Underwater Speleology

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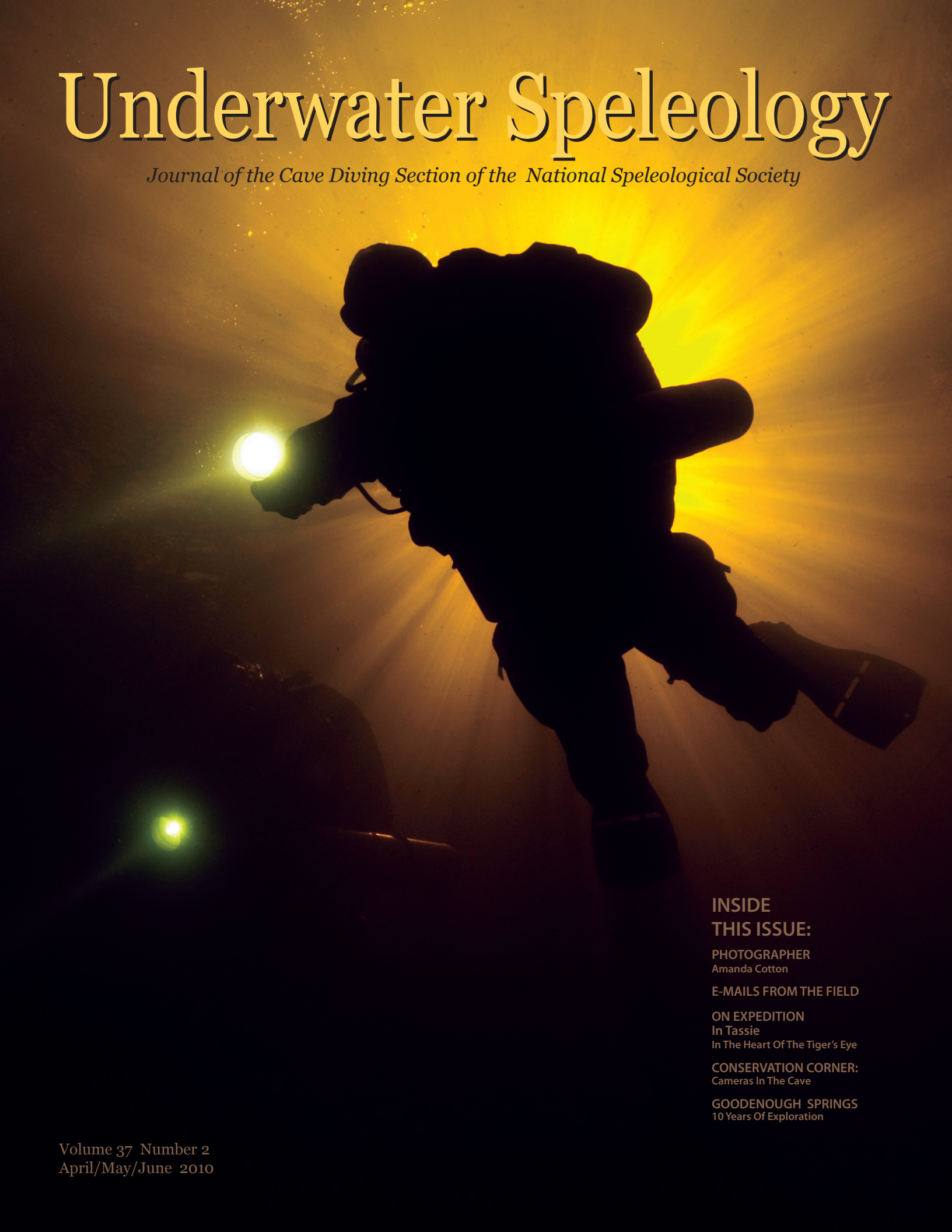

INSIDE
THIS ISSUE:

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Goodenough Spring

By Chuck Noe

Goodenough Springs Exploration Project Summary Report 2000-2010

In the semi-arid desert region of west Texas and northern Mexico, near the present-day cities of Del Rio and Ciudad Acuna, water has always been a precious commodity. Historically, only a few sources in the area, such as San Felipe Springs and Goodenough Springs, have supplied reliable amounts of water for regional inhabitants. For several thousand years, individuals of the Lower Pecos River Culture occupied these desolate lands. Ruins and pictographs dating back nearly 5,000 years to the time of Egypt's Great Pyramids, such as those found in nearby Panther Cave, are evidence of these native Americans' ability to survive and even flourish in their hostile environment.

For area residents in more recent times, Goodenough Springs (known also as Hinojosa Springs) has provided a near-constant source of water for consumption by humans and animals, and for irrigation. Recorded measurements of the spring's outflow have shown an average discharge of 62,000 gallons per minute (gpm). Throughout most of the 1900s, this rate of flow qualified Goodenough as the third largest spring in Texas. In 1968, an international water conservation venture between the United States and Mexican governments constructed a dam on the Rio Grande. Within a few short months of the dam's completion, the upstream river valley filled with water creating Amistad Reservoir and inundating Goodenough Springs. Originally a surface feature, the spring opening now lies submerged beneath approximately 165 feet of impounded water. Once the reservoir was created, speculation arose regarding whether the lake had affected the spring's discharge.

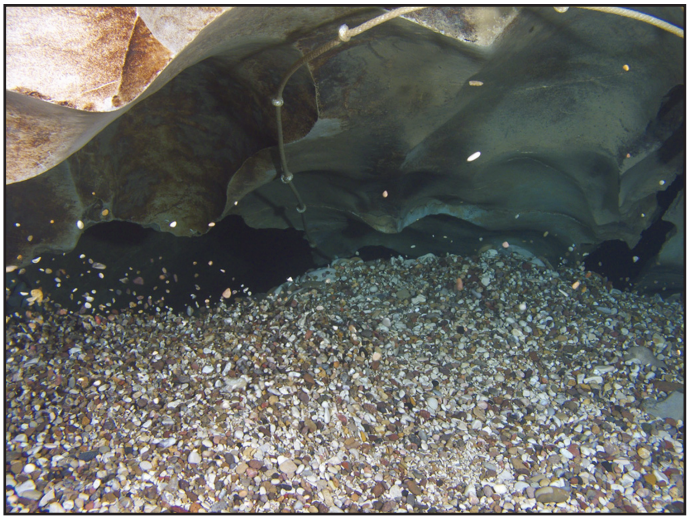
Since the year 2000, the Goodenough Springs Exploration Project (GSEP), an all-volunteer dive team, has conducted research and exploration activities at this site. Over multiple years of regular observations, the GSEP has documented a variable, but substantial, spring outflow. During the course of our investigations, we have observed a wide range of conditions. In 2003, in the weeks following Hurricane Claudette, discharge from the spring was estimated to be in excess of 158,000 gpm. The GSEP has recorded discharge rates approaching 27,000 gpm during periods of normal rainfall. Most recently, following an extended period of drought in the region, the outflow is near historical lows (likely less than 16,000 gpm based on flow velocities obtained in 2009). However, even under these conditions, it is not unusual to see a surface boil or slick on the lake's surface created by water exiting the spring opening more than 160 feet below.

Underwater Investigations - 1995-1999 (Pre-GSEP exploration) The first documented dives into Goodenough Springs were made in early 1995 by R.D. Milhollin and Dr. Ise Kalsi. Later that year, Milhollin was joined by Robert Laird who made the first sketches of the cave's entrance tunnel and main conduit. This particular passage, characterized by smooth chert walls, a loose gravel floor, and an extraordinarily strong

flow, was later named the Fire Hydrant Tunnel. Water velocities typically range from 150 to 300 feet per second (fps) in sections of this tunnel. After several attempts to negotiate the tunnel, Laird was finally able to penetrate this area by repeatedly heaving and anchoring a short piece of heavy iron pipe along the gravel floor. When no longer able to proceed using this technique, Laird managed to pull himself along a ceiling crack to allow the first look at a gravel-filled restriction. The dimensions of this low, narrow opening made it impassable to divers. A line was left trailing from the iron pipe to facilitate access on future dives in the Fire Hydrant Tunnel. Throughout 1996 and into the following year, Laird was joined by Kurt Olsen in the efforts at Goodenough. During dives conducted over the next couple of years, other sections of the cave nearer the entrance were successfully explored and additional, but futile, attempts were made at passing the restriction.

2000

(GSEP beginnings) In October, Chuck Noe, Rick Aurich, and Jonathan Gol sought assistance from Laird in establishing the location of Goodenough, as no marker existed and no GPS coordinates were available for the site. With Laird's help, after several hours of scouting, the cave entrance was found and the group completed a brief dive into the spring. Intrigued by findings on the initial trip, we decided to begin a concerted effort to systematically prepare the cave for further exploration. The first task would be to install a permanent marker/mooring-buoy, anchor, and ascent line. Later jobs would include the installation of heavy knotted guidelines in the cave's primary passages. As diving efforts continued, the extreme difficulties of diving at Goodenough became more apparent. Unlike any other cave we had seen, Goodenough discharged unusually warm water (~82F). Initially, this was considered an advantage as the warm temperature allowed the use of wetsuits, thus minimizing resistance when trying to overcome the strong flow. However, in late fall, as lake temperatures above the spring plummeted, the lengthy decompression stops following deep dives became quite arduous. When divers opted to use drysuits, they encountered overheating issues while exerting in the warm, high-flow cave water. To cope with these conditions, the team elected to conduct the majority of diving activities during those months when the lake temperatures were more tolerable.



First photo ever taken (in 2003) of the Laird Restriction at ~200 ffw. Note the suspended rocks and small opening. Photo by Rick Aurich.

2001

With the installation of a surface mooring system, the team became increasingly concerned about the possibility of open-water divers visiting the site. The team was joined by Mike Gault, Bill Graham, and Daniel Lloyd who assisted in placing a "Grim Reaper" warning sign at the cave's entrance, thus adding a reminder to untrained divers to not enter the cave. As work progressed, team members began to utilize mountain climbing hardware and techniques to more easily perform penetrations to the gravel restriction at the end of the Fire Hydrant Tunnel (FHT). By year's end, a series of pitons, carabiners, and knotted pull-lines were deployed which allowed our first detailed examination of the restriction. Sadly, near the end of October while completing our first survey of the cave, we received news that our dear friend and team member Jonathan had perished in a tragic diving accident in Florida. All planned activities were canceled and the team ended its work for the year.

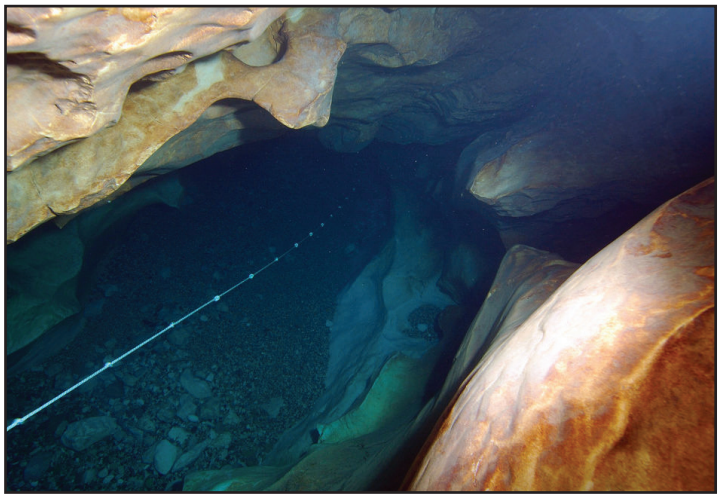
2002

In early spring, a small independent group of divers from Odessa, led by David Diffie, began efforts to replace our nylon ascent line with a lightweight chain. But as that original chain quickly corroded we opted to install a heavier galvanized replacement chain a short time later in July. This year marked the commencement of the first coordinated efforts to pass beyond the restrictive gravel dam in the FHT with the assistance of new participants David French and Paul Thompson. Following a suggestion by Laird, a landscape timber was moved into the cave and staked to the gravel floor just outside the restriction. This provided a new foothold that divers were able to use to stabilize themselves in the high flow and excavate a small hole in the dam (pictured above). Once a portion of the dam was cleared away, this allowed Noe, the team's smallest diver, to barely squeeze through using sidemount gear. Carrying a hammer and knotted line, he installed a steel piton and line into a crack further in the passage and quickly returned to the gravel dam and exited through the ever-shrinking hole. A second penetration beyond the restriction allowed Noe to attach another line to a boulder on the cave floor at 207 ffw. This dive provided the first hint at Goodenough's depth potential as it revealed a steeply-dropping passage. When subsequent attempts to pass the restriction failed, the team experimented with several different methods of removing gravel from the restriction, but all yielded little success. Despite significant effort, the year ended without another dive beyond the gravel dam.

2003

The GSEP conducted the first of several public presentations at the Seaspace dive show in Houston, Texas which led to renewed levels of interest and new participants joining the project. On the first day of summer, Mark Johnson joined Noe and Aurich in the annual rite of maintenance work at Goodenough (replacing corroded/damaged carabiners, pitons, and lines). By this time in the project, we had discovered that aluminum hardware could not withstand the effects of the cave's harsh water chemistry. Corroded equipment was systematically swapped out with stainless-steel components. On this particular trip, Aurich

captured the first photographs of the gravel dam/restriction at nearly 200 ffw. The following month, only five days after Hurricane Claudette made landfall on the south Texas coast, team members were joined by another new diver, South African Lovan Chetty. Successive teams descended from the lake surface only to be turned back prior to reaching the cave entrance. Each team encountered a torrent of dark, turbid water spewing from the cave. The second team pulled down and forward along the new descent chain with our regulators uncontrollably purging and bodies being buffeted violently by the flow. Visibility was only a few inches at best, and progress was halted when the chain disappeared into mounds of newly-deposited gravel outside the cave opening. Two weeks later, Noe and Laird visited the site again and witnessed continued strong outflow. Visibility had improved slightly to approximately two feet, but divers were unable to make headway much beyond the entrance to the FHT. Seven weeks passed before another dive was attempted; at this time visibility had improved to 10-15 feet. A hard-fought journey down the FHT brought Noe to within ten feet of the restriction, but its appearance was far different from what had been previously observed. Surprisingly, most of the gravel had been blown out of the restriction by the prolonged storm surge. Although the opening now looked passable for a sidemount-configured diver, the intense flow remained insurmountable. The season ended with no additional penetrations through the restriction.



Knotted pull-line heading towards the Laird Restriction in the Fire Hydrant Tunnel. Photo by Ryan DeSpain.

2004

On the first dive of the year, Noe, Aurich, and Gault dived the cave and verified that the gravel restriction had indeed been opened by the incredible flow experienced in late 2003. The 1/2" thick nylon pull-line was intact but the thinner guidelines had been torn loose from their tie-offs. Although passing through the restriction was now possible in sidemount gear, the force of outrushing water prevented taking a stage bottle due to the increased drag created by the additional cylinder. After making the decision to remove his stage bottle, Noe pulled through the restriction and then dropped down a steep vertical fissure to a depth of 275 ffw. A new guideline was tied off to a boulder overhanging a large room below. More passage was visible winding downward from this location. The following month, Gregg Tatum, a new setup/support diver from Austin, joined the team. On this mid-August dive Gault became the second diver to ever pass the restriction. After nearly relenting, he slowly pulled ahead and made a brief visual survey of the adjacent room before exiting. In typical fashion, the remaining dives involved maintenance of the lines and hardware, and the installation of a new commercial-grade mooring buoy at the surface. In August, a seven-man team was assembled to undertake the most ambitious project dive to date, to extend the depth of exploration. Pee Wee Dwire provided both diving support and an additional boat while professional photographer Jesse Cancelmo captured images from the surface and cavern opening. Using a custom-designed rope system, setup divers required several dives to pull stage bottles through the restriction one-by-one. Noe and Gault then teamed up for the push dive. Using travel gas to reach the restriction, each diver then retrieved a deep-stage to augment gas supplies provided by sidemounted, steel 125 cf cylinders. This deep dive revealed even larger passages with steep eroded walls. Before turning back, the divers noted the cave's continuing descent. At only 443 feet of linear cave penetration, the team was 393 feet deep and 580 feet from the lake's surface. The final dives of the year included another new support diver, Kyle Gage from Austin. Maintenance and winterizing duties were the primary focus of the event although Noe and Gault executed another brief dive beyond the restriction. On the final dive, Gault took the first photographs documenting the flowstone formation in a shallower section of the cave.

2005

This dive season was notable for the creation of a new partnership with scientist and doctoral student, Ray Kamps. In association with Texas State University and Dr. Alan Groeger, Kamps was conducting federally-permitted research at Amistad Reservoir and Goodenough Springs. Our dive team volunteered to deploy instrumentation in the cave to assist with Kamps' studies; in return, we would benefit from the addition of another capable partner and use of a state-owned boat. This association would also bolster the scientific credentials for our project. Our initial joint efforts involved installing Hydrolab Datasondes and temperature-recording thermistors. On later excursions, we were fortunate to be able to use an expensive Doppler flow-velocity recording instrument. Carrying this device into the FHT, we recorded an average velocity of approximately 255 feet/minute in the newly-designated "Laird Restriction". Even more importantly, utilizing a precisely created grid at the cave's opening, we conducted the first accurate spring-flow measurement at Goodenough since its inundation in 1968. As the year continued, additional divers including Ryan DeSpain, Ryan Eastman, and Jeff Chance joined our efforts. Instrument deployment and water sampling became a regular part of team operations as we began routine monitoring of site conditions and characterization of water quality. It quickly became obvious that Goodenough was an ever-changing resource. This year also marked the beginning of increased underwater photo-documentation of project activities.

2006

We began our seasonal diving operations with a renewed effort to safely extend our previous exploration of Goodenough.

Noe designed and constructed a heated-water supply system that divers could use to flood their suits during ascent, to allow more effective off-gassing during long deco stops in the cold lake water. The team also acquired several Sensus Ultra data recorders that were deployed at various locations in the cave and lake to provide continuous measurements. Most importantly, Noe also acquired a 24' pontoon boat and reconfigured it from the deck up for use in the GSEP project. A third pontoon was retrofitted to the craft to fully support the immense load of dive cylinders and other essential equipment. Modifications and continual testing of the heated-water system proved it possible to comfortably complete long deco stops. Houston diver Martin Pollizotto joined the team and quickly familiarized himself with the cave to be able to help further ongoing mapping efforts. Kamps purchased another Hydrolab Datasonde which we deployed for the first winter-long comprehensive data-recording interval.

2007

Prior to beginning of regular diving operations, the project purchased three additional Hydrolab Datasonde water-quality instruments, allowing full-time deployment of redundant instrumentation. Kamps, now a member of the dive team, completed basic SCUBA training to expand his role. Larry Hack, another Houston diver, and Jesse Armantrout completed their first dives with the team. Since Hurricane Claudette's impact on the cave, a considerable amount of gravel in the FHT had been re-deposited in the low bedding plane of the Laird Restriction. In addition to equipment maintenance and instrument deployment activities, the team again focused on keeping the restriction passable. As the original passageway continued to become more obstructed, we eventually established a new path with a separate 1/2" pull-line in September to improve our ability to access the restriction. The group was unable to organize a full team event for the remainder of the year; however, DeSpain and Pollizotto completed necessary instrumentation swaps in December.

2008

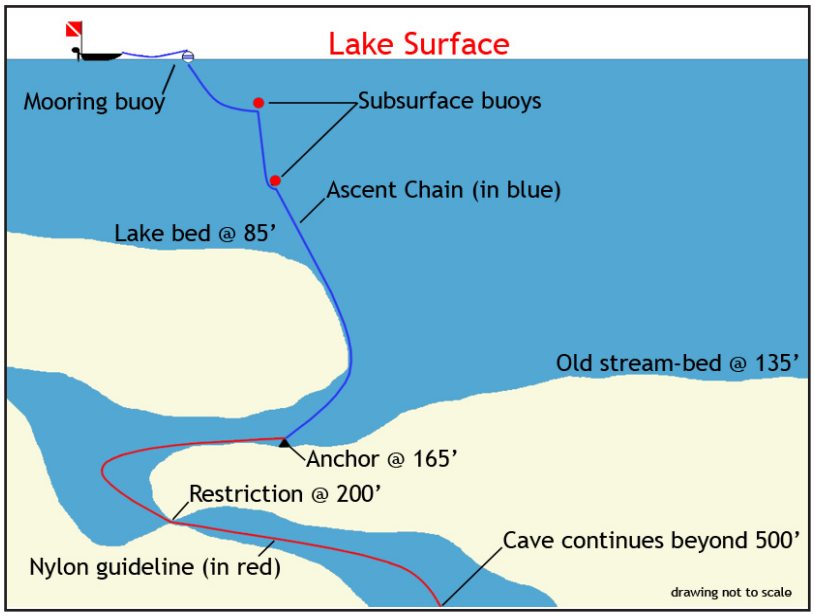
This year was one of great accomplishment for the GSEP. Following a late-winter visit to replace depleted batteries in various instruments, work began in earnest during May. New participant Jay Dryden assisted the team in performing maintenance and inspection services on the mooring system. At that time we noted a continuing degradation of the mooring chain due to corrosion. We renewed efforts to enhance the accuracy and resolution of the survey of the system by placing new station-markers throughout the cave. In June, survey work continued and a knotted pull-line was finally installed beyond the restriction to a depth of 280 ffw. This much-needed safety enhancement would now help divers exit this steep section of the cave, even in the event of a catastrophic buoyancy failure. Goodenough was demonstrating continually strong flow and the shape of the gravel restriction continued to change, effectively blocking the original passage. Still, by mid-summer, conditions were quite good for another attempt at extending the previous exploration limits. Over the weekend of July 19-20, seven members of the GSEP combined efforts to facilitate a record-setting exploration dive to a depth of 515 ffw. This was believed to be the deepest cave exploration performed in the United States to date. With invaluable assistance and setup work of team members Aurich, DeSpain, Dryden, Eastman, Hack, and Tatum, the project's director, Noe, completed the successful dive in a surface-to-surface time of 6.5 hours. The lead diver utilized a total of 12 gas cylinders and setup/support divers used an additional 27 cylinders to complete the dive within a comfortable margin of safety. Noe reported another steep drop in the cave profile near 400 ffw to a gravel floor at approximately 500 ffw. The cave walls were deeply eroded from the repeated rise and fall of gravel within the system. At the bottom of this "pit", the cave turned 180 degrees underneath itself and headed off in a wide passage at a much shallower pitch of <15 degrees. At 515 ffw, the guideline was secured to a 3-pound lead weight and placed on the cave floor. Even in this large passage, Noe reported flow of sufficient force to push him backwards as he tied off the guideline. Noe's ascent was uneventful except for the shock of entering the cold temperatures found at the lake bottom. The heated-water system provided much-needed supply of 90-100F water to the divers' wetsuits, making decompression more efficient and comfortable. Noe consumed bananas and Gatorade throughout the shallower stops while perusing the most recent issue of Popular Mechanics. All deco was completed in-water and no divers reported even the slightest indication of a decompression injury. For the significant achievement, the team was awarded the 2008 Exploration Award by the NSS-CDS. By September, the flow had unexpectedly increased to the second highest level encountered by project divers in the nine years of their investigation. Visibility was poor and the FHT had become impenetrable due to the strength of the discharge. In spite of the flow, divers were able to swap several instruments before tending to mooring maintenance issues.

Before the year ended, the GSEP documented another accomplishment rivaling the deep exploration dive. In November, our first technical paper describing scientific studies at Goodenough was accepted for publication by the peer-reviewed Hydrogeology Journal. Research scientist and GSEP team-member Ray Kamps was the lead author with team members Gregg Tatum and Mike Gault serving as the team's co-authors. Dr. Alan Groeger of Texas State University served as a fourth co-author on the article. Titled "Goodenough Spring, Texas, USA: Discharge and water chemistry of a large spring deeply submerged under the binational Amistad Reservoir," the paper examines the effect of this spring on the water chemistry of the surrounding lake, rivers, and aquifer. Additional research continues with plans for expanded publication efforts in the future.

2009

Following our successes of the previous year, project goals involved further development of the team to facilitate the continuation of deep exploration. However, prior to our first planned dives, we were contacted by area open-water divers who reported that the mooring chain had broken at about 160 ffw. The remaining chain, sub-surface buoys, and surface mooring ball had drifted 0.5 miles from their original location. For the first time in nearly ten years, the spring was once again unmarked. While we were glad to hear that no injuries resulted from the mooring failure, there was disappointment as we learned that our plans to replace the equipment were a couple of months too late.

A small group mobilized in May to retrieve what remained of the mooring system and evaluate the situation. Aided by a new team participant Ian Riddington, and independent open-water divers Dennis Spangler and Mark Bewley, the mooring components were located, recovered, and examined for the cause of the failure. While most of the chain remained in good shape, that portion in the transitional zone from cave to lake water was severely eroded through an apparent galvanic reaction. A funding drive was organized to pay for 220 feet of new mooring chain; this time we decided to upgrade from galvanized steel to 316 stainless-steel construction. With generous donations from our membership, the necessary funds were quickly obtained to purchase chain, hardware, and sacrificial anodes. The anodes protect the new mooring from corrosion-inducing electrical potentials existing between the waters of the spring and lake.



Mooring Buoy Layout

On the first weekend of June, eight team members completed the re-installation of the strongest and most permanent mooring system used to date. In addition to the new, heavier gauge stainless-steel chain, a second, redundant concrete anchor was installed to add additional strength and durability to the mooring system. We were also pleased to discover that our longest instrumentation deployment to date was recovered with 233 consecutive days of data. On subsequent events, worn pull-lines in the cave were replaced. Team members also worked to prevent imminent blockage of the Laird Restriction as extreme drought in south Texas and northern Mexico brought sharply decreased flow to the spring. Once again employing the Doppler water-velocity recorder, we found that flow had already dropped to 50% of previous recordings with continuing decline. Ward Beecher made his first dives at Goodenough and proved adept at moving bucket-loads of gravel.

By August, we were able to address a previously stated goal of having certain team members familiarize themselves with deeper portions of the cave. Divers Aurich, DeSpain, and Tatum completed their deepest dives to date at nearly 350 ffw. Progressive penetration and depth attainment is the best method of advancing one's exploration limits safely, and all GSEP divers are afforded a continual progression towards their own personal exploration goals. During this series of dives, DeSpain captured the first photographs taken beyond the restriction. These images are some of the best documentation of Goodenough obtained to date and have won awards in photographic contests. In September, a small team convened to conduct water-sampling dives for a new cooperative effort with the Texas Water Development Board (TWDB). In conjunction with the Goodenough sampling task, team members collected samples at San Felipe Springs (the municipal drinking water source for the City of Del Rio), and at Slaughter Bend Springs on the Devil's River north of Del Rio. Plans are to continue to acquire samples for laboratory analysis for the TWDB to further our research efforts at Goodenough and the associated aquifer. As the year concluded, the GSEP confronted a controversial situation. In response to issues related to potential legal liability and site access, the project's Board of Directors elected to temporarily remove mooring equipment and cave lines that were purchased, installed, and maintained by our team. We support the right of others to dive this public site, as evidenced by the significant amount of information provided to the public about Goodenough (including site GPS coordinates and depths of cave features). However, the GSEP does not provide tacit approval or assistance to individuals whose activities we regard as potentially detrimental to our project's goals.

2010

Currently, the project is making preparations for another season of research and exploration. Plans include additional discharge velocity measurements and a continuation of water quality sampling and analysis efforts. The GSEP is proud of its safety record and research contributions to the knowledge base of the hydrogeology of Goodenough Springs. Since the inception of the project, over 30 individual team participants have safely completed more than 700 working dives at the site, created a database of physical and chemical measurements, and explored one of the most unique and challenging underwater caves in North America.

Project Officers

The following individuals currently serve as members of the Board of Directors: Chuck Noe, Rick Aurich, Mike Gault, Robert Laird. and Gregg Tatum

Acknowledgements

The GSEP Board of Directors wishes to thank all past and present team members and other contributors for their hard work and financial support. We also wish to recognize the following entities for their assistance and support to our project: NSS-CDS, NACD, Dive Rite Manufacturing, Gulftex Scuba, O2 Dive Technologies. U. S. National Park Service

Project Website

For additional information and photos of our ongoing research and exploration, please visit our website at: www.goodenoughsprings.org