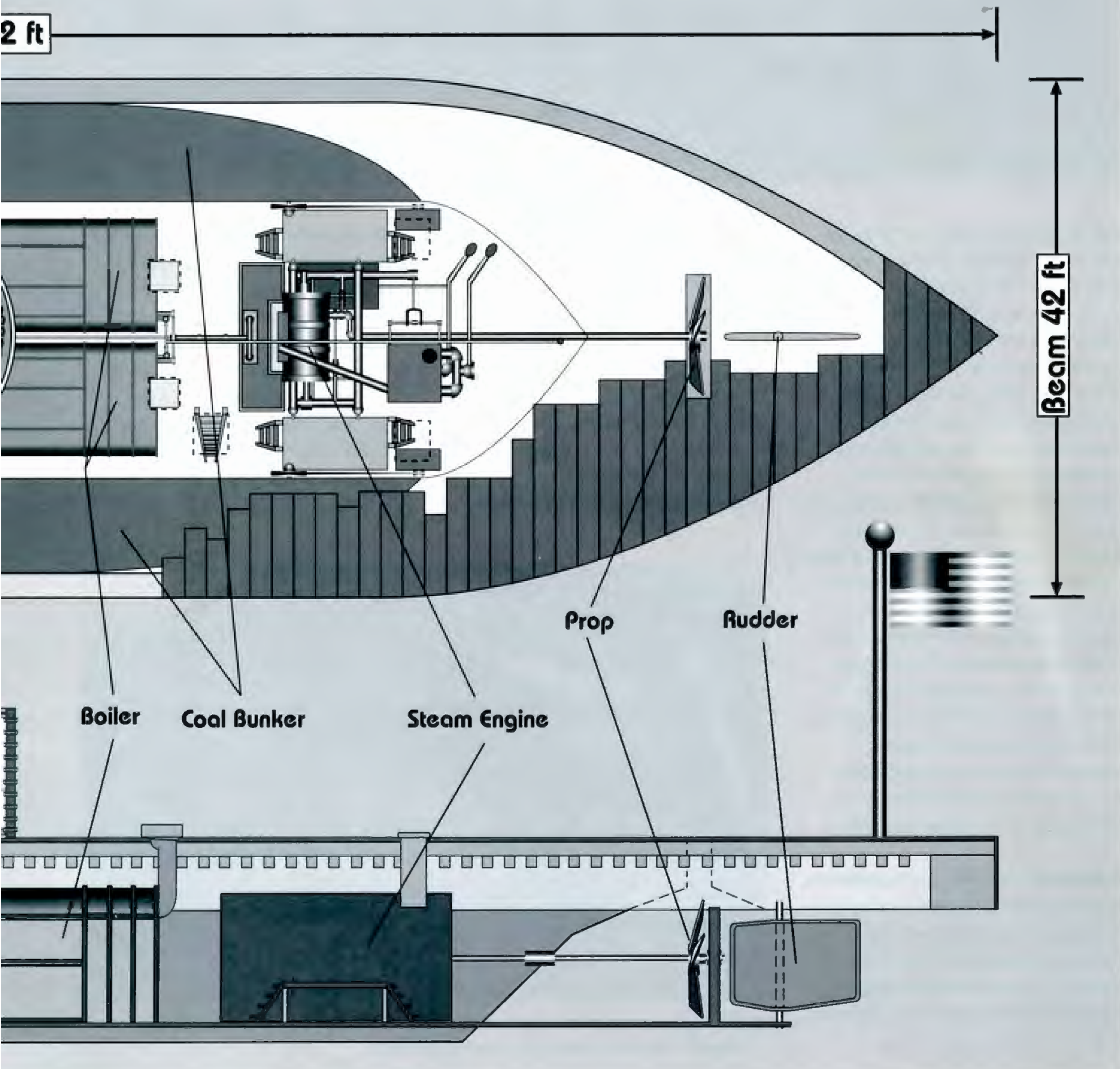
Armaments

Two 11-inch Dahlgren cannons mounted in the turret. They fired lead shots weighing 166 pounds each.

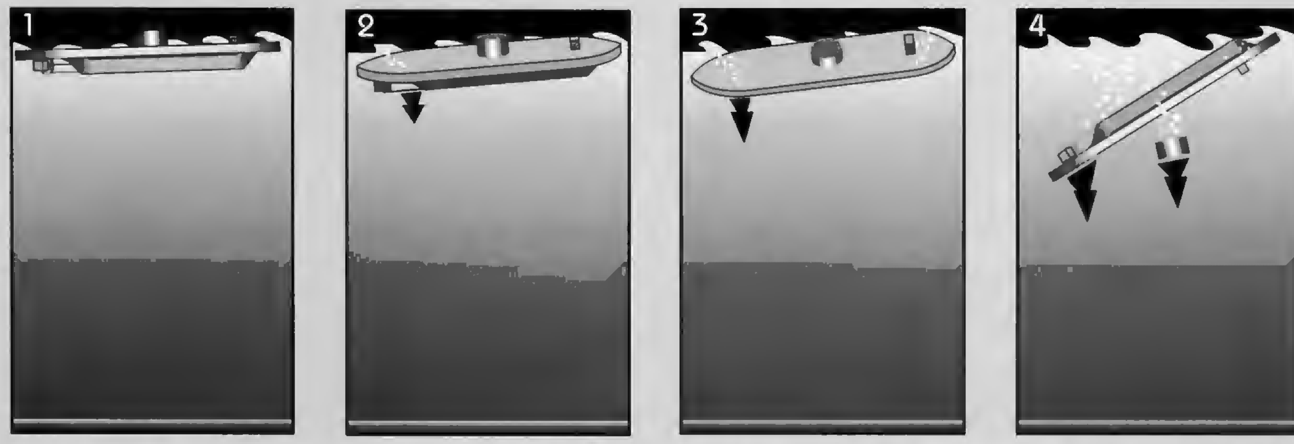
Crew Complement

60 crewmen including the Captain and officers.

16 crewmen perished when the Monitor sank.



The Mechanics of the Sinking—A Theory



1. Due to its design the Monitor was generally unstable in rough seas. Water leaking in through the access hatches was a frequent problem.

2. Survivors reported the boiler room in the aft portion of the ship began taking on water rapidly, causing the stern to ride lower in the water.

3. When the stern dipped below the surface, water quickly filled the compartments in the rear half of the ship. The Monitor began to sink.

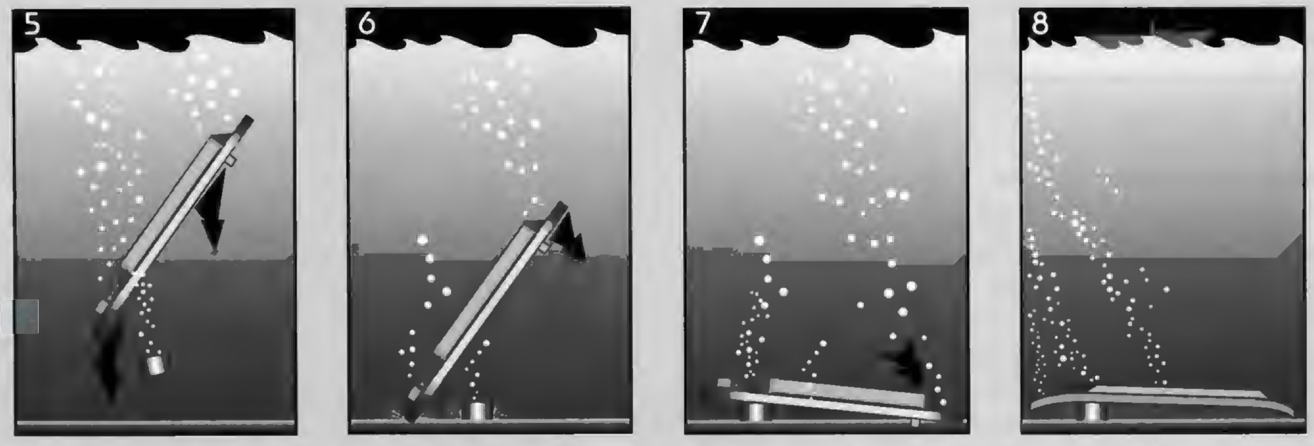
4. As the Monitor's bow was finally pulled under, it must have rolled over since the gun turret apparently fell off during the descent.

and for the first time, the Virginia was under her own power. Never before had the Virginia been tested for performance in handling and fire power. The Virginia slipped down the Elizabeth river for the first time. At about 12:40 pm, the Virginia came upon the Mount Vernon, a Union ship, that was anchored in shallow water for repairs. Upon seeing the long awaited Virginia, the Mount Vernon began firing in the Virginia's direction. The Virginia was unable to reach the Mount Vernon due to the shallow water. The Virginia required more than 20 feet of water to navigate. The Virginia turned to the west and entered the south channel of Hampton Roads. Anchored just ahead awaited several Union war ships including the Congress and the Cumberland, the largest of the Union vessels.

In order to reach the Cumberland the Virginia had to cross the path of the Congress. As she passed, they exchanged direct fire. The shots from the Congress did no damage to the Virginia's iron shell as it steamed by. Suddenly the air became filled with smoke and thunderous cannon fire. The Virginia found herself in her first real battle. The Congress, Cumberland, several smaller gunboats, and shore batteries all concentrated their weapons on the Virginia simultaneously. The Virginia steamed at full speed directly towards the Cumberland and rammed the starboard bow. The Cumberland's wooden frame was no match for the Virginia's iron plated hull. Cannon fire from the Virginia continued even at point blank range. Upon pulling free, the Cumberland began sinking quickly. Repositioning, the Virginia rammed the Cumberland again and pounded the remaining hull with intense cannon fire. The Cumberland was destroyed.

Rod Farb

▲ **The Monitor's turret, it's most distinguishing feature, lies trapped upside down beneath the stern of the ship, also upside down.**



Since the turret was found beneath the stem, it probably fell slightly faster than the rest of the ship. The turret landed first upside down.

The rest of the ship was probably not far behind due to the final proximity of the pieces. As the stern dug into the silt, the bow simply fell over.

The ship landed directly on top of the turret. There may have been some small air spaces left in the some of the bow compartments.

Laying in 235 feet of water it is not likely that any crewmen survived to the bottom. The ambient pressure is over eight atmospheres absolute.

The Virginia now turned and headed back up the river to gain enough room to turn back on the Congress. The Captain of the Congress tried to escape destruction by running aground in shallow water. For over an hour, the Virginia raked the Congress with shot after shot from deeper water until the Congress was also destroyed. Having demonstrated its ability to decimate the Union fleet, the Virginia turned for home port.

The Monitor vs. the Virginia

While the Virginia headed for port, the Monitor was steaming its way through rough sea's towards Hampton Roads. At 10:00 am the next morning, the Monitor pulled along side the Minnesota, another Union ship that had run aground for safety. In the distance, the Congress lit up the sky as she continued to burn. With the Minnesota grounded, the Monitor was ordered to protect her from the onslaught of the Virginia.

Rod Farb

▲ Artifacts like these glass mustard and pepper bottles were among the first to be recovered from the Monitor by Government divers.

The Virginia steamed into Hampton Roads during the early morning light expecting to destroy all that remained, but to her surprise a small Union iron clad, the Monitor, stood ready for battle. The Monitor steamed at full speed towards the Virginia. As the ships came closer, the Monitor crew began firing the massive 11-inch guns at the Virginia. The shots proved ineffective against the Virginia's armor. The Monitor came along broadside, and the battle began in earnest. The cannon fire roared as both vessels fired, reloaded, and fired again and again. Each direct shot bouncing off with little damage to either ship. The awesome battle raged for over four hours. Shot after shot struck each ship leaving only dents and ringing ears. With all ammunition

(continued page 26)

exhausted, the Virginia turned towards port leaving a tired and discouraged Monitor crew behind to guard the remaining Union ships. Months passed with little or no action while the Monitor waited for another confrontation.

The Demise of the Virginia

On May 10th, 1862 a large force of Union soldiers pushed the Confederate troops back and captured Norfolk, stranding the Virginia in the Elizabeth River. Being trapped, the Confederates had no choice but to scuttle the ship for the second time and retreat by land. While the Virginia burned, the 300 man crew rowed to shore and escaped.

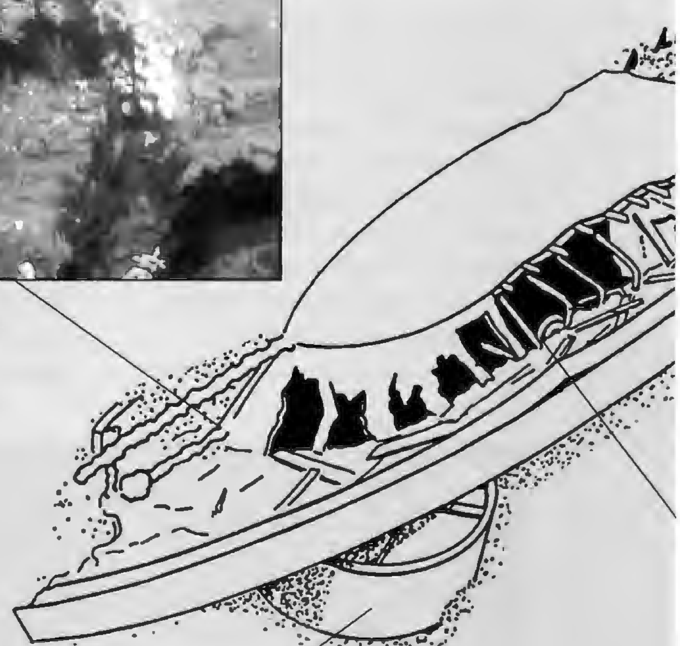
The Monitor Sinks

With the Virginia gone, the Monitor continued with other missions. For several months it served in small skirmishes but nothing as spectacular as the confrontation with the Virginia. On December 24, 1862 the Monitor was ordered to Beaufort, North Carolina. Because the Monitor was unstable in rough seas, a sidewheeler, the Rhode Island, was ordered to tow her. Aboard the Monitor many preparations were made to prevent sea water from entering. Traveling through the Atlantic Ocean, the seas kept building and pounding the Monitor and its crew. The seas grew to over 20 feet, and the situation became dangerous for both vessels. The Captain of the Rhode Island feared for the safety of his ship and crew so at 10:30 pm he ordered the tow lines cut. The Monitor had been taking on water which had grown to over a foot deep in the boiler room. The Monitor quickly signaled distress and the Rhode Island turned to give what little assistance they could in the 20 foot seas. As the Rhode Island came along side, lines were thrown to the Monitor. Several crewmen were washed overboard due to the waves and the flat deck.

Divers examine and photograph a break in the hull.

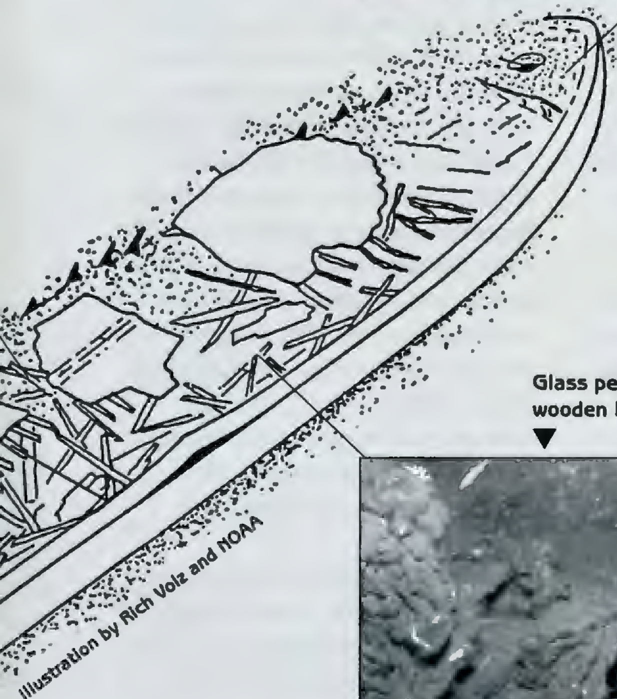
THE MONITOR

Propeller shaft tunnel inside rear of engine room. Never before seen until recently formed opening at the ships stern provided access to interior of engine room.

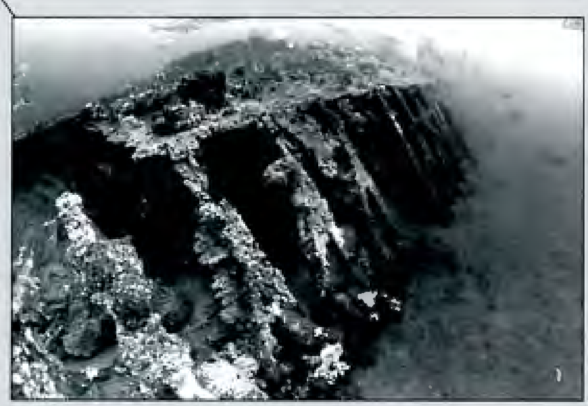


Diver surveys the diameter of the gun turret trapped beneath the stern of the Monitor.

Mysterious opening at base of port armor belt near the bow.



Glass pepper and mustard bottles in wooden box. Part of ships stores.



Side of engineering spaces within the aft portion of the hull.

All above photos by Rod Farb

With the crashing seas and swaying motions of the ships in close quarters, the Rhode Island had to back away for safety.

Life boats were launched to help the crew of the sinking Monitor. The men had to climb down a ladder on the gun turret and cross the flat deck to get into the life boats. Timing was critical for this maneuver to be successful in the rough seas. After filling the lifeboats to capacity, they returned to the Rhode Island which was now also dead-in-the-water due to a tow rope being caught around the starboard paddle. Dropping off the rescued crew members, the life boats returned to the Monitor. Again men jumped from the top of the turret. With the life boats again full and the Rhode Island drifting one to two miles in the distance those still below deck were abandoned never to be seen again. Shortly after midnight on December 31, 1862 the crew of the Rhode Island watched the red distress light of the Monitor slip beneath the surface to join the 16 crewmen who lost their life in the rough seas that night.

The Monitor is Found

For the next one hundred and eleven years, the Monitor sat undiscovered with only Mother Nature to torment her. On April 1, 1974 the Alcoa Seaprobe confirmed the identity of the Monitor. Lowering electronic equipment, Alcoa took over 4 hours of video, 1200 black and white photos, and 450 color photos. The Monitor was discovered, lying upside down in 235 feet of water 16 miles from shore. The seawater had done considerable damage, but most of the hull was intact. Much of the wood planking, flooring, and personal items had disintegrated leaving only the iron frame and some artifacts. Along with the discovery came stiff political pressure to preserve the wreck.

(continued page 28)

On October 11, 1974 the Monitor was added to the National Register of Historic Places. Preservation groups, however, continued to pressure the government for further protection. On January 30, 1975 the Monitor was designated the first National Marine Sanctuary and placed under the protection of NOAA. NOAA in return conducted an extensive archeological survey recovering many artifacts, and photo-documenting the wreck.

Diving the Monitor

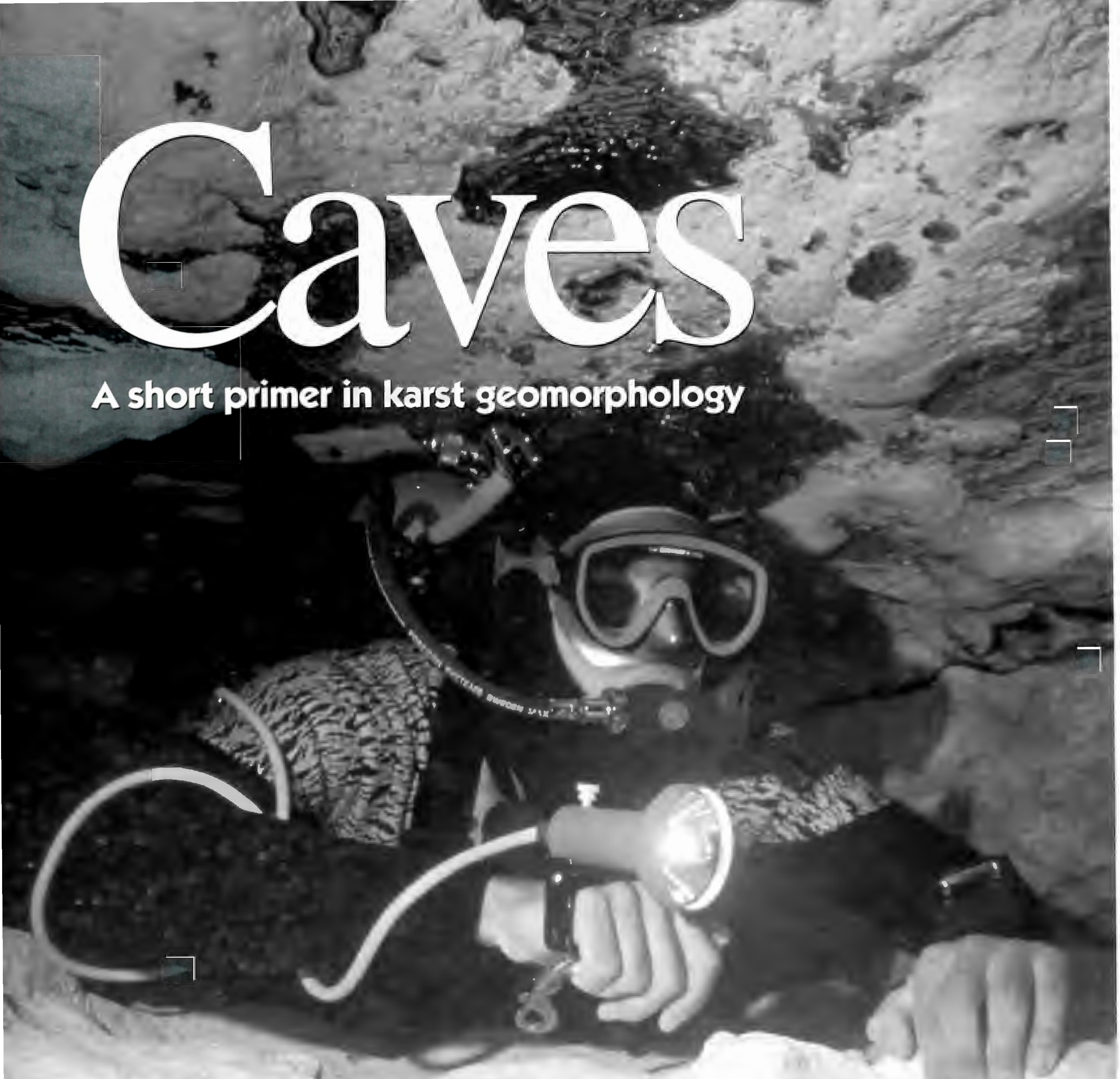
During the past 20 years, several experienced wreck divers including, Gordon Watts, Richard Lawrence, Gary Gentile, Rod Farb, Terrance Tysall, and others have successfully dived the Monitor and taken many detailed survey measurements and photographs. Sanctuary regulations require persons requesting to dive the Monitor to submit a research proposal. Since 1990 nearly a dozen permits have been issued to private groups who have primarily conducted photographic studies. In 1993 and 1994 private groups also recovered artifacts in cooperation with NOAA. In 1994 NOAA issued a special use permit to Capt. Arthur Kirchner, of Cape Hatteras, for the conduct of the first non-research dives to the Monitor. This permit allows a larger group of divers to visit the wreck without the constraint of performing research. These divers, however, must obey strict rules regarding contact with the vessel per NOAA's regulations. Unauthorized diving on the Monitor is generally not possible since the Coast Guard keeps a vigilant eye on things for NOAA.

The Monitor lies roughly four miles west of the western edge of the Gulf Stream so currents can be stiff. Contingency planning for divers being blown off the wreck is essential. Visibility is typically 60-80 feet in June and July, which are the best times to dive the Monitor. Some reports say that the day after a North-Easterly wind dies out gives the best conditions since the gulf stream is blown further away from the site, reducing the current and improving the visibility. Visibility extremes of both 120 feet and 5 feet have been observed on rare occasions. Water temperature for the dive varies from 60°-80°F depending on the season and how close the Gulf Stream is passing.

At 235 fsw the Monitor is considered a mixed gas dive. Air is considered hazardous at this depth due to oxygen toxicity and the heavy narcosis. NOAA uses TriMix 18/50 (18%-O2, 50%-He, 32%-N2) when diving the Monitor. They mix it on the boat using banks of helium and banks of NOAA Nitrox II (36%-O2, 64%-N2). They simply mix these two banks of gasses in a 50:50 ratio. The gasses are analyzed at each step to ensure proper mixing. TriMix 18/50 yields a ppO2 of 1.46 ATA at this depth and an Equivalent Narcosis Depth (END) of only 75 fsw. With bottom times around 25-30 minutes the total dive time is usually around 90 minutes with decompression.

When speaking of the Monitor, few divers have actually "Been There." However, those Americans who have made this dive describe the experience as emotionally moving due to the history involved. Had the Monitor not stopped the Merrimack (Virginia) the entire Union fleet may very well have been destroyed and the Confederates may have gained enough advantage to win the war. Had that happened the entire world could have a considerably different make-up today due to the changed influence of the United States.

DeepTech Journal wishes to thank John Broadwater, Gary Gentile, Rod Farb, and Terrance Tysall for their generous contributions to this article. Gary Gentile's book, Iron-Clad Legacy, is an excellent source of additional information on the Monitor. It can be purchased by sending $25 U.S. to Gary Gentile Productions at P.O. Box 57137 Philadelphia, PA 19111.



Caves

A short primer in karst geomorphology

by Jeff Petersen

One of the most often asked questions of a cave diver by non-cave divers is "What is there to see?" (this is usually said with a quizzical and/or suspicious tone.) Although a myriad of images flash in the cave diver's mind (seeing any one of which would make the point clear), he finds it hard to articulate what he sees.

Ironically, cave divers are typically groping for descriptions of the emotional impressions their dives give them instead of exactly what they see. Part of this is because, during the cave training course, many cave divers are only given a superficial exposure to the forces that created the dive site. After that, they never find out more about the factors that make each cave so unique (or in some cases, what make certain caves so similar).

For the casual cave diver, knowledge of hydrogeology can make an otherwise agendaless dive capture more significance as the diver tries to identify the geological forces at work

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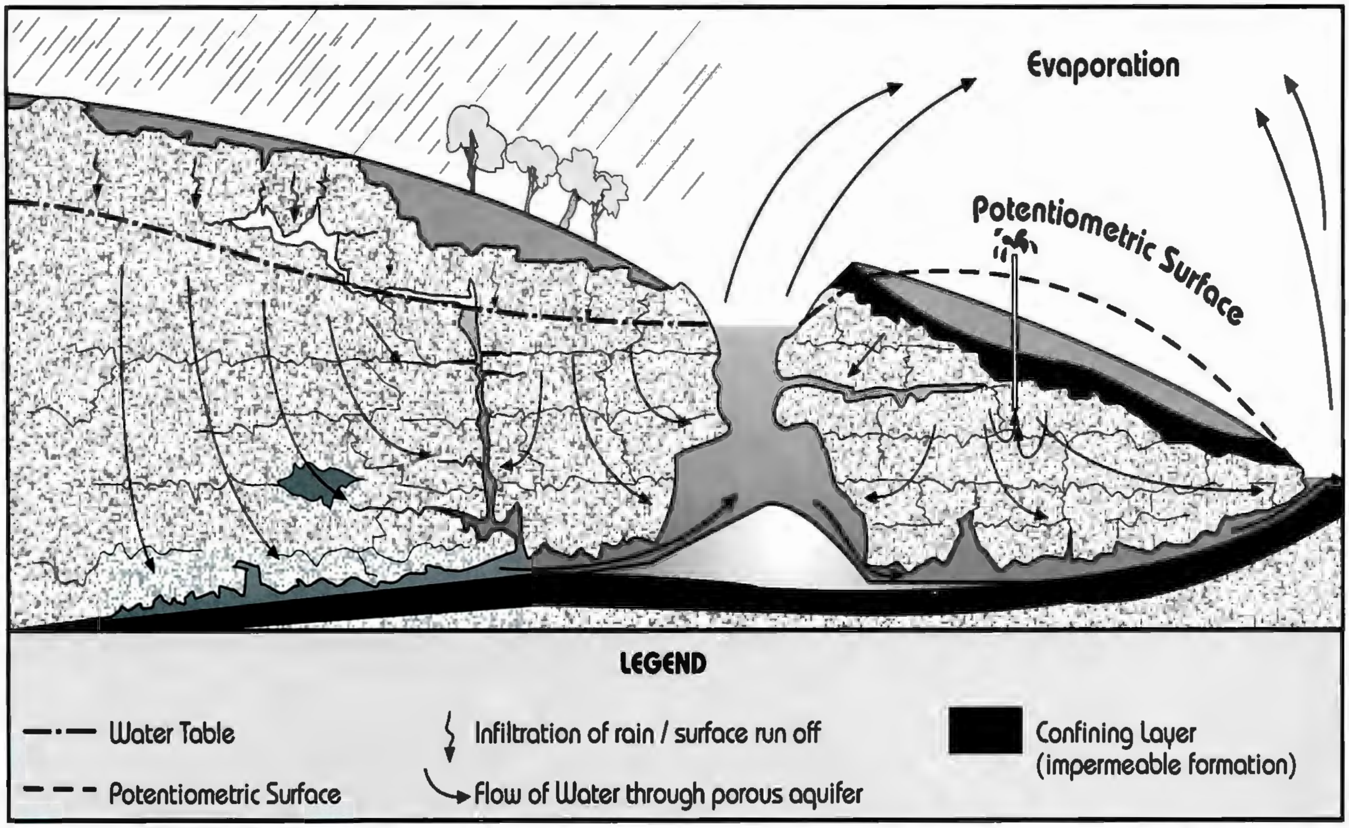


▲ **Groundwater is one phase of the hydrologic cycle. Groundwater describes the storage of all water underground. The step before groundwater storage/transmission is the input of water into the aquifer in the form of rain. The step following the groundwater phase is the final discharge of water to the surface through springs, and seepage into streams, lakes, and the ocean.**

in the system based on the surrounding clues. For the would-be explorer, this knowledge can help identify which tunnels will most likely continue and help the diver communicate the environment more effectively to academics (who often can be instrumental in securing access to a closed site).

This article begins with an overview at the broadest level, the hydrologic cycle, and how it controls cave development. Then, applying more specific concepts, it will follow the evolution of a hypothetical cave. Finally, it will evaluate specific types of tunnels to identify what mechanisms guided the formation of the tunnels and the cave system at large. This article is meant to give the reader a conceptual foundation in hydrogeology, provide insight into the formation of underwater caves, and a primer for those who wish to learn more about the topics covered herein. A glossary of terms is provided on page 35 for those new to cave hydrology.

Groundwater In the Hydrological Cycle

Lets cover the basics first. Groundwater is one phase of the hydrologic cycle and underwater caves are one aspect of the groundwater phase. Groundwater describes the storage of all water underground. Before discussing the groundwater phase, it is necessary to understand the steps in the cycle before and after the groundwater phase.

The step before groundwater storage/transmission is the input of water into the aquifer in the form of rain. The step following the groundwater phase is the final discharge of water to the surface through springs, and seepage into streams, lakes, and the ocean. Sinkholes that reach the water table are essentially points of input for the system, while springs are outputs. The strength of recharge and the amount of discharge are critical factors because they represent the most fundamental variables in the process of cave formation—the water pressure gradient. This concept is used in the discussion of cave formation in the next section.

Groundwater can be subdivided into various aquifers. In most cases, these formations are either limestone or dolomite due to their susceptibility to carbonic acid, which increases the ability of these materials to transmit water. All aquifers are classified in two major categories, unconfined and confined. Unconfined aquifers receive and discharge water from the surface without restriction (i.e. the water table can rise and fall in response to rainfall/infiltration and discharge).

A confined aquifer has at least one layer of rock/sediment that does not allow water to pass through. Confinement is both above and below the rock formation capable of transmitting water. Figure 1 illustrates an unconfined aquifer from the left margin to the sinkhole; the aquifer between the sink and the spring is confined both above and below. All aquifers will have a confining layer below them at some depth.

Unconfined aquifers (and semi-confined aquifers) are divided into two zones: the vadose zone and the phreatic zone. The vadose zone is characterized by allowing water to flow through it to a deeper level (the phreatic zone); all pores (any spaces between solid rock), regardless of size, are air filled. The point where the pores remain saturated with water marks the beginning of the phreatic zone. These divisions played pivotal roles in earlier theories about the formation of caves, but expanded knowledge of fluid mechanics and chemistry have generated more robust theories of cave development (White).

The line of separation between the two zones is called the water table. The water table in Figure 1 is below the surface except at the sink and at the spring. The rule of thumb says unconfined aquifers have water tables and confined aquifers have potentiometric surface.

The level of the water table is by no means stationary in an unconfined aquifer. With increased precipitation, the water table will rise in response and drop after the precipitation surge has passed to an area where the aquifer is under less pressure. In a drought, the water table will drop as water is continually discharged without being replenished by rainfall in recharge areas.

Once water has infiltrated downward (under gravitational forces) to the phreatic zone, its direction and velocity change, but it will essentially follow two physical rules.

1. The overall flow trend will be from recharge areas (high pressure areas) to discharge areas (lower pressure areas). Energy moves from a point of concentration outward to lower concentration areas until (theoretically) an equilibrium is reached. In the aquifer context, this is the same as a hydraulic pressure gradient—the direction of energy/water flow.

2. The path taken along the pressure gradient (from recharge to discharge) will be the path of least resistance. As the water moves toward the discharge point(s) it will dissolve the rock formations along areas of weakness such as bedding planes and fractures. This produces progressively larger and larger openings along the water pressure gradient.

The Cave Formation Process

In this section, we will take some of the concepts defined before and see them in action. The geomorphology (direction and shape) of a cave in a limestone aquifer is a function of many variables. The two primary variables are chemically based (dissolution as a function of carbonic acid, temperature, and in rare instances other acids in water) and geologically based (the lithology and structure of the sedimentary beds comprising the aquifer).

Carbonic acid (H_2CO_3) forms in groundwater by combining water with CO_2 present in the water; CO_2 is usually introduced to the system via infiltration from the surface. In Florida, fluctuations in sea levels have been responsible for much of the dissolution in the 100-300ffw strata. When the sea level and corresponding water table dropped, portions of the karst terrain were raised close to the vadose zone creating greater dissolution rates because carbonic acid is typically more concentrated near the water table. Other portions were brought into the vadose zone creating partially dry caves that drain surface water into the aquifer. Subsequently, when the sea level rose, the caves were returned to the phreatic zone in new, larger forms and began to discharge water from the aquifer again (this is referred to as a "reactivated karst").

The series of illustrations on the following page provide a visual frame-work for these concepts. This example assumes that all conduits remain in the phreatic zone until the point of surface discharge and the aquifer is essentially artesian (see glossary under potentiometric surface). The time-date for each phase is mostly for comparative purposes; growth rates will vary based on water temperature, CO_2 levels in water, recharge, lithology and struc-ture of each portion in the aquifer. These phases are adapted from White.

Initiation Phase (1)

Initially, water is moving through the aquifer with an even distribution based on the pressure gradient to a discharge region. At two points, solutional pathways or "proto-tunnels" are forming. These initial pathways may have come from bedding planes particularly susceptible to dissolution or existing fracture lines in the limestone. These proto-tunnels are less than 1.0cm cross sections, although they may extend for considerable distances. At this point, a self perpetuation cycle of cave growth begins with the expansion of the first proto-tunnels.

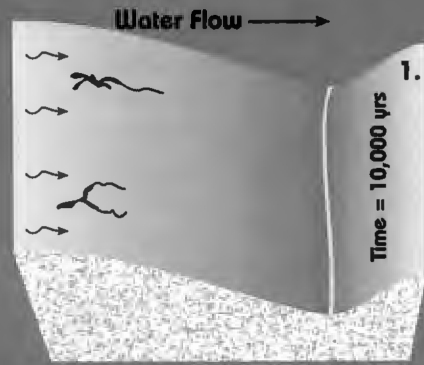
Critical Threshold Phase (2)

This phase is characterized by changes in the proto-tunnel resulting in greater diameters; generally, achieving a 1.0cm diameter enhances growth at much greater rates.

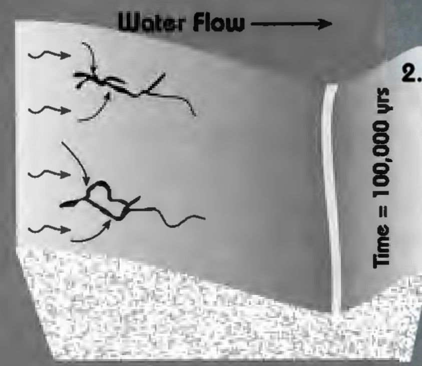
Turbulent flow develops in apertures of 0.5 to 5.0 centimeters with a

(continued page 32)

The Cave Formation Process



(1) Initiation Phase



(2) Critical Threshold Phase

shift from planar to tubular tunnel formations at about 1 cm of proto-tunnel size. Turbulent flow allows for more efficient mixing of acids against the rock surface, yielding faster dissolution rates. The faster dissolution rate widens the aperture, allowing more acid contact and the loop begins again.

At this point the aquifer, in the immediate area, is being "short circuited." In this case, short circuiting means a distinct path of least resistance has developed, and the trajectory of the water surrounding the proto-tunnel is being shunted to these tunnels, almost to the complete exclusion of water transfer through non-conduit portions of the surrounding aquifer.

Velocities typically provided by a 1cm or larger tunnel are generally adequate to allow transport of particles so that the tunnels do not subsequently choke themselves shut (at least for a while, see Discharge Bias Phase).

Exploration Phase (3-4)

Multiple branches work their way downstream (toward the discharge region). Solutional pathways distribute themselves under principals discussed above (biased toward rock formations with faster dissolution rates and structural advantages, such as fractures and unconsolidated bedding planes). Aside from structural factors, all tunnels will grow at similar rates during this phase (Palmer, 1991).

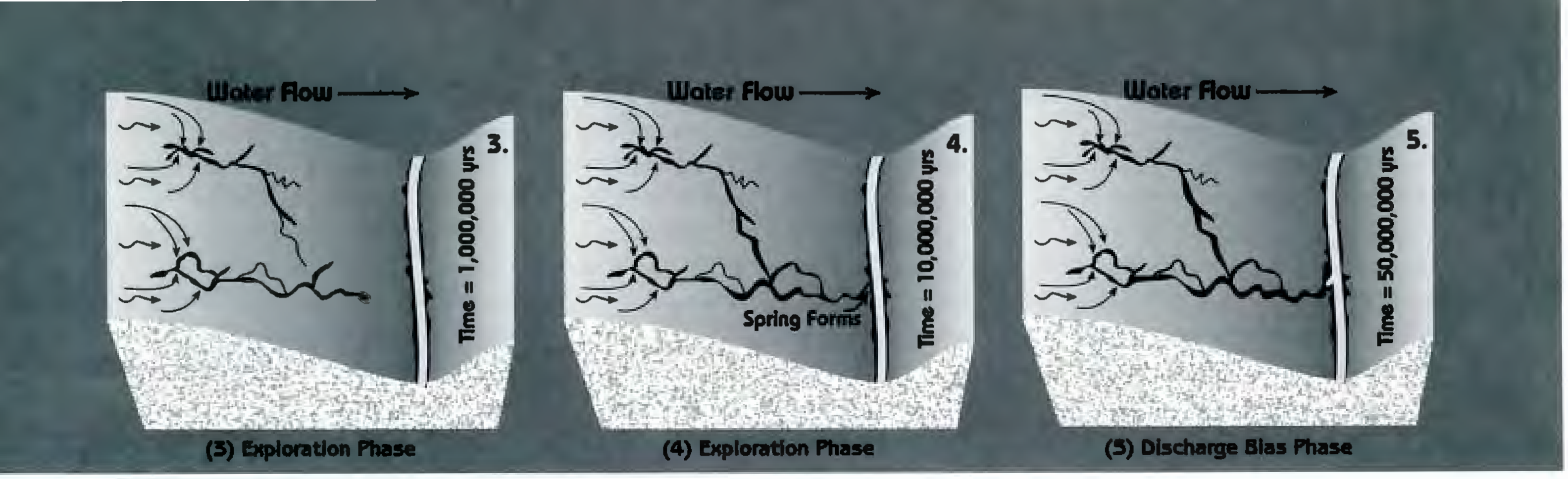
Discharge Bias Phase (5)

This phase starts when a conduit begins to discharge at the surface (such as the formation of a spring or aquifer water seeping into a river bed). As a result, the "best" path of least resistance has been located by the developing cave system. Because the flow is able to move through certain tunnels to the exit point under less resistance, relative to the other tunnels, velocities increase along these paths. The "best" path will grow at a greater rate than the less favored paths. The "best" path may not necessarily be the shortest path, but it is the path that has the highest pressure from the recharge area (source) and the least back pressure from the discharge area (open spring).

With the increased flow established by a discharge point, other tunnels' growth rates will decrease and may reverse (these tunnels begin to act as sediment traps). Many cave divers have swam down tunnels with almost no flow as compared to the main tunnel's high flow; these tunnels tend to be smaller with much higher concentrations of silt on the floor and walls. These are the "could-have-been" tunnels that nature abandoned because the main tunnel was acting as a more efficient transport. As the flow drops in these dying distributary tunnels, acid levels in the water drop and are not replaced as quickly (or at all); in turn, dissolution rates drop off significantly as opposed to the primary tunnels where acids are continually replenished.

In the main tunnels (where flow is now biased towards), dissolution increases by both chemical and mechanical means (i.e. breakdown and abrasion from particles transported in the water). As the tunnels widen enough (here "enough" depends on the structure and lithology of limestone dissolving), breakdown of the cave walls and ceiling begins. This can lead to the formation of dome rooms and breakdown piles as a result of shearing forces on blocks of limestone along the ceiling. In essence, as the tunnel widens, the limestone is not able to support its own weight and eventually breaks and falls to the floor where it may or may not dissolve and be carried away. This shearing process continues until a stable dome or arch shape to the ceiling has developed.

External variables may also cause other radical changes in the cave over time. If the water table were to drop significantly, to the extent that some of the cave passages were now in the vadose zone, the tunnel would no longer have flow but be partially dry and, instead, drain water from the surface cutting new paths into the limestone. Additionally, air cavities that have now formed may



exacerbate more catastrophic tunnel collapses due to the lack of water to support the ceiling.

If a sinkhole were to develop that reached down into a tunnel, the cave morphology could be changed drastically downstream from the sink; acid levels and mineralization downstream from the sinkhole would differ from those affecting the walls upstream.

This difference is most poignant at the furthest upstream sinkhole in the cave system. Upstream from this sink, all water is fed to the system through slow infiltration from the surface and then through some amount of non-conduit aquifer. Downstream from the sinkhole, water is introduced directly to the conduit aquifer without any filtration. The direct contact alters the pH levels in the water, introduces other minerals, and may alter the dissolution rates. This is evident at such places in Florida as Chip's Hole (Wakulla County), Cow Spring (Lafayette County), Alachua Sink (Alachua County) and Sullivan Sink (Leon County). In these places, the tunnel shapes and mineralization vary drastically between the upstream and downstream tunnels.

Cross Sections

Now that we have seen the macro perspective on the formation of a whole cave system, we can take a more detailed look at how each section of the cave is formed. There are two critical controls involved in the formation of any cave passage: structural controls (where the tunnel shape is governed by fractures in the limestone and bedding planes) and hydraulic controls (where the shape is driven by the water's movement through the passage). It is important to remember that both of these factors, plus the lithology of the limestone and the dissolution rates, are all working simultaneously to determine the current shape of a tunnel; generally, one or two of these will have a greater influence than the others on a given passage.

Structural controls are typically evident in the form of a prominent fracture or a bedding plane parting. In a study of approximately 500 caves by Arthur Palmer, he noted that 57% of the total passage length was governed by favorable bedding planes or parted bedding planes; 42% were guided by fractures in the limestone.

This means that essentially half of the tunnels evolved from the presence of a bedding plane. In this discussion, a bedding plane also includes an adjacent layer of limestone that is more susceptible to dissolution than the main formation. In bedding plane cases, the water has found it easier to dissolve the sediment or simply transport it out of the cave (when adequate flow rates were obtained). Often the bedding plane will erode until insoluble limestone (usually forming the final ceiling of the passage) is reached and a confining layer of sediment (such as clay) remains to limit downward dissolution. Passages of this nature tend to be sinuous. Examples of this are evident in almost every tunnel in the Devil's System at Ginnie Spring (Gilchrist County, Florida) and the tunnels between the Florida Room and the Dome Room in Little River Spring.

The other half of the passages were formed from preexisting fractures or faults in the limestone. These can be either horizontal or vertical, depending on the structure of the overall limestone beds. These passages tend to be linear with angular intersections. Classic vertical fractures can be found at the entrance to Diepolder II (Hernando County, Florida) and Edwards Spring (Madison County); examples of horizontal fractures can be seen in the bedding plane (at 140 ffw) just before "Henly's Castle" in Peacock III (Lafayette County, Florida) where the limestone bottom is hidden by only a few inches of silt. Occasionally, an "L" shaped passage develops where the water has found a joint (the intersection of a vertical and a horizontal fracture).

As fractures and softer limestone beds widen due to dissolution , flow may decrease enough to allow some sediment to settle at the bottom of the fissure, obscuring the

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original shape of the tunnel. The silt level may rise high enough to create a more triangular tunnel with possibly 80-90% of the limestone fracture concealed below. Often these paleo-fractures can be spotted during a dive by looking for consistent cracks or vertical rifts in the ceiling which run the same direction as the tunnel.

Composite tunnels come in two shapes: "T"s (keyhole shaped tunnels) and inverted "T"s (a vertical fracture with a broad, low expanse cutting outward at the base of the vertical section). A "T" shaped tunnel usually develops when a bedding plane is cut downward from a drop in the water table bringing the top portion of the plane into the vadose zone (creating an air pocket). This leaves a stream running through the middle of the tunnel until the water table rises again returning the entire passage to the phreatic zone. Under this scenario, the running water carves an ever deepening trench until the water level rises. This downward cutting is actually a hydraulic control of the tunnel's shape.

An inverted "T" is occasionally seen in tunnels that have always been in the phreatic zone. One possible source for this shape comes when flowing water erodes a bedding plane and cuts into a fracture above the bedding plane. The water then passes through both sections and begins to widen the newly discovered fracture by dissolution. The initial passage may be either the fracture or the bedding plane; the primary and secondary structures are determined by the local structure and lithology. Examples of these types of passages can be seen in Telford Spring , Little River Spring and Hart Spring.

Most phreatic caves exhibit both fractures and bedding planes. During the cave's evolution, the water might follow a fracture until it hits a soluble bedding plane, then its course shifts to the new path of least resistance, meandering along the bedding plane until a new bedding plane or another fracture is encountered. The shape changes back and forth as the water works its way toward what will someday be a spring.

Hydraulic mechanisms are generally less significant in caves explored by cave divers because these caves have spent almost their entire existence in the phreatic zone. The most common shape resulting from water flow is the elliptical tube. A prime example of this is the peanut tunnel in Peacock I. This shape typically develops in situations where the water begins (and continues) to move through a large homogenous block of limestone; in this scenario, dissolution occurs evenly in all directions (because there is little to no variation in the composition in limestone). Breakdown from tunnel expansion can cause variations on an initially elliptical tunnel.

Hydraulic effects are most noticeable along walls in the form of "scallops" (pock-like divots uniformly distributed along walls subjected to high flow). The width and depth of scallops are both a function of the flow that created them. Deeper, shorter scallops are characteristic of high flow; broad, shallow scallops are characteristic of lower flow. Formulae exist for calculating the mean flow responsible for sculpting a set of scallops based on the passage shape/size and the width of the scallops (Blumberg and Curl).

In Summary

And now to take a step back and look at the big picture, since you are no doubt well past your saturation point. You learned that water is stored underground in geologic units called aquifers. Water is almost always in motion within these aquifers. The direction of the motion will always be along the pressure gradient - from high pressure to low pressure. When the aquifer is of the non-conduit type, the water flow will be between individual grains of the limestone and no cave passages will exist. If the aquifer is the conduit type, almost all water flow will be directed to the tunnels and transferred by tunnels to discharge areas.

The conduits in a conduit aquifer form from the presence of carbonic acid in the water; the process by which this, or other acids, erode limestone is called dissolution. During the cave formation process, limestone will be dissolved along paths of least resistance, such as bedding planes and preexisting fractures in the limestone. Once a distinct discharge point develops, the tunnels capable of transmitting the water along the pressure gradient, with the least reduction in energy, continue to grow at the expense of less efficient tunnels.

The shape of any given tunnel is a function of several collaborative variables: limestone structure (fractures and bedding planes), lithology of the limestone (susceptibility to dissolution), and hydraulics (water flow velocity). By applying these concepts during your next cave dive, you will discover a much richer appreciation of the alien world we dive in.

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Hydrology Buzz Words

Aquifer
(Confined/Unconfined, Fracture/Conduit) A rock formation (an area of reasonably constant lithology) capable of retaining and transmitting large quantities of water. An aquifer may be comprised of many different formations with varying hydraulic conductivities. Additionally, there is a distinction between a porous or Fracture Aquifer (fractures are less than .1mm in width) and a Conduit Aquifer (the presence of conduits larger than a 1mm); in a conduit aquifer, the conduit carries almost all water in the local area.

Discharge Area
An area where groundwater flow is directed toward the water table. Flow trends upward and horizontal to the water table from higher pressure areas to lower and lower pressure levels. The water table is typically at the surface in discharge areas.

Dissolution
The breakdown and removal (by water) of rock formation as a result of acids in the water reacting with the chemical make up of the rock formation. The predominate acid responsible for dissolution in limestone is carbonic acid from CO_2 in the atmosphere and soil; to a much lesser extent, hydrosulfuric acid also plays a role in the dissolution process.

Hydraulic Conductivity
The rate at which water moves through a porous medium in any given direction. The direction is usually the path of least resistance from recharge areas to discharge areas. A map of varying levels of conductivity also represents the potentiometric surface for confined aquifers where the water table is below the surface.

Lithology
Describes the mineral composition, grain size distribution and grain shape characteristics which control hydraulic conductivity within a formation.

Phreatic Zone
The area beneath the water table. All pores (regardless of size) in the rock formations are water filled. Water moves through pores vertically or horizontally from higher pressure to lower pressure (recharge to discharge points).

Potentiometric (Piezometric) Surface
The surface (below, at, or above the land surface) that water will rise to based on the amount of hydraulic pressure at that point. When the potentiometric surface is above the land surface, the aquifer is artesian producing free flowing springs or, if a cased well were drilled into the aquifer, the water would rise in the well to the level of the potentiometric surface. See also discussion in water table definition.

Recharge Area
A region where groundwater flow is directed away from the water table. Downward trends will tend to create higher pressure levels for the water. Typically the water table will be below the land surface.

Stratigraphy
The age relationships among various formations; these formations are typically layered.

Structure
The general disposition, attitude, arrangement or relative positions of formations in their current state and as modified by folding, faulting, and intrusion.

Vadose Zone
The area from the land surface down to the water table. Characteristics may vary except that water is capable of transferring through it downward (by gravitational force) and no water is retained in pores of the rock formation(s).

Water Table
The level at which pores in rock formations change from containing air to containing water. The water table will rise and fall based on various factors such as amount of rainfall, drawdown from pumping, or tidal changes near coastal areas. The water table will be the same as the potentiometric surface when the aquifer is unconfined; if it is confined the potentiometric surface will be above the water table as a function of the amount of pressure. The greater the pressure, the higher the potentiometric surface will be above the water table.

Women in

ANN KRISTOVICH

by Curt Bowen & Win Remley

As far as sports go, diving is still in its infancy. After all, the inventor of the open circuit scuba system, Jacques Cousteau, is still alive and diving. Like most sports that have been invented by men, diving began as a man's sport. Initially, it was considered too dangerous for women the gear was too heavy for them. As our society grew beyond these chauvinistic notions, however, women started diving in greater numbers. According to NAUI, women now account for almost 40% of beginning open water certifications. They have proven that there is little men can do that women cannot do at least as well in diving. There is even a scuba association exclusively for women called the National Women's Scuba Society, which began in 1993.

As our technology progressed over the years our dives became more extreme. Open circuit dives below 400 feet, and 10,000 foot cave penetrations began occurring on every continent. The term technical diving was coined to distinguish this type of extreme diving from open water sport diving. Women were slower than men, initially, to get into technical diving but not by much.

Today women can be found diving everywhere men dive. The ratio still leans towards the men, although women are closing the gap quickly. According to IANTD roughly 15% of all technical certifica-

Tech Diving


BARB LANDER

tions they issue today are being earned by women. At the recent NSS-CDS workshop, held in May of this year, 28 divers received the prestigious Abe Davis award for cave diving. Seven of these recipients (25%) were women. Women technical divers are diving everywhere men dive. Many women have received national and international recognition for their diving accomplishments.

Ann Kristovich and Barb Lander are two such women who have distinguished themselves among technical divers. Ann is the current record holder of the women's deep open circuit dive, and Barb is a representative for Prism rebreathers and holds one of the precious few NOAA permits to dive the Monitor.

Ann Kristovich
Ann Kristovich has many accomplishments to her credit. She holds the women's deep open circuit record of 554 feet; she is an instructor for NAUI, IANTD, and TDI; she actively teaches diving at all levels from beginning open water to trimix and full cave; and she has participated in some of the worlds most difficult explorations. She and the men's deep record holder, Jim Bowden, regularly train together. As if these accomplishments were not enough, Ann also happens to be a surgeon. She was the first woman resident in her specialty program at Parkland Hospital in Dallas, Texas.

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▲ Ann Kristovich

Ann is 44 years old, lives in Austin, Texas and has been diving since about 1980. She was originally trained by what she calls the "old school" of NAUI instructors. As a beginning open water student, and a woman, she felt she had to perform above the level of the men to prove she had the "right stuff." She earned her first instructor certification in 1989. Today, Ann is very active in exploring, dive training, and teaching. She can frequently be found in Lake Travis, Texas with a class of students in training.

Ann's desire to see more and explore further eventually led her into technical diving. Redundancy, training, skill and experience were all necessary for extended range diving so she pursued the more advanced certifications and went diving every chance she got. Ann has received most of her training from Jim Bowden. Sheck Exley trained her in deep diving and trimix.

Ann has participated in several significant expeditions within the United States including, Rochelles Cave, Honey Creek, and Emerald Sink. In Mexico she was active in expeditions to El Nacimiento Mante, Rio Santa Clara, El Sotano de las Calenturas, Rio Sabinas, Rio Corona, Rio Huichihuayan, Poza Verde, Poza Caracol, Poza La Pilita, and of course Zacaton, the site of her record deep dive to 554 feet. She has also explored St. Hermanns, Petroglyph, Inland Blue Hole, and Actun Tah, all located in Belize. Ann's future plans include a return trip to Zacaton, as well as other expeditions within Mexico. Her diving expertise combined with her medical training make her one of the most sought after members of expeditions to remote areas of the world.

Barb Lander

Barb Lander is an instructor for both PADI and IANTD. She is an IANTD Technical Instructor Trainer, an accomplishment attained by only a select few, and she holds a full cave certification issued by the NSS-CDS. Barb was a key member of the famous 1994 Lusitania exploration led by Polly Tapson, another renowned woman technical diver, and she holds an active NOAA research permit to dive the Monitor. Barb was the USA representative for Prism Rebreathers until Cochran Undersea Technologies recent announcement to take over this product. Now she is active with Cochran promoting and training in Cochran's rebreather technology.

▲ Barb Lander

Barb is 38 years old, a registered nurse, lives in Jacobus, Pennsylvania and has been diving since 1988. Most of her technical training was conducted under the guidance of Capt. Billy Deans of Key West Divers and Steve Berman of Ginnie Springs. Barb says she didn't find it particularly difficult to pursue technical diving as a woman, saying, "Women can do anything they want to do in diving, there are no limitations. Women [and men] should leave gender on the dock." Barb progressed in her dive training and experience level rapidly. She was diving the Andrea Doria only three years after her beginning open water certification.

Barb participated in Polly Tapson's expedition to the Lusitania (320fsw) in 1994. She was selected as a key team member on this expedition due to her extensive deep wreck experience. Barb has dived many interesting deep wrecks over the years including the Andria Doria, the Monitor, the U-550, the U-Who, the Bill Mitchell, the Norness, and the Lusitania, among others.

After submitting a research proposal to NOAA in 1994, Barb was granted a permit to dive the Monitor. She, along with Terry Tysall, of the Orlando Dive Center, dived this historic wreck and conducted valuable photo documentation and wreck surveys. Her permit to dive the monitor remains open while she plans an ambitious expedition to conduct a photo mosaic of the Monitor, consisting of over 1,000 photographs. Barb also plans to continue working with Cochran as an instructor in the Prism program.

The Future

Both Barb and Ann have proved that there is little men can do in technical diving that women cannot. Both in terms of the actual diving activities and in terms of their professional recognition. These two women serve as examples that women are every bit as good as the men in technical diving. In fact, there are those who argue that women have certain physiological advantages over men including stamina, emotional maturity, and typically lower rates of gas consumption.

Jim Bowden's last cave expedition to Mexico included himself and three women (Ann Kristovich was one). They spent weeks hacking their way through the bush carrying hundreds of pounds of cave and scuba gear. Jacques Cousteau is currently building a more advanced version of his famous ship the Calypso to accommodate the women that have become members of his expert team (separate bunk rooms, shower and head facilities, etc.). These examples, more than anything, demonstrate that women can excel in technical diving. Kudos to Ann and Barb and all of the other women who have proved that sexist notions do not apply to extended range diving.

Diving News, Exploration Updates, and Discoveries.

Rebreather Training Expedition with Humpback Whales

Bret Gilliam, of TDI, will lead an expedition to the Silver Bank to dive with the Humpback whales in February 1996. This area between the Turks & Caicos Islands and the Dominican Republic is the winter home for the whales where they return each season to give birth to their calves.

Hundreds of whales are typically encountered in this remote spot during January through March. February has been selected to ensure optimal conditions. This is the only place in the world where divers can interact in the wild with these magnificent creatures.

A unique feature of the trip will be the chance to take a full certification course in rebreathers on board using the new Drager Atlantis I nitrox units with new computer software displays engineered by Uwatec. These rebreathers are noted for their lightweight (approximately 30 pounds), and ease of maintenance. They can provide up to two hours of dive time and can be used to 150 feet.

Space is limited to 14 persons on the 110 foot chartered vessel. Cost is approximately $2200 per person and includes both the charter and rebreather training and certification. To register, or more information, call TDI at 207-442-8391, or write to 9 Coastal Plaza, Suite 300 Bath, Maine, USA 04530.

The Hunley is Discovered

In one of the greatest discoveries since the Monitor, a team of divers led by top-selling author Clive Cussler, author of *Raise the Titanic*, has discovered the long-sought sunken hull of the Civil War submarine, the Hunley. The Hunley was the first submarine in history to sink a warship.

The Hunley, a Confederate Navy submarine, was found off the coast of Charleston, South Carolina on May 3, 1995 when underwater explorers, using a metal detector, located an unknown target in 18 feet of water. After digging through two feet of silt, they located one of the submarine's two small conning towers.

The sub is said to be completely intact and remarkably well-preserved. Diving the Hunley will be difficult, however, since South Carolina plans to raise the sub for placement in a museum.

The Hunley was often called the Peripatetic Coffin for sinking three times and killing all three crews, including designer and builder Horace Hunley. The submarines last voyage was the night of February 17, 1864. The cause of the Hunley's demise is unknown. Its disappearance has been a mystery for more than 131 years.

Abe Davis Awards

DeepTech Journal wishes to congratulate the following 1995 Abe Davis Safe Cave Diving Award Recipients.

Jesse P. Armantrout	Gary Ashburn
Murray Bilby	Donald A. Black
Karolyn S. Booth	W. David Booth
Stephen Brooker	Lawrence M. Care
Gina Chenoweth	Michael Garman
Sherry Garman	Richard J. Horgan
J. Scott Landon	Barbara Jo Lewis
Paul T. Logan	Mark W. Meadows
Greta Mullen	Joe Mullen
Allen Pertner	Steven J. Porter
Robert A Power	Susan Rouse
Harvey Storck, Jr.	William Streever
Mark Strong	Richard Wackerbarth
Robert Wallace	Denny Willis

TDI Offers "Hands-On" Tech Workshop

A special event for technical diving enthusiasts is set for September 22-24th in Pompano Beach, Florida. Sponsored by Technical Diving International (TDI). The workshop will be the first to focus on practical diving on several superb deep wrecks as well as opportunities to participate in programs for trimix, nitrox, rebreathers, and preparation of specialty breathing gases.

The main emphasis of the workshop will be on diving some of the best wreck sites in the U.S. with top professionals in the technical diving field. The workshop will have a core program on Friday, Saturday and Sunday that features a different deep wreck each day with seminars scheduled in the morning and evening surrounding the midday dives. Divers will have a chance to dive the 380 ft. freighter Hydro Atlantic and the massive 460 ft. Lowrance located only minutes from the dock. Dive depths will range from 110 to 180 feet. Visibility can exceed 100 feet with water temperatures anticipated between 75°-82° F. Both wrecks attract large marine life and pelagics and offer extraordinary photographic opportunities. The three day program costs $495 per person, double occupancy, and includes workshop fees, hotel accommodations, breakfasts, diving, all boat fees, and a cocktail party and fish fry. Divers must supply their own equipment. Seminar topics include equipment selection and rigging, risk management and insurance, drifting decompression techniques in currents, computer software programming for custom tables, contingency management, dive planning, blending & mixing gases, and a hands-on clinic with multiple dives on a rebreather that will be premiering at the conference.

Speakers include Bret Gilliam (President TDI), Fred Garth (Scuba Times), Joe Odom (Chairman of NSS-Cave Diving Section), Capt. Jim Mims (owner Ocean Diving), Rob Palmer (TDI Europe), Mitch Skaggs (Oceanic), Chris Parrette (Abyss Computer Programs), attorney Bill Turbeville, Dr. Bill Hamilton, Ph.D. (Hamilton Research) and several leading manufacturers of tech gear and computers who will be displaying new equipment.

Qualified divers wishing to become instructors for TDI can sign up for special classes that begin a few days prior to the workshop. To register or to receive a full information packet, contact: TDI at 9 Coastal Plaza, Suite 300 Bath, Maine 04530, or call 207-442-8391, fax: 207-442-9042.

1995 BTS/Dive Scuba Expo

Beneath the Sea, a nonprofit agency, presents the 1995 Dive Philadelphia Scuba Expo at the Valley Forge Convention Center in King of Prussia, Pennsylvania on October 6-8, 1995. This annual expo features exhibits, speakers, and workshops on CPR, VCI, first aid, photography, and other topics. Also presented at the expo will be the Undersea and Hyperbaric Medical Society's Medical Symposium (in plain English), Techs/Mechs Symposium (Technical/Mechanical aspects of technical diving), a Cayman Islands party, Bloodmobile, and the Dive Philadelphia Lawrence Factor Air Aware Awards. The grand prize of a one week charter aboard the M/V Aggressor in the Turks and Caicos will be given to one lucky attendee. Admission is $6 for adults, $4 for seniors and students, children under 12 are free. To register write BTS/Dive Philadelphia, P.O. Box 547 Southampton, PA 18966, or call Dr. Jolie Bookspan, Senior Director BTS/Dive Philadelphia, at 215-557-0165.

Techs Mechs Symposium

The technical and mechanical aspects of technical diving symposium will be presented concurrent with the annual BTS/Dive Philadelphia Scuba expo on October 6-8, 1995. Speakers, exhibits, and workshops will be presented on technical diving topics including rebreathers, full face masks, underwater communications, ice diving, mixed gas diving, technical diving in Europe, contaminated

(continued page 42)

water diving, hard suits, and heads-up displays among others. Speakers for the symposium include Barb Lander of Prism, Tom Maddox of MAR-VEL Underwater Equipment, John Comly, Bernie Chowdhury, Dr. Maurice Cross of DDRC, Rick Williams, and Robert Wass. Registration prior to September 15 is $79, and $89 thereafter. To register write BTS/Dive Philadelphia, P.O. Box 547 Southampton, PA 18966, or call Dr. Jolie Bookspan, Senior Director BTS/Dive Philadelphia, at 215-557-0165.

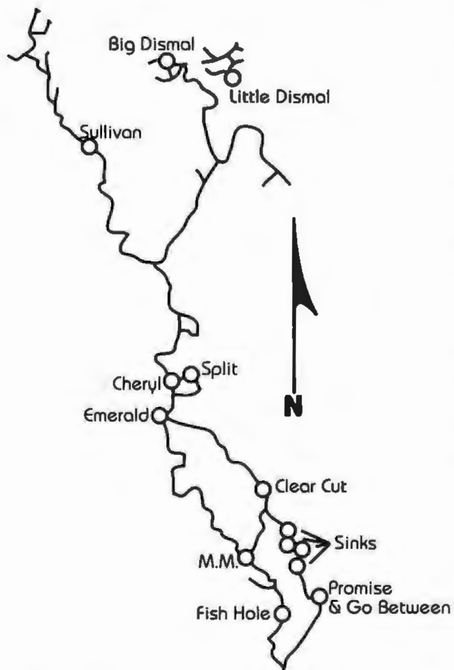
Woodville Karst Plain Project

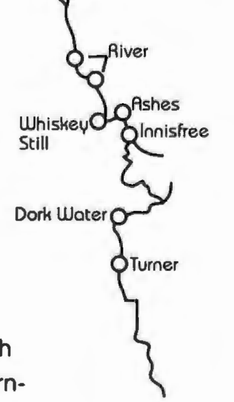
The Woodville Karst Plain Project (WKPP) is a research and exploration project of the National Speleological Society. The project was founded in 1987 by Parker Turner with assistance from Bill Gavin, Bill Main and Lamar English. The project mission is to explore the Leon Sinks Cave system.

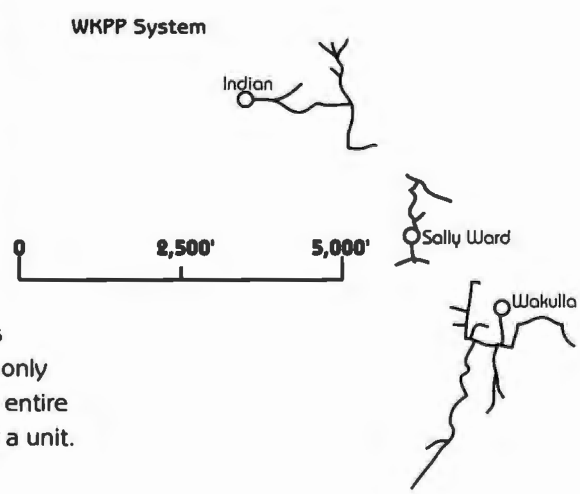
The Leon Sinks Cave is the third largest wet cave system in the world spanning over 400 sq. mi. of land in the North Florida area Southeast of Tallahassee. The WKPP team has already laid over 64,000 feet of continuous line in the system and another 50,000 feet of non-continuous line. There are currently 22 sink holes that have been connected together via underground caves with another 25-30 that could potentially be connected to the system through continuing exploration efforts. Sinks already connected stretch from Sullivan in the north to Turner in the South and may eventually include Indian, Sally Ward, and Wakulla.

The project is receiving assistance from the State of Florida as well as several federal organizations including the Department of the Interior, the Environmental Protection Agency (EPA) and the Department of Environmental Protection (DEP), among others. The University of Florida and several other private organizations also contribute various resources to the effort.

The Project Director is currently George Irvine who joined the team five years ago. The team consists of 18 cave diving members plus another 20 persons involved in research and support. Government and University groups also participate in special projects. Bill Gavin is in charge of equipment technology and dive planning, while Casey McKinlay coordinates diving activities, and Steve Irving manages the cartography efforts. Mr. Irvine stresses that the project functions only through the efforts of the entire team working together as a unit.







The team has a strict set of standards that cover all aspects of the exploration activities including physical fitness, dive gear, dive planning, data collection, and gas mixing. The team has become staunch supporters of mixed gas diving due the depth of the cave system. Many of the connections range in depth from 200-300 feet. According to Mr. Irvine, the team always mixes their breathing gas so that the partial pressure of oxygen doesn't exceed 1.4 ATA at depth, and 1.6 ATA on decompression. Additionally their Equivalent Narcosis Depth END is calculated for a maximum of 130 feet. To mix their bottom gas, they typically use a partial pressure filling system, adding Helium first then topping off with air.

The team makes 8-10 exploration dives per month, rotating dive responsibilities and dive locations depending on the current focus. Most of the system has general access. For those sites not open to the public exploration permits have been obtained primarily through the efforts of Mr. Irvine.

[Future updates on WKPP activities will be published in DeepTech Journal as they are available.]

NACD 1995 Annual Workshop

The National Association of Cave Divers (NACD) will host their annual cave divers workshop on November 10-12, 1995 at the Holiday Inn West in Gainsville, Florida. The program begins Friday the 10th at 8pm with a social gathering, followed by registration at 7:30 am on Saturday the 11th. Special guest speakers, presentations, and mini-workshops on several cave diving related topics will be presented. Cost for the workshop is $25. Send registration to NACD Committee, P.O. Box 14492, Gainsville, Florida 32604. For more information contact Lloyd Bailey at 904-332-0738.

PSA Rebreather Training

The Professional Scuba Association now offers rebreather training at the Forty Fathom Grotto facility in Ocala. Florida. The course certifies divers to dive with semi-closed systems over a five day training period. Course includes classroom and open water dives. Course topics include packing CO2 scrubbers, gas analyzing, dive planning, emergency procedures, and maintenance. For registration, cost and scheduling contact Hal Watts at 407-896-6294.

Diving Physiology in Plain English

Dr. Jolie Bookspan's new book on diving physiology is a layman's dream come true. It contains well written, understandable, information on all aspects of diving and the human body. The organization is superb and illustrations supportive. Dr. Bookspan is a research physiologist with graduate degrees in exercise physiology and environmental physiology. To order contact the publisher, UHMS, at 10531 Metropolitan Ave, Kensington, MD 20895-2627 or call 301-942-2980.

DeepTech Glossary

ANDI
American Nitrox Divers, Inc.

ATA
Atmospheres Absolute

atm
Atmosphere

Bottom Mix
A breathing mixture used at the deepest portion of a dive

CO2
Carbon Dioxide

DAN
Divers Alert Network

DCS
Decompression Sickness

EAN
Enriched Air Nitrox

EPA
Environmental Protection Agency

FFW
Feet of fresh water

FSW
Feet of sea water

ft/min
Feet per minute

HE
Helium

Heliox
A mixed gas containing helium and oxygen

IANTD
International Association of Nitrox and Technical Divers

NACD
National Association for Cave Divers

NAUI
National Association of Underwater Instructors

Nitrox
Any mixture of nitrogen and oxygen above 20.9% O2

NOAA
National Oceanic and Atmospheric Administration

NSS-CDS
National Speleological Society-Cave Diving Section

O2
Oxygen

PADI
Professional Association of Diving Instructors

ppN2
Partial Pressure of Nitrogen

ppO2
Partial Pressure of Oxygen

PSA
Professional Scuba Association

psi
Pounds per square inch

TDI
Technical Diving International

Trimix
Any mixture of oxygen, nitrogen, and helium

Unit Conversions

1 psi	= 2.31 ffw
	= 2.25 fsw
	= 0.068 ata
1 atm	= 14.696 psi
	= 33.9 ffw
	= 33 fsw
1 fsw	= 0.445 psi
1 ffw	= 0.434 psi
1 kg/cm2	= 1000 gm/cm2
	= 10 m of fresh water
	= 9.75 m of sea water
	= 14.22 psi
	= 32.8 ffw
	= 28.96 in of mercury
1 cm	= 0.155 inches
1 meter	= 39.37 inches
	= 3.28 feet
1 liter	= 33.81 fluid ounces

SOLO DIVING

A Prescription for Self-Sufficiency

by David R. Miner

Why be self-sufficient underwater? The reason seems obvious enough to me but I've met many divers—yes, even some of you tech divers—who simply say those two magic words "buddy-system" and summarily dismiss responsibility for their own safety. I personally prefer to maintain control over my own life, make my own decisions and implement my own plans. Depending on someone else to have two functional regulators, for example, doesn't exactly fit in with my definition of safety.

Becoming self-sufficient underwater is the most important result in diver training. Without the experience, training, and desire to resolve your own situations underwater, there is little chance that your buddy will posses these resources and be able to assist you. Divers who give lip service to the buddy system for a cure all, or remedy for their own lack of training, experience, or confidence place themselves in far greater danger than do confident, well equipped self-sufficient divers. There are many incident reports of double drownings due to improper buddy reactions in an emergency. Your buddy may not and sometimes cannot be there to get you out of a sticky situation.

Don't misunderstand me. I don't support permanently ditching your buddy in favor of solo diving. However, I am saying that practicing proper reactions to underwater emergencies and making a few solo dives to get accustomed to being on your own and building self confidence is not a bad idea. By solo diving, you are experiencing a dive without real prospects of assistance from another diver. This requires a conservative state of mind and a heightened awareness of potential problems. You must observe both your personal condition as well as the environment you're diving in.

Self-sufficiency requires you to become confident in your own ability to safely manage the stress and demands of a problem. Since a solo diver is in total control of the dive, he must assume complete responsibility. Solo divers make their own dive plan, set up their own gear, execute the dive according to their dive plan, and surface with a whole new appreciation for their own abilities. Self-sufficiency requires self-regulation, self-discipline, and self-reliance.

How often, for example, do you check and test your dive equipment prior to the dive? Do you really know how much burn time your light or scooter batteries have, or do you rely on the manufacturers specifications? This kind of question can be posed for much, if not all, of your dive gear. Many divers rely on others for information. This can be avoided by accepting responsibility for your own safety and formulating plans for how to get yourself out of a potentially dangerous situation.

To be self sufficient, divers should honestly assess their own mental and physical abilities to cope with potential problems underwater. Once you've determined your mind-set on underwater self-sufficiency, either seek further training to work towards this goal, or simulate an emergency situation and see how well you resolve it—without your buddy. Most rescue courses teach self-rescue techniques in addition to traditional rescue topics. Self-sufficient divers determine their own limitations.

Everyone can remember some past event from their life experiences where someone let them down. Usually these situations are benign, but occasionally they are serious. The same holds true underwater. Depending solely on a buddy to save your butt is a recipe for disaster.

In fact, I think solo diving should be a requirement for all advanced certifications. We make airplane pilots fly solo before we give them a license. Why not divers too? A solo dive would truly determine how serious and how confident a diver is before he is able to delve into any advanced forms of diving. I don't feel that diving should be considered exclusively an interdependent sport, but a sport that can be enjoyed either on a personal level or within a group.

Solo diving, better than anything else, teaches self-sufficiency. And, as many of us have discovered, it also teaches us about ourselves and our character. This kind of experience can only make us better, more capable divers. With the proper mind-set, training, and equipment, solo diving and self-sufficiency can be safe and enjoyable.

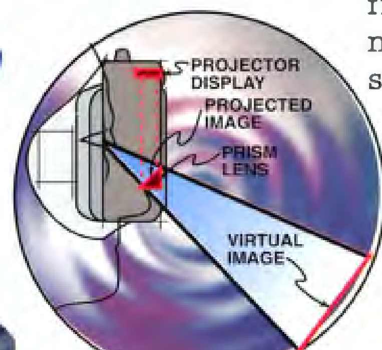
en·a·bling tech·nol·o·gy (en ā´bling tek nol´ə jē), noun 1. An applied science or engineering that, by its very existence, empowers a person to do what he otherwise would be incapable of doing. 2. A scientific or technical breakthrough that lays the foundation for entirely new activities and groups of products.

A Peek Inside the Lab at Cochran Undersea Technology

Cochran's patented hoseless dive computer technology is a classic example of an "enabling technology". The exclusive Cochran Nemesis® dive data telemetry methodology provides a high-throughput data path, rapid data sample rates, extreme reliability and display independence.

The unique ability of the Nemesis to work with multiple displays lays the foundation for more exciting new products... like Cochran's Dive Master™ group diver management system. Dive Master, which allows a dive leader to track key dive telemetry from up to ten neighboring Nemesis series computers, is already in use today by progressive student training operations around the world.

And even more exciting products are being tested now in the laboratories at Cochran Undersea Technology. What would trip *your* trigger? How 'bout a small, low profile dive mask with integrated "heads up" display?



We've seen one under development in the Cochran lab! Codenamed "Spectacle", this mask displays all mission dive information directly at the bottom of the

Spectacle is being developed as part of the growing family of alternate displays for existing Nemesis series dive computers. Insiders expect it to be on the market next year.

Dive Master™ and the Spectacle™ are two more reasons to make your next dive computer a Nemesis II. From Cochran Undersea Technology. World leaders in dive instrument science.

To preview the latest Cochran enabling technology call 1.800.856.DIVE for the name of a Team Cochran retailer near you.

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Diving Into The 21st Century