Tech Diving Mag

Research - Development - Exploration

Deep Stops Revisited

The First Helium Dives in the Gulf of Mexico

Special Edition – June 2018

Contents

Front cover image courtesy of René B. Andersen.

Editorial

Welcome to this special edition of ***Tech Diving Mag***.

This special edition contains two book excerpts. The first is from the revised edition of ***Deep Into Deco: The Diver's Decompression Textbook***, which has been released earlier this year,and the second is from ***The History of Oilfield Diving: An Industrial Adventure***.

In case you don't know, Ultimate Planner has been updated to accommodate for the M11F6 algorithm, in addition to the already-existing VPM-B and ZH-L16. Determined by late Dr. Bill Hamilton and colleagues during the development of decompression tables for the Swedish Navy, M11F6 has worked well for both nitrox and trimix diving. Download your free, Lite version and give it a play.

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Asser Salama
Editor, *Tech Diving Mag*

Deep Stops Revisited
By Asser Salama

We have seen how theories about deep stops have changed over time. At first, the norm was to follow the schedules generated by raw dissolved-gas models as is. Then some anecdotal data favored inserting arbitrary deep stops by using protocols such as Pyle or GVE. A significant step on the road was tailoring gradient factors as a one-stop M-value reduction mechanism that provides both deep stops and increased conservatism. Finally, automatically generated deep stops became an inherent part of the newer dual-phase models. The vast majority of divers now use one of the latter two.

These emerging trends led the navies around the world to explore further. They are still investing time and money in developing dissolved-gas models such as the USN E-L. They wanted to make sure they would be on the right track if they changed their research directions because there is still a debate on issues such as when to stop, for how long, and how often. More important, is there any evidence that deep stops limit bubble growth or decrease the risk of DCS?

Wayne Gerth, David Doolette, and Keith Gault from NEDU presented their work at DAN's Technical Diving Conference in January 2008.[1] They concluded two distinctive classes of deep stops can be identified. The first class is stops added deeper than the prescribed by a given decompression algorithm. This class would be beneficial under certain circumstances, but it should be remembered that it serves to fix a deficient algorithm. Adding these deep stops cannot allow cutting time off the originally prescribed schedule unless switching to a breathing gas with a higher ppO2 is associated with the added stops. This is a direct answer to the divers who incorporate a GF low to add deep stops and concurrently increase the GF high above 100%, claiming that bubbles have been suppressed as a result of the introduced deep stops.

The second class is deep stops that arise in comparison of schedules for a given ascent computed with different algorithms and types of supposedly safe ascent criteria. A serious attempt to empirically confirm the theoretical benefits of deep stops by conducting a comparative study was unsuccessful. The results of this attempt were actually at odds with the anecdotal data that favor deep stops.

In June 2008 a workshop was conducted to clarify the role of deep stops and to point out what our current thoughts are as well as indicate future research needs.[2] This workshop brought together a number of high-profile speakers, and some heated discussions took place. Anecdotal data seemed to favor deep stops. On the other hand, two presentations of particular importance from the U.S. Navy and the French Navy indicated they were worse for decompression.

The same work of the NEDU group was presented again. It included the results of a controlled comparative study of two approaches — the traditional dissolved-gas model approach that prescribes schedules that advance rapidly to shallow stops where most of the total stop time is spent, versus the recent dual-phase model approach that prescribes schedules with total stop time skewed toward deeper stops. Divers wearing swimsuits and T-shirts, breathing surface-supplied air via full-face masks, and immersed in 30°C (86°F) water were compressed to 52 meters (170 feet) for 30 minutes. Divers were decompressed with stops prescribed by one of two schedules. The first schedule was generated by the VVal-18 Thalmann dissolved-gas model. The second schedule included deeper stops and was generated by the BVM(3) bubble volume model. The two schedules were matched for total stop time, which was 174 minutes, making the total run time 204 minutes.

Unexpectedly, the DCS incidence in the deep-stops schedule were more than three times higher than that in the other schedule.

Moreover, two of the DCS cases resulted from following the deep-stops schedule involved rapidly progressing CNS DCS manifestations (Type II DCS, which is more serious than Type I DCS, which usually involves joint pain frequently accompanied by localized swelling, itch and/or skin rash). The study concluded that the deep-stops schedule had a greater risk of DCS than the matched traditional schedule. Slower gas washout or continued gas uptake at the deep stops offset the benefits of reduced bubble growth at deep stops.

The work of Jean-Eric Blatteau, Michel Hugon, and Bernard Gardette from the French Navy was presented, including the results of their studies on deep stops versus conventional schedules for both air and trimix dives until a 100-meter (330-foot) depth. They concluded the advantages of deep stops in human decompression have yet to be demonstrated.

NEDU's original study was released to the public in July 2011, and it struck a nerve with a lot of technical divers. In December 2013 a poll was created on one of the popular technical-diving Internet forums asking whether the participants agreed that NEDU study made sense. A total of 112 technical divers participated, with 91% (102 out of the 112) saying yes, it made sense, and we should actually be more cautious about deep stops. Ten out of the 112 (a little less than 9%) said the study was flawed. The discussion was very interesting.

The participants argued that dual-phase models were unproven, regardless of the large databases of successful dives their advocates collected. On the other hand, empirically derived dissolved-gas models, such as Bühlmann's ZH-L16, worked because they are based on actual decompression trials. In conclusion, a common feeling was that the scientific data we have in hand would not seem to support our current deep-stop practice. It was intriguing to see accomplished technical divers talking about significantly increasing their GF low to the 40 to 50% range to accommodate shallower first stops.

In 2017 a study aiming to compare Bühlmann's ZH-L16 algorithm with gradient factors 30/85 versus the "ratio decompression strategy" was published.[3] Ratio deco is a technique for calculating decompression schedules without using dive tables, decompression software or dive computers. It is generally taught as part of the so-called "Doing It Right" philosophy of diving and the schedules it generates employ deep stops. The study's comparison was based on an analysis of changes in diver circulating inflammatory profiles caused by decompression from a single dive. 51 technical divers performed a single 25-minute trimix dive to 50 meters (165 feet) followed by EAN50 and oxygen for decompression. Twenty-three divers decompressed according to ZH-L16 with gradient factors 30/85 and the rest decompressed according to a ratio deco schedule. Peripheral blood for detection of inflammatory markers was collected before and 90 minutes after diving. Venous gas emboli were measured 30 minutes after diving using 2D echocardiography. Matched groups of 23 recreational divers and 25 swimmers were also enrolled as control groups to assess the effects of decompression from a standard air dive or of exercise alone on the inflammatory profile.

Echocardiography observation post dive showed no significant differences between the two decompression procedures. Divers adopting ratio deco showed a worsening of post-dive inflammatory profile compared to the ZH-L16 group. The study concluded that the ratio deco strategy did not confer any benefit in terms of bubbles but showed the disadvantage of increased decompression-associated

secretion of inflammatory chemokines involved in the development of vascular damage.

In conclusion, the current position on deep stops was that although they were operational trends, documenting their efficiency was difficult because all the reported cases were uncontrolled anecdotes, not scientific data.

References

1. Vann RD, Mitchell SJ, Denoble PJ, Anthony TG, eds. *Technical Diving Conference Proceedings*; 2008 January 18-19. Durham, NC: Divers Alert Network; 2009.

2. Bennett PB, Wienke B, Mitchell S, eds. *Decompression and the Deep Stop Workshop Proceedings*; 2008 June 24-25; Salt Lake City, Utah. Durham, NC:Undersea and Hyperbaric Medical Society; 2008.

3. Spisni E, Marabotti C, De Fazio L, Valerii MC, Cavazza E, Brambilla S, Hoxha K, L'Abbate A, Longobardi P. A comparative evaluation of two decompression procedures for technical diving using inflammatory responses: compartmental versus ratio deco. *Diving Hyperb Med* 2017, 47 (1): 9-16.

Excerpted from the revised edition of *Deep Into Deco: The Diver's Decompression Textbook*. The title is available at:

https://www.bestpub.com/component/hikashop/product/deep-into-deco-the-diver-s-decompression-textbook-revised-edition.html?Itemid=2561

https://www.amazon.com/Deep-Into-Deco-Decompression-Textbook/dp/1947239090

"As divers push the boundaries of traditional recreational diving limits, the value of a comprehensive yet immensely readable source of information has become paramount. *Deep Into Deco* Second Edition is an outstanding compendium of information on decompression history, theory, and practice. It also contains supporting information from many of the diving world's most knowledgeable pioneers and innovators."

-Dan Orr, President Emeritus of Divers Alert Network (DAN)

"*Deep Into Deco* is a stimulating read which covers almost every facet of diving from breathing to technical decompression. It is well referenced and dives into (forgive the pun) great detail concerning the past and present of diving theories. I recommend this book for all divers from novice to technical expert because Asser Salama makes even the most difficult topics seem easy and understandable. No diving collection is complete without this super overview book. I will keep mine on the coffee table as a discussion piece."

—Commander Joseph Dituri,
US Navy Saturation Diving Officer (ret) and Vice President of IANTD

"This book is long overdue. And it's worth the wait. What Asser Salama has accomplished with this book is remarkable. He has taken that early history of experimental trial and error and produced a stunning reference text that brings the science into sharp focus."

–Bret Gilliam, founder of TDI

This second edition of *Deep Into Deco* has been fully updated to reflect the latest research outcomes. Chapter summaries have been added to give a quick overview of each chapter. A new section on nitrogen and helium kinetics has been added as well as a second appendix for calculating the acceleration in post-diving no-fly time associated with breathing surface oxygen.

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DEEP INTO DECO: THE DIVER'S DECOMPRESSION TEXTBOOK

DEEP INTO DECO

REVISED & UPDATED

The Diver's Decompression Textbook

Asser Salama

The First Helium Dives in the Gulf of Mexico
By Christopher Swann

An excerpt from *The History of Oilfield Diving: An Industrial Adventure*

During the first half of the 1960s, the diver Shell Oil relied upon more than any other in the Gulf of Mexico was Norman Ketchman. Like most Gulf coast divers, Ketchman was essentially a freelancer in that he got his own work; but to secure insurance coverage he operated in conjunction with Gulf Coast Diving Services, Norman Knudsen's one-man company. Although Ketchman had not been in the Gulf as long as Knudsen, whose experience in the area predated offshore drilling—he was a former shrimp fisherman who started diving in the US Navy during the Second World Wa4—Ketcman proved more adept at securing contracts with the oil companies, the most important of which was the account with Shell.

Since Shell had, or was about to have, a considerable amount of work in deep water, Knudsen and Ketchman decided they should demonstrate that they were able to dive with mixed gas: something no company in the Gulf was yet capable of doing. To pull this off Knudsen and Ketchman lined up Peter Edel, a chain-smoking deep-diving specialist from Connecticut.

Edel was completely self-taught. When a senior naval officer asked about his qualifications at a diving symposium, he replied 'high school.' He started out doing light salvage at weekends to earn extra money, using heavy gear and a Desco mask from a 36-foot boat. When the 'scuba craze' hit, he found he could no longer compete and he turned his attention to the physics and physiology of diving. His studies led him to the conclusion that the Momsen computational method the US Navy had used to establish the helium-oxygen decompression tables was far from satisfactory.

To Edel, this was obvious. He wrote to Captains George Bond, Walter Mazzone and Robert Workman, whom he considered the pre-eminent authorities in America, and to Dr Val Hempleman at RNPL in England. Through the correspondence and discussions that ensued, Edel obtained an informal education in decompression modelling, from which solid point of departure he developed a set of helium tables that took into account the difference in gas uptake and elimination between work and rest: something Behnke had demonstrated in a study some time before but which, according to Edel, no one was yet factoring into decompression tables.

From theory, Edel moved to chamber dives, which he financed with donations and grants from various firms. He started out modestly enough at 200 feet, then progressed to 20–30 minutes at 400 feet, compressing at 100 feet per minute with helium-oxygen and switching to a nitrogen-oxygen mixture on ascent. The longest runs were in the 170–220 foot range, the deepest a bounce-dive to 500 feet breathing a helium-nitrogen-oxygen mixture. In the deep experiments Edel discovered that the depth at which he switched to nitrogen-oxygen during decompression was critical. Shifting at 150 feet or deeper resulted in a central nervous system bend in the form of a violent vestibular disturbance. In all, including two central nervous system episodes, Edel got the bends some two dozen times.

In October 1963, Edel went to Morgan City to make his preparations with Knudsen and Ketchman. With him, he brought a Jack Browne dry suit with an attached Desco mask fitted with a side-mounted regulator. This gear was to be used on the dives in conjunction with an incredibly complicated collection of plumbing on the diver's chest.

The rest of the equipment consisted of a topside manifold connected to the regulators and gas banks, an air backup system, and a standard pneumofathometer on the diver to read the depth. Edel's deftest touch was to hook a differential pressure gauge into the supply and the pneumofathometer to ensure that the diver was always supplied at the correct pressure. The man who was given the job of putting most of this together, on the strength of having a degree in civil engineering, was Mike Hughes, who had been working with Gulf Coast Diving Services since that March.

Knudsen and Ketchman had a rival in the helium stakes: Sanford Brothers. Sanford was the dominant diving company in Morgan City and it was common knowledge that Joe Sanford wanted his company to be the first in the Gulf to make a mixed-gas dive. To that end, Sanford had hired Jack Lahm, a US Navy Master Diver experienced in helium diving who had just retired after 22 years in the navy.

Everybody expected Sanford to beat Gulf Coast Diving Services hands down. But Sanford was running into delays. According to Tom Angel, Sanford's assistant diving superintendent, this was because Lahm had difficulty obtaining the dome-loading regulators he needed for the gas manifold. Furthermore, when they finally arrived, it turned out that the supplier had not cleaned them properly, with the result that the first application of pressure dislodged particles of grit, which ruined them.

The story Hughes heard was that the regulators were not the same size as those shown in the US Navy Diving Manual, and were thus deemed inadequate—although they were a new model which had superseded those in the manual.

'It was actually a better regulator, with a higher flow-rate, but they did not know enough about specifications to understand that part of it,' said Hughes. They just knew it wasn't as big as the one in the picture so they sent them back.'

Photograph of Mike Hughes, showing the elaborate chest manifold he built to allow gas switching during the dives. The tender is 'Corky' Downer (*James Smith*)

In any event, when Knudsen and Ketchman went to Union Carbide to order their helium they found that Sanford Brothers already had a supply waiting to be picked up. According to Angel, the manager at Union Carbide told them Lahm was going to need all of it; but he telephoned him anyway. On learning that Lahm had postponed his dive for a week to ten days—enough time to lay in a replacement stock—he sold the order to Knudsen and Ketchman. So while Sanford waited for the replacement regulators Knudsen and Ketchman went out and made the first helium dives in the Gulf of Mexico.

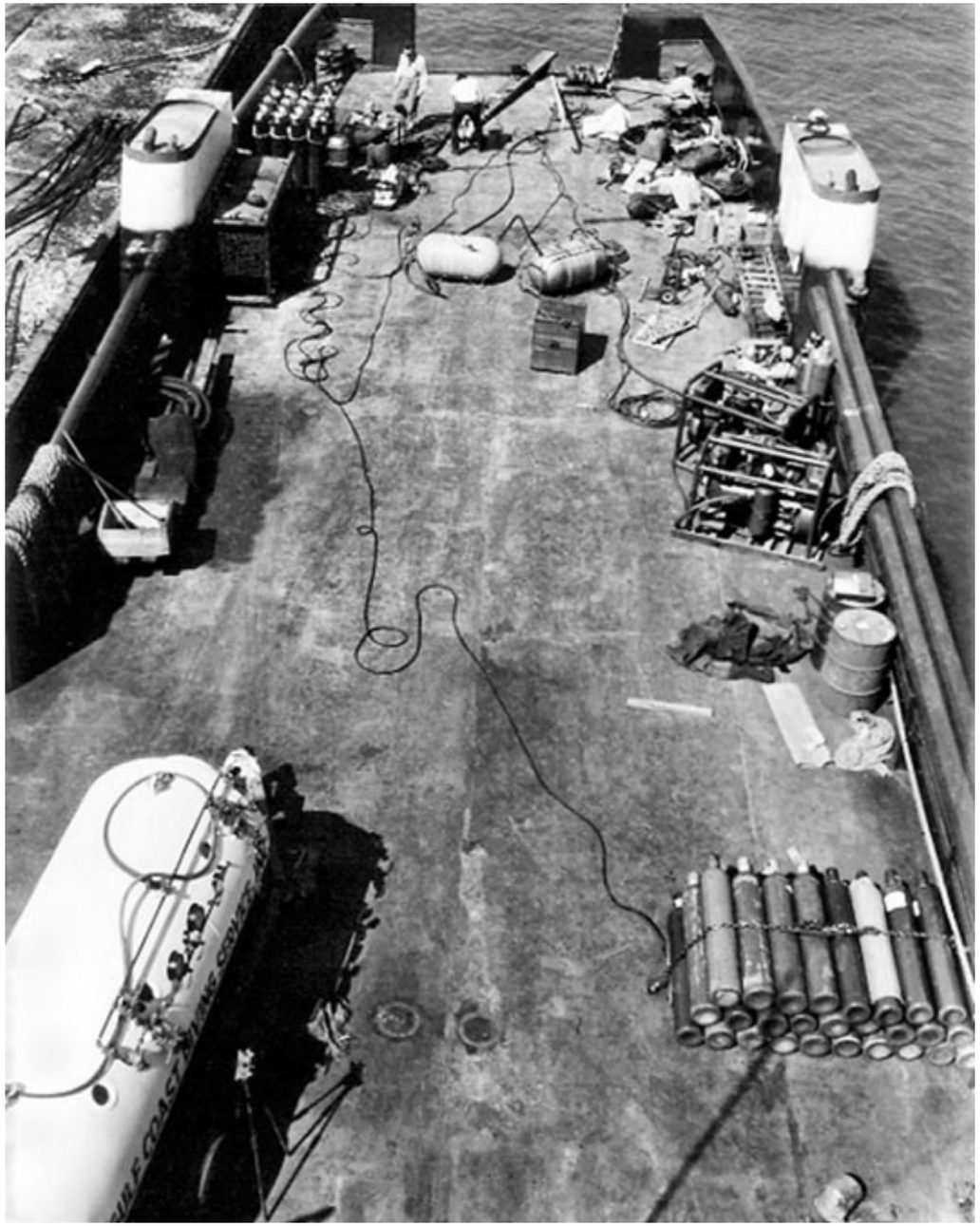
Since the main object of the exercise was to put on a demonstration for Shell, on the morning of Sunday October 20th the party anchored within earshot of the *Blue Water I*, the world's first semi-submersible rig, which was drilling for that company. Mindful of Keller's dive the year before and nervous about any potential liability, however, Shell made it clear it was not officially sanctioning the activity.

The first man down was Edel. The descent and ascent were to be made on a stage with a backup supply of gas sufficient (at least in theory) to bring the diver back to the surface should he lose his surface supply. Edel's procedure for the first dive called for the descent to be halted at 30 feet and at 60 feet to check the equipment: a step that was eliminated in the dives that followed. During the checkout Edel breathed pure oxygen to delay the start of the dive—since from a decompression standpoint, as long as a diver is not taking up inert gas he is considered to be still on the surface. That Edel was also flushing the nitrogen out of his system was purely a by-product. The dive was to begin on completion of the checkout, with the switch to the 84% helium, 16% oxygen mixture that was to be used all the way to the bottom.

However, as Hughes later recounted, Edel did not get beyond 60 feet: 'Peter had put on layers of thick wool underwear under the Jack Browne suit. Because of all the messing around getting him in the water with all this new equipment, he was on deck baking in the sun in that hot underwear for probably a couple of hours, with sweat pouring off him and with him dehydrating. By the time he got in the water, even a fit man would have been a wreck, and Peter was far from fit. He had an associate he had brought down with him, a nice guy but not terribly knowledgeable, who worked as his helper. We were basically taking our directions from Peter, who was in the water, and this guy was the only person on deck who supposedly knew anything.'

'Peter got down to 30 feet and I went down and checked him out. The fittings on his chest were leaking like mad, so I tightened them up with a couple of crescent wrenches, trying to reduce the flow of bubbles so he could see. The stage was bouncing around and he didn't look so good through the faceplate; he looked kind of wide-eyed and strung-out. I went back up after tightening the leaks and then he said he wanted to be lowered to 40 feet, then 50 feet, then 60 feet. We explained to him that he was on pure oxygen and it was time to shift over. He said, 'I'm having trouble with my ears. I need to make sure I can clear my ears before I shift over.' Of course, the idea of breathing oxygen was to delay the start of the dive. The problem was, he never quite got ready. I think he had been breathing oxygen for close to 45 minutes, and he was still messing around at 60 feet. I had made a couple of dives just to look at him, and he looked bad.

'I had just got back to the surface and pulled my mask off, and I walked over to the diving phone and I heard this really incredible laugh, like the laugh of a maniac. It was the weirdest sound I've ever heard. It was enough to chill your spine. Then I heard a gurgling sound. I thought, Crap! What's that? I threw my mask back on and hit



The deck of the MV Floodtide before the first dive (*James Smith*)

the water. In the meantime, they tried to reach him, and couldn't; so they started up on the stage. I met it at about 20 feet. Peter's faceplate was full of water and his eyes were rolled back, so we jerked him on up and cut open his suit around the neck and got the mask off. Water was gushing out of his mouth and he wasn't breathing. We rolled him over and squeezed the water out of him and gave him artificial respiration. He started coughing and coming around. He was delirious. He was saying, "Help me! Help me!" Here was our guru, laid out on deck!

'We finally got him to the point where we thought he was probably going to live, and we hauled him inside and put him in a bunk. He was totally exhausted and he passed out and went to sleep. Then we had a big conference as to what to do next. We were all pretty shaken by this event, and our expert was now unconscious. A logical person might have decided to back off and try again, but Ketchman said, "Hell! I'm paying for half this trip and I want to make a dive." '

With this, they cut away the remaining canvas of the Jack Browne suit from around the mask. Ketchman then put on a wet suit, the mask and the array of chest-mounted plumbing, got on the stage, and was lowered without fanfare to the bottom. The depth was 335 feet, a record for the Gulf. He was on the bottom for between ten and 20 minutes, during which time he filled a canister with mud to present to Shell as a unique and rather messy calling card. Approximately four and a half hours later, after going through the gas switches on the way up according to Edel's schedule, he climbed on board, fit and happy. At about the same time, Edel emerged on deck, looking completely shot.

Then Knudsen wanted to make a dive. The idea, after all, was to share the glory as well as the expenses; but since darkness had fallen, it was decided he should wait until daylight.

In the morning it quickly became apparent that Knudsen wanted to take the record from Ketchman, for he radioed the *Blue Water* to ask the depths in different directions, after which he got the skipper to move a short distance.

Sure enough, when he was lowered to the bottom, he was two feet deeper than Ketchman had been; but the deck crew, Hughes related, were not about to tell him: 'He asked how deep he was. We told him 335 feet—which was the same as Ketchman. He said, "Huh ..." You could tell he was thinking what he could do to get a little deeper. At this point, he was still on the stage. He said, "Just a minute." You could hear him; you knew he was getting off the stage and lying down on the mud. He said, "How deep am I now?" We checked him with the pneumo again. He was about three feet deeper but we told him the same depth as before. He started cursing, then he said, "Just a minute." We heard him grunting—I guess he was digging a hole—then he said, "How deep am I now?" So we took another reading, and he was about two feet deeper. I don't know if he stuck his pneumo in the hole but we kept telling him, "335." We never told him he was actually deeper. Finally he gave up and got back on the stage, and we cranked him up and decompressed him. Everything was fine. But as far as he knew—and I believe as far as he knows today—he and Ketchman went to the same depth. We didn't want Knudsen to take the record away from Ketchman, who had the balls to make the first dive.'

Hughes was then supposed to make a hydrogen-oxygen dive. But having enjoyed enough success for one trip the party decided not to push their luck. So Hughes made a helium dive to 100 feet for 30 minutes: a dive which, if carried out according to the US Navy helium tables, would have called for about 20 minutes of decompression but which using Edel's procedures required no decompression at all. The dive went off without incident, 'disproving the USN tables and providing Peter with another point for his tables.'

Norman Ketchman, after surfacing from his 335ft dive, being congratulated by Norman Knudsen. Mike Hughes, who was Ketchman's standby diver, is in the background (*James Smith*)

To come to the Gulf, Edel had taken a leave of absence from his current employer, the research department of the oil well logging company Schlumberger, where he was involved in strata analysis. His approach to the job was that of a racetrack punter who takes gainful employment to put money into his business, but unlike a punter, he exploited to the full the company's policy of allowing employees to work on private projects during their lunch hour and coffee breaks to build equipment for diving research. He also enlisted his fellow workers, sometimes as many as a dozen, to help him. This had become such an irritation to his superiors that when he overstayed his leave of absence by a day his boss seized the opportunity and fired him.

With news of the dives all over the Gulf, Edel returned to Morgan City. Since Knudsen and Ketchman were unable or unwilling to pay him a salary, he called on Sanford Brothers, anticipating one of two possible outcomes.

'Either they would kick me out of the office because I had hurt them so badly, or they would decide that if I could operate against them so effectively maybe I could operate as effectively for them. They took the latter approach.'

In the interim, some ten days after Knudsen and Ketchman, Sanford Brothers carried out their first helium dive. The diver was Tom Angel. Whereas Ketchman and Knudsen had done their dives as an attention-grabbing demonstration, Angel's was a working dive, one of several for Esso to recover a conductor pipe that Sanford had blown off with explosives. The pipe lay on a slope at 220–285 feet. Angel made the dive in a Scott mask, with Jack Lahm, as the company's mixed-gas specialist, supervising and running the manifold. For posterity, Angel had the barge captain film the event: Angel jumping over the side, Lahm furiously turning valves. That it was Angel rather than Lahm that made the dive did not bother Lahm; he was more concerned with setting standards and training his crews in the correct procedures.

Sources

Taped Interviews:
Tom Angel: Houma, Louisiana, July 8 1989
Peter Edel: Harvey, Louisiana, July 6 1989
Mike Hughes: May 28 1991 (telephone)
Joe Sanford: Morgan City, Louisiana, July 7 1989

Additional Information:
Tom Angel
Mike Hughes