In June of 2011 a joint field expedition occurred between the Institute of Nautical Archeology from Texas A&M University and the Institute for Diving Medicine at Southern Ocean Medical Center in New Jersey to complete an excavation of a 1st century B.C. Roman shipwreck located off the coast of Kizilburun, Turkey. Members of the expedition included Dr. Deborah Carlson, the principal investigator and now President of INA, was in charge of all archeological aspects of the expedition. My organization, the Institute for Diving Medicine (IDM), provided on-site medical assistance as diving medical officers. The scientific aims were two-fold: complete the archaeological excavation of the shipwreck, as well as to conduct several studies related to diving physiology.

The eastern Mediterranean circa 150 B.C. was a world dependent on maritime trade. At that time, Western Turkey was part of the Roman Empire, and settlements dotted the entire coast. There were several important trade centers in the area, and transport of trade goods was vigorous. This wreck was likely transporting the components of a newly quarried monumental column comprised of a single Doric capital and eight enormous unfluted drums, each about 1.5 meters in diameter and over a meter tall. Once assembled, the drums and capital would have formed a column nearly ten meters tall, weighing around 60 tons. Scientific study of the marble indicates an origin in the quarries of Proconnesus Island in the Sea of Marmara, while transport amphorae and associated ceramics suggest that the wreck dates from the first century B.C.

The findspot at Kizilburun constitutes important evidence for the use of Proconnesian marble outside of its local application in Pergamene and Troad building of the Hellenistic era. The size of the drums suggests a supporting role for nothing smaller than a temple, while the presence of Doric architecture at this time – when Ionic and Corinthian were clearly the preferred orders – invited speculation about whether the column constituted a repair to an existing building or renewed work on an unfinished project. Ultimately, during a several day hiatus from diving in the summer of 2007, an attempt to pinpoint the intended destination of the cargo was made. After an exhaustive search, the most likely candidate seems to be the Temple of Apollo at
Claros, Turkey, approximately 40 km southeast of the wreck site. This is based on the known window for active construction at the temple as well as the strikingly similar size and style of Doric columns between the wreck and the temple. This turned out to be a remarkable connection, as it marks the first time that archaeologists have been able to pinpoint the origin and intended destination of an ancient cargo at sea.

In 2006, the team caught its first glimpse of the ship itself, preserved beneath more than 70 tons of stone cargo. This was accomplished by carefully ballooning off-site four of the eight massive marble drums, weighing nearly 7 tons a piece. As the excavation continued in 2007 through 2009, the goal was to study the wooden hull remains in order to gain insight into the vessel’s construction and determine whether or not this was a purpose-built stone carrier of the type the Romans called a *navis lapidaria*. *In 2011, this last season's excavation was used to bring the drums to the surface to begin conservation.*

The archaeological aspects of the excavation notwithstanding, there were significant logistical aspects related to SCUBA diving including but not limited to concern for decompression sickness. Excavating a shipwreck to archaeological standards in 45 meters (150 feet) of water is no easy task. During each dive, the excavators breathe air as opposed to more exotic gas mixtures including helium; therefore the risk of decompression sickness is palpable. DCS is a clinical syndrome characterized by the formation of supersaturated gas bubbles in the tissues of the diver after decompression and its associated inflammatory cascade that causes joint pain and rash with more severe cases causing neurological impairment such as paralysis. It is difficult to diagnose due to the frequently vague nature of symptoms. The prevention of supersaturated inert nitrogen bubbles in the tissues is the key to minimizing risk of DCS. Therefore, several strategies were employed to account for risk mitigation. These included specifically designed dive tables by Dr. Richard Vann at Divers Alert Network, one of the world's foremost authorities on decompression theory. These tables differ from standard recreational dive tables significantly. While a normal recreational dive table would restrict a diver to depths less than 38 meters, the Vann INA dive tables allow for up to twenty minutes at depths up to 57 meters. This was built into the design of the table to allow for more excavation time. This change significantly adds to decompression stress; therefore a decompression stop is added at the end of the dive whereupon divers breathe 100% oxygen at 6 meters for anywhere from five to thirty five minutes. This hastens removal of nitrogen from the tissues of the body, thus reducing risk of DCS.

Perhaps the most important safety measure employed by INA is the presence of an on-site multiplace hyperbaric oxygen chamber. INA has employed this recompression chamber at all dive sites in Turkey for the past fifteen years; this has added an extra safety margin not found in many scientific diving operations. During their fifty years excavating shipwrecks in Turkey, INA has logged over 50,000 cumulative dives and has had five cases of decompression sickness during that time, which mirrors known data on incidence of DCS in the scientific population. There were no episodes of DCS during this year's expedition.
Decompression sickness is only one of many life-threatening situations that may arise during the course of a dive, but frankly is much less common than something much more mundane like drowning. The most common low air situations are overexertion and nitrogen narcosis leading to inattention and depletion of air sources. Nitrogen narcosis, once coined by Jacques-Yves Cousteau as "The Rapture of the Deep," is an alteration of mental status akin to alcohol inebriation thought to be due to effects of elevated partial pressures of inert nitrogen on chemical receptors in the brain. Effects are magnified with increasing depth, and can cause inattention, euphoria, extreme paranoia, and generalized poor decision making. Understandably, the margin for error on deep dives such as these makes the addition of nitrogen narcosis a clearly dangerous combination. Fortunately, our divers did experience some attenuation of symptoms after repetitive diving, which is similar to alcohol tolerance. However, we maintained extreme diligence in monitoring gas consumption. In these situations, 45 meters is deep enough that emergency ascent during an out-of-air situation is not feasible, so there were several other safety implementations around the dive site to provide alternate emergency air sources. These included spare air tanks spread about the dive site as well as a “telephone booth” which is an inverted Plexiglas dome filled with air. These preparations added a level of safety not normally found on recreational dive sites.

Divers at Kizilburun also contended with the possibility of a variety of marine envenomations, poisonings that occur after contact with potentially hazardous marine life. In this part of the Aegean, the most common envenomation is the Scorpion fish, of the genus Synanceiidae. These fish carry several spines along the dorsal fin that are able to deposit a potent systemic neurotoxin that also has local wound effects, most predominantly severe pain at the site of injection. The toxin is heat labile and does not function well in temperatures greater than 40 C; therefore immersing the affected extremity in water ranging from 40 to 43 C can temporarily relieve the pain. While an antivenin is available, it is prohibitively expensive and is itself heat sensitive, unlikely to last very long in the hot Turkish sun.

All of the aforementioned issues must be considered when providing medical control for a diving operation, notwithstanding the fact that Kizilburun is approximately four hours by boat from the nearest hospital. Therefore, a significant degree of independence and preparation were required to adequately care for any potential medical emergency. Medications, wound care supplies, and other equipment were brought to the site in advance. Fortunately, with the myriad safety nets available to a large scientific diving operation such as this, the most serious maladies this year were orthopedic injuries like broken toes from kicking heavy SCUBA tanks or difficulties with ear pain either from "swimmer's ear" or trauma to the eardrum from frequent pressure changes.

In addition to practical and logistical considerations for medical care on this expedition, our academic group from IDM spearheaded several scientific studies related to diving physiology. These were primarily related to microparticles in the bloodstream and their relation to decompression stress as well as a study on to
the effects of breathing oxygen at depths and how it affects long term vision. Lastly, we initiated a study of the use of in-water recompression (IWR) to treat DCS in the event a recompression chamber is not available.

One of the principal investigators was Dr. David S. Lambert, who holds joint appointments with IDM and the University of Pennsylvania's Institute for Environmental Medicine, one of the nation's foremost authorities on hyperbaric and diving medicine. Dr. Lambert's main scientific focus on this expedition was the study of "microparticles," microscopic chemicals in the bloodstream that experts believe may serve as a biochemical marker for decompression stress and therefore risk of decompression sickness. Over the past forty years, scientists have attempted to pin down a way to discover who is most at risk for DCS; some studies have examined macroscopic bubbles in the blood stream measured by hand held Doppler radar probes similar to what meteorologists use to track weather systems, but these have been somewhat disappointing in their ultimate relationship to the risk of DCS. Sponsoring our project was Dr. Stephen Thom from Penn and focuses his research studying the biochemical mechanisms of hyperbaric oxygen therapy in relation to diving as well as other maladies. He and Dr. Lambert hypothesize that there are several biochemical markers in the bloodstream before and after a dive that may correlate clinically with the risk of developing DCS. Surrounding these rather physiologically strenuous dives, blood samples were drawn from each diver, hopefully providing insight into what is happening on a microscopic basis in the bloodstream and whether or not these markers will lead to a more definitive method of diagnosing DCS.

A second research project headed up by IDM during this excavation centered on physiological changes to the eye during decompression. The dive profile designed by Dr. Vann at DAN calls for approximately forty minutes per day breathing 100% oxygen at 6 meters of depth. We hypothesized that this may induce something called hyperoxic myopia, which is a temporary nearsightedness brought on by a conformational change in the shape of the eye lens. This is well documented in patients receiving hyperbaric oxygen treatments for conditions not related to diving, such as poorly healing wounds of the lower extremity secondary to diabetes or long-term radiation damage. However, it has not been studied well in the diving population. Breathing oxygen at the decompression stop at 6 meters essentially constitutes a hyperbaric oxygen treatment, and while our data has not been evaluated yet, we will continue this important research during further expeditions with INA.

The Institute for Diving Medicine also spearheaded a new logistical project for INA centering on in-water recompression, or IWR. This involves treating potential cases of DCS by placing the patient back in the water and breathing oxygen instead of air, at depths varying from 9 to 18 meters. In-Water Recompression, similar to the scheduled decompression stop, is a form of hyperbaric oxygen treatment and can be used in situations where more definitive therapy in a formal recompression chamber is not available. It tends to be significantly more hazardous than conventional therapy due to the risk of seizure and drowning inherent with breathing elevated partial pressures of oxygen at greater than 6 meters of depth. However, in the situation of an asymptomatic hugely omitted decompression obligation or a patient with a mild to moderate case of the bends, it may be a very effective bridge to more definitive therapy while waiting for transport to arrive to the nearest
hospital, or in a pinch can be used as a definitive therapy in and of itself. If used as a "bridge," the data has shown that earlier treatment, especially in the case of spinal cord paralysis, has lead to better outcomes. There is intriguing anecdotal data from sponge divers in the pacific who have been employing a more rudimentary form of IWR using air instead of oxygen. These cases have shown some significant improvement in DCS cases, converting paralyzed patients into those who are able to walk again. We sought to standardize this treatment into a more user-friendly and less hazardous method.

The initial system consists of measured decompression stops using a custom designed "trapeze," which is a collapsible frame on which patients may rest during IWR. In addition, full face masks were employed delivering 100% oxygen to the patient as well as air to a "tender," a second person underwater next to the patient who is responsible for taking care of them while in-water. The face masks differ from standard open circuit SCUBA regulators in that they are strapped to the head. This allows for two very important safety factors during IWR. The masks allow communication to the patient and to the surface with floodable waterproof microphones and mastoid transmitters to allow the user to hear underwater; in addition if the patient were to experience a seizure due to elevated levels of oxygen at depth, it would theoretically prevent drowning by making it impossible for the seizing patient to spit out the regulator. Our IWR dry run went relatively smoothly and not only confirmed several of our operational hypotheses, but highlighted several areas in need of improvement.

The 2011 diving season at Kizilburun will likely be the last, as this year's goals were to raise the enormous unfluted drums to the surface and begin the lengthy conservation process at INA's research center in Bodrum, Turkey. There the staff will work tirelessly to clean and protect this beautiful Proconnesus Marble in preparation for eventual display. While not a certainty, both INA and the Turkish government are hoping that arrangements may be made to deliver the marble and remainder of the ship's cargo to the Temple of Apollo at Claros, thus completing a 2100 year journey that, many years ago, was unexpectedly and likely violently brought to a premature end. It seems a fitting tribute to the original architects, stonemasons, and sailors to preserve their ancient legacy of seafaring trade that has persisted through the centuries of life on the cool, clear waters of the Aegean.
Questions related to this expedition should be directed to:

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